The Potomac Water Supply Program
Operational Considerations for the
Intake, Ozonation, & Disinfection Systems

2016 Plant Operations Conference

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Loudoun Water
Agenda

1. Presentation Objectives
2. Background on Loudoun Water & Potomac Water Supply Program
3. Raw Water Intake & Pumping Station
   - Air Burst System
4. Trap Rock Water Treatment Facility
   - Ozone
   - Biofiltration
   - Disinfection
Loudoun Water

- Revenue neutral water authority created in 1959
- 9 member Board appointed by the Loudoun County Board of Supervisors
- Serves about 220,000 customers

Potomac Water Supply Program

- Developed as a response to increased water demands as dictated by Loudoun County’s Comprehensive Plan
- Result of years of planning and collaboration between local and regional stakeholders
- Benefits LW customers by providing a reliable source of drinking water for many years into the future
Potomac Water Supply Program

1. Raw Water Intake
2. Potomac Raw Water Pumping Station
3. Raw Water Transmission
4. Water Banking
5. Trap Rock Water Treatment Facility
6. Finished Water Transmission
7. Connection to Distribution System
Key Players

- Owner
- Design Engineers
- PMCM /Program Controls
- Environmental Compliance
- Construction Contractors
Potomac River
Offshore Intake Structure

River Bank Vault

Pumping Station
5,500 sq ft

30-ft x 30-ft Shaft Transition

Main Tunnel
205-ft L x 13-ft H
(Horseshoe w/ curved invert)

Shaft
28-ft ID
125-ft Deep
4-ft Base

~150 ft
Traditional Intake Structure
VWP Requirements for new Intakes

- The Permanent intake structure in the Potomac River shall be designed with screens having a maximum mesh opening of one millimeter and a maximum through-screen intake velocity of 0.25 feet per second.

- The intake structure shall be designed to avoid a boating or other recreational-use hazard. The permittee shall employ all appropriate signage and channel markings as necessary.
New Intake Screen Requirements
Operational Challenges

• Sediment buildup
• Frazil Ice
• Screen Protection from objects floating down the river
• Safety of boaters and kayakers
• Screen Maintenance
Raw Water Intake

16 Half Barrel Screens

Bed Load Deflector

Two 36-inch RW Lines

8-inch Compressed Air Lines
8-inch Flushing Water
1-inch Sample
1-inch Sodium Permanganate
Bed Load Deflector

- Head wall designed to deflect debris and sediment to ensure flow line from middle and top of river enter through the screens.
- CFD Analysis provided optimal headwall height for sediment deflection during average water depths.
- In River Flow Velocity and Direction Measurements Aligned Intake with direction of flow.
Intake Screens

- 16 Half Barrel Screens
- Screen Capacity – 2.5 MGD each
- Screen Dimensions – 140” long x 48” wide x 24” high
- Screen Wire and Opening Size - #69 Wire Mesh w/ 1mm slots
- Maximum Slot Velocity – 0.25 fps
- Air Burst Connection
- Sample Line Connection
- Air bubbler differential pressure indicator
Protecting the Screens

- Deflector Rail to protect the screens from large debris
- Designed for 0.5 kip/foot
Raw Water Intake - Screens

RAW WATER INTAKE - SCREEN DETAIL

NOTE:
1. ONLY SCREENS A, B, AND C HAVE CONNECTIONS TO 1"-SAM-HDPE OR 1"-LS-HDPE.
2. WATER SURFACE ELEVATIONS ARE NOT TO SCALE.

SCALE: 3/4" = 1'-0"
Air Burst System

- Side by side screens to be airburst together.
- Piping sized to achieve air release in seconds.
- Air Compressors (2) - 125HP rotary screw compressors
  - Air compressors controlled by receiving tank pressure set point to allow strength of air burst to be adjusted for changing river levels
  - Each compressor delivers 440 acfm @ 175 psi(g)
- Receiving Tank - 3800 gal, 96" dia X 144" high
- System designed to recharge in less than 5 minutes
Air Burst System Monitoring and Safety

Safety Considerations:

- Recreational Boaters, Kayakers, Tubers, Fishermen
- Means to ensure safety of all river users
- Cameras
- Appropriate Navigation and Regulatory Buoys
- Ability to Restrict Access
Screen Differential Pressure

- Air line/ bubbler pressure measurement for:
  - Potomac River elevation (upstream intake screens)
  - Downstream intake screens
- Fed from air burst aux tank
- Large-digit indicators in pump room for level (standpipe/river elev.)
Flush Water System

Purpose:
- Keep Concrete Pad Free of Sediment and Debris
- Optimize Screen Performance

Hydraulics:
- Four lines each flushing a sector of the intake
- Each sector contains 11 Flushing Nozzles (2/intake screen)
- 44 Total Flushing Nozzles
- 157gpm flow per Nozzle
- Jet Nozzle - 16 fps at the 2" nozzle

FLUSHING NOZZLE DETAIL
Potomac Raw Water Pumping Station

West Elevation
## Potomac River Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Years 2006 through 2010</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
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<td>Min</td>
<td>Average</td>
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<tr>
<td>Aggressiveness Index No.</td>
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<td>Alkalinity, mg/L as CaCO₃</td>
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<td>56</td>
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<td>Aluminum, mg/L</td>
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<td>0.26</td>
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<td>Bromide, mg/L</td>
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<td>0.03</td>
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<td>Chloride, mg/L</td>
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<td>8.7</td>
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<td>Hardness, total</td>
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<td>Iron, mg/L</td>
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<td>Manganese, mg/L</td>
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<td>N, Ammonia, mg/L as N</td>
<td>BQL</td>
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<td>0.01</td>
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<tr>
<td>N, Nitrate, mg/L as N</td>
<td>BQL</td>
<td></td>
<td>0.9</td>
</tr>
</tbody>
</table>

BQL = Below Quantitation Limit

1 Data from Fairfax Water (http://www.fcwa.org/water/imar.htm). Water Quality Analytical Reports, Corbalis WTP Source Water

2 Data BQL were treated as zero values for the computation of the average
# Potomac River Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Years 2006 through 2010</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Min</td>
<td>Average</td>
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<tr>
<td>Nitrite, mg/L as N</td>
<td>BQL</td>
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<td>0.01</td>
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<tr>
<td>pH</td>
<td>7.1</td>
<td>7.9</td>
<td>8.9</td>
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<tr>
<td>Phosphate as Phosphorous, mg/L</td>
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<td>0.01</td>
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<tr>
<td>Solids, Total, mg/L</td>
<td>16</td>
<td>181</td>
<td>258</td>
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<tr>
<td>Solids, Total Dissolved, mg/L</td>
<td>10.7</td>
<td>207</td>
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<tr>
<td>Solids, Total Suspended, mg/L</td>
<td>BQL</td>
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<tr>
<td>Total Organic Carbon (TOC), mg/L</td>
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<td>TON</td>
<td>1</td>
<td>5</td>
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<tr>
<td>Turbidity, NTU</td>
<td>1</td>
<td>9</td>
<td>55</td>
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</tbody>
</table>

TOC Removal >35%

CFE < 0.3 NTU

BQL = Below Quantitation Limit

1 Data from Fairfax Water (http://www.fcwa.org/water/imar.htm). Water Quality Analytical Reports, Corbalis WTP Source Water

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## Water Quality Treatment Goals

### Level 1 WQ Goals
- Meet USEPA Standards and VDH Standards, including:
  - Turbidity
  - TOC
  - Disinfection
  - DBPS
  - Secondary Standards

### Level 2 WQ Goals
- Incorporate Advanced Treatment Processes, including:
  - Ozone (Oxydation of endocrine disruptors or other emerging contaminants)
  - Biofilters (DBP Precursor Reduction)
  - UV (3-log Inactivation of Crypto)
  - GAC or IonExchange (Reduction of Perchlorate)
  - Future
TRWTF Consolidated Treatment Facility

- Ozone Building
  - Rapid Mixing Basins (2 Trains)
  - Floculation Basins (8 Trains)
- Intermediate Ozone Contactors (2 Trains)
- Filter Building
  - 48" UV Treated Water (Future)
  - 48" Filtered Water (Future)
  - 36" Waste Backwash Water
  - 36" Overflow
  - 60" Preozone Contactor Pipelines
- 10" Sludge
- Sedimentation Basins (4 Trains)
  - 36" Overflow
Why Treat with Ozone and Biofiltration?

- Primary Disinfection for Giardia (1-log) and Viruses (2-log)
- Extra barrier concept
- Enhances coagulation
- Taste & Odor/Aesthetics
- Biofiltration removes biodegradable Ozone Byproducts such as Carboxylic Acids and Aldehydes – Cleaner Distribution System
- Disinfection Byproduct Control (D/DBPR - Stages 1 and 2 and future 3/NDMA)
- Removals of Contaminants of Emerging Concern (CEC)
Ozone Is The Most Powerful Chemical Disinfectant for Pathogen Inactivation

The CT value required by ozone is about 1/100th that of chlorine and 1/1000th that of chloramine.

- **Ozone**
  - CT Value = 1.43 mg-min/L

- **Chlorine**
  - CT Value = 112 mg-min/L

- **Chloramine**
  - CT Value = 1,850 mg-min/L

CT value for 3-log *Giardia* cyst inactivation @ 10° C and pH 7
Ozone System – Major Equipment

- LOX Storage and Evaporators
- Ozone Generators
- Ozone Destruct Units
- Ozone Cooling System
Ozone System – Design Criteria

- 2-Stage Ozonation Major equipment:
  - 2 generator (700 ppd ea)
  - 2 Lox tanks (3000 gal ea)
  - 3 vaporizers (145 cfm ea)
  - Supplemental nitrogen system
  - 2 PSU
  - 2 Cooling Water Systems (plate heat exchangers)
  - 4 Sidestream Injection Systems
  - 4 off gas destruct units
Advantages:
- Enhances coagulation turbidity and particle removal
- Taste and odor control
- Color removal
- Oxidation of Iron and manganese removal
- Algal cell lysing/control
Preozonation Process Design Criteria

1. 36" RAW WATER PIPE (2)
2. 36" BLIND FLANGE (FUTURE TRAIN)
3. CHEMICAL INJECTION QUILLS (6)
4. OZONE FLASH REACTOR (2)
5. OZONE OFFGAS TEE OUTLET (2)
6. 60" PREOZONE CONTACTOR PIPELINE (2)
7. ACCESS MANWAY (2)
8. 36" OXONATED WATER PIPE (2)
9. OZONE OFFGAS DESTRUCT UNIT (2)
10. SIDESTREAM INJECTION BOOSTER PUMP SKID (2)
11. FUTURE OZONE OFFGAS DESTRUCT UNIT
12. FUTURE SIDESTREAM INJECTION BOOSTER PUMP SKID
13. PREOZONE INJECTION BUILDING
## Settled Water Ozone Design Criteria (Stage 2)

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Units</th>
<th>New Plant (Phase 1)</th>
<th>Plant Expansion (Phase 2)</th>
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<tbody>
<tr>
<td><strong>Unit Process Description</strong></td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Ozonation for Primary Disinfection</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Using Sidestream Injection and Flash Reactor</td>
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<tr>
<td><strong>Design Flows</strong></td>
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<td>-</td>
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<tr>
<td>Maximum</td>
<td>mgd</td>
<td>21</td>
<td>42</td>
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<tr>
<td>Average</td>
<td>mgd</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Minimum</td>
<td>mgd</td>
<td>4</td>
<td>8</td>
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<tr>
<td><strong>Intermediate Ozone Design Dose (2)</strong></td>
<td></td>
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<td>-</td>
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<tr>
<td>Disinfection Target</td>
<td>--</td>
<td>1-log Giardia Inactivation, 2-log Virus Inactivation</td>
<td></td>
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<tr>
<td>Maximum</td>
<td>mg/L</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Average</td>
<td>mg/L</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>mg/L</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td><strong>Total Ozone Design Dose (Preozone and Intermediate Ozone)</strong></td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Maximum</td>
<td>mg/L</td>
<td>4.0</td>
<td>4.0</td>
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<tr>
<td>Average</td>
<td>mg/L</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>mg/L</td>
<td>1.5</td>
<td>1.5</td>
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<tr>
<td><strong>Ozone Production Requirements</strong></td>
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<td>-</td>
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<tr>
<td>Maximum Ozone Production</td>
<td>lb/day</td>
<td>701</td>
<td>1,401</td>
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<tr>
<td>Average Ozone Production</td>
<td>lb/day</td>
<td>229</td>
<td>450</td>
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<tr>
<td>Minimum Ozone Production</td>
<td>lb/day</td>
<td>50</td>
<td>100</td>
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<td><strong>Intermediate Ozone Contact Time</strong></td>
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<tr>
<td>Number of Contact Basin Trains</td>
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<tr>
<td>Effective Contact Volume Per Train</td>
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<td>14,400</td>
<td>14,400</td>
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<tr>
<td>Available HRT at Design Flow</td>
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<td>14.5</td>
<td>7.4</td>
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<tr>
<td>Baffle factor (Assumed)</td>
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<td>0.7</td>
<td>0.7</td>
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<tr>
<td>Available TiO at Design Flow</td>
<td>min</td>
<td>10.1</td>
<td>5.2</td>
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Ozone Generation Room and Contactor Layout

Figure 3 – Velocity Contours (ft/s) at Elevation 319 feet
10.5 mgd Scenario
# Rapid Biological Filtration Design Criteria

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Units</th>
<th>New Plant (Phase 1)</th>
<th>Scenario 1 (4 gpm/sf)</th>
<th>Scenario 2 (5 gpm/sf)</th>
<th>Scenario 3 (6 gpm/sf)</th>
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<tbody>
<tr>
<td><strong>Unit Process Description</strong></td>
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<td>Dual-Media GAC-Sand Filter and Nozzle Underdrain System</td>
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<tr>
<td><strong>Design Flows</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>mgd</td>
<td>21</td>
<td>42</td>
<td>42</td>
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<tr>
<td>Average</td>
<td>mgd</td>
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<td>22</td>
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<tr>
<td>Minimum</td>
<td>mgd</td>
<td>4</td>
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<td>8</td>
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<td><strong>Filtration Process Criteria</strong></td>
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<tr>
<td>Number of Filters</td>
<td>No.</td>
<td>6</td>
<td>11</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Number of Filters online</td>
<td>No.</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>7</td>
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<tr>
<td>Rated Capacity Per Filter (w/1 filter offline)</td>
<td>mgd</td>
<td>4.2</td>
<td>4.2</td>
<td>5.25</td>
<td>6</td>
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<tr>
<td>Filter Loading Rate w/1 filter offline</td>
<td>gpm/sf</td>
<td>3.9</td>
<td>3.9</td>
<td>4.9</td>
<td>5.6</td>
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<tr>
<td>Filter Loading Rate w/all filters online</td>
<td>gpm/sf</td>
<td>3.3</td>
<td>3.6</td>
<td>4.4</td>
<td>4.9</td>
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<td>Filter Width</td>
<td>ft</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Filter Length</td>
<td>ft</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
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<tr>
<td>Filter Surface Area</td>
<td>sf</td>
<td>740</td>
<td>740</td>
<td>740</td>
<td>740</td>
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<tr>
<td>GAC Filter Media Depth</td>
<td>in</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
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<tr>
<td>GAC Empty Bed Contact Time (w/1 filter offline)</td>
<td>min</td>
<td>7.6</td>
<td>7.7</td>
<td>6.1</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Filtration Equipment – Monolithic Nozzle and Plenum Underdrain System
Filtration Facility Layout

A. FILTER BUILDING
   UPPER LEVEL

B. FILTER BUILDING
   LOWER LEVEL

C. TYPICAL FILTER UNIT

D. TYPICAL FILTER
   OUTLET PIPING

1. GRAVITY FILTER (6)
2. FILTER CONTROL CONSOLE (6)
3. WEIR CHANNEL HATCH (3)
4. BLOWER & ELECTRICAL BUILDING
5. 48" FILTERED WATER PIPE (FUTURE)
6. 48" FILTERED WATER PIPE
7. 18" FILTER-TO-WASTE PIPE
8. 36" FILTER BACKWASH PIPE
9. ELECTRICAL ROOM
10. AIR SCOUR BLOWER ROOM
11. AIR SCOUR BLOWER
12. UV REACTOR
13. FILTER/UV WEIR CHAMBER
14. 12" AIR SCOUR PIPE
15. 18" FILTERED WATER PIPE
16. 18" FLOW METER
17. 24" FILTER INLET VALVE
18. 36" WASTE BACKWASH PIPE
19. GAC/SAND DUAL FILTER MEDIA
20. FILTER WASHWATER TROUGH
21. 48" FILTERED WATER HEADER PIPE
Operator Involvement
Operational Implications

- Consolidated design makes for shorter walking distances to plant equipment
- Sidestream injection system will minimize the need for confined space entry
- Specialized training in ozone equipment and ozone safety
- Ozone dosage optimization
- Ozone sampling and monitoring system
- Need to monitor ozone residual and be ready to dose CATS
- Biofilter monitoring – DO, EPS, Microbial Community, TOC, UV254, Nutrients (N&P)
- Filter under drain should require low maintenance
## Disinfection Process and Credits

<table>
<thead>
<tr>
<th>Unit Process</th>
<th>Target Organism</th>
<th>Applicable Federal Regulation</th>
<th>Disinfection Log Reduction Requirements</th>
<th>Disinfection Log Reduction Credit</th>
<th>Primary or Secondary (Back-up) Treatment Barrier</th>
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</thead>
<tbody>
<tr>
<td>Mix/Floc/Sed/Filtration</td>
<td>Giardia</td>
<td>SWTR</td>
<td>2.5</td>
<td>2.5</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Virus</td>
<td>SWTR</td>
<td>2.0</td>
<td>2.0</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Crypto</td>
<td>LT2ESWTR</td>
<td>3.0</td>
<td>3.0</td>
<td>Primary</td>
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<tr>
<td>Ozone</td>
<td>Giardia</td>
<td>SWTR</td>
<td>0.5</td>
<td>1.0</td>
<td>Primary</td>
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<tr>
<td></td>
<td>Virus</td>
<td>SWTR</td>
<td>2.0</td>
<td>2.0</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Crypto</td>
<td>LT2ESWTR</td>
<td>Bin 1 = 0; Bin 2 = 1</td>
<td>No Credit</td>
<td>NA</td>
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<tr>
<td>Free Chlorine in Clearwell</td>
<td>Giardia</td>
<td>SWTR</td>
<td>0.5</td>
<td>0.5</td>
<td>Secondary</td>
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<tr>
<td>(temporary)</td>
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<td>SWTR</td>
<td>2.0</td>
<td>2.0</td>
<td>Secondary</td>
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<tr>
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<td>Crypto</td>
<td>LT2ESWTR</td>
<td>Bin 1 = 0; Bin 2 = 1</td>
<td>No Credit</td>
<td>NA</td>
</tr>
<tr>
<td>UV*</td>
<td>Giardia</td>
<td>LT2ESWTR</td>
<td>0.5</td>
<td>3.0</td>
<td>Primary</td>
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<tr>
<td></td>
<td>Virus</td>
<td>LT2ESWTR</td>
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<td></td>
<td>Crypto</td>
<td>LT2ESWTR</td>
<td>Bin 1 = 0; Bin 2 = 1</td>
<td>3.0</td>
<td>Primary</td>
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<td>Chloramine in Clearwell</td>
<td>Giardia</td>
<td>SWTR</td>
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<tr>
<td></td>
<td>Virus</td>
<td>SWTR</td>
<td>2.0</td>
<td>No Credit</td>
<td>NA</td>
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<tr>
<td></td>
<td>Crypto</td>
<td>LT2ESWTR</td>
<td>Bin 1 = 0; Bin 2 = 1</td>
<td>No Credit</td>
<td>NA</td>
</tr>
<tr>
<td>Total Primary Disinfection Credits</td>
<td>Giardia</td>
<td>SWTR</td>
<td>3.0</td>
<td>6.5</td>
<td>NA</td>
</tr>
<tr>
<td>(with chloramines in clearwell)</td>
<td>Virus</td>
<td>SWTR</td>
<td>4.0</td>
<td>4.0</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Crypto</td>
<td>LT2ESWTR</td>
<td>3.0 plus Bin Classification</td>
<td>6.0*</td>
<td>NA</td>
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</tbody>
</table>
# UV Disinfection Process Design Criteria

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Units</th>
<th>Alternative UV-1 Phase 1</th>
<th>Alternative UV-1 Phase 2</th>
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</thead>
<tbody>
<tr>
<td><strong>Unit Process Description</strong></td>
<td>--</td>
<td>Post-Filter UV Disinfection System</td>
<td></td>
</tr>
<tr>
<td><strong>Design Flows</strong></td>
<td></td>
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</tr>
<tr>
<td>Maximum</td>
<td>mgd</td>
<td>21</td>
<td>42</td>
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<tr>
<td>Average</td>
<td>mgd</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Minimum</td>
<td>mgd</td>
<td>4</td>
<td>8</td>
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<tr>
<td><strong>UV Process Criteria</strong></td>
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<tr>
<td>Cryptosporidium</td>
<td>--</td>
<td>3-Log Credit per UVDGM Validation Requirements</td>
<td></td>
</tr>
<tr>
<td>Giardia</td>
<td>--</td>
<td>3-Log Credit per UVDGM Validation Requirements</td>
<td></td>
</tr>
<tr>
<td>Validated Dose (VD)</td>
<td>mJ/cm²</td>
<td>12</td>
<td>12</td>
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<tr>
<td>Reduction Equivalent Dose (RED)</td>
<td>--</td>
<td>Determined by UV Vendor Based on Validation Test Results</td>
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</tr>
<tr>
<td>UVT Design Value</td>
<td>%</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>
Finished Water Clearwells
Operational Implications

- Decide how to meet primary disinfection
- Monitor ozone dose, UVT, and/or chlorine residual
- Monitor TOC and DBPS
- Maintain minimum level in the clearwells to satisfy the CT requirements – chlorine or chloramines
- Maintain good records
Any Questions?