City of Tempe
PUBLIC WORKS

THE MICROBIOLOGY OF DRINKING WATER: A UTILITY PERSPECTIVE

2012 AZ INFECTIOUS DISEASE TRAINING AND EXERCISE

AUGUST 2, 2012

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THE MICROBIOLOGY OF DRINKING WATER: A UTILITY PERSPECTIVE

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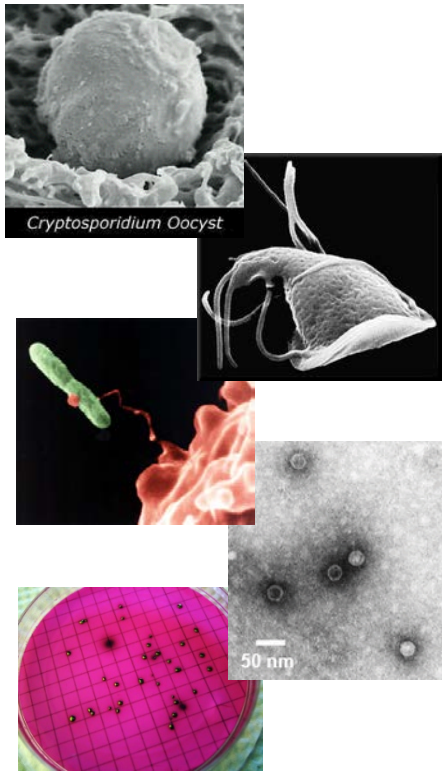
REGULATED MICROBIAL CONTAMINANTS

- Cryptosporidium
- Giardia lamblia
- Legionella
- Enteric Viruses
- Total Coliforms / E. Coli



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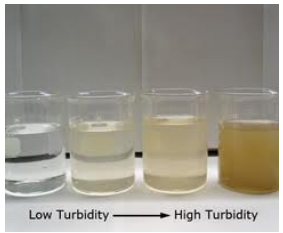
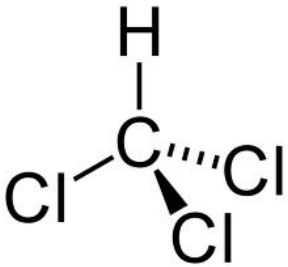
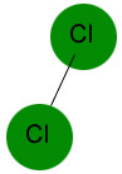
REGULATED NON-MICROBIAL…BUT RELATED… CONTAMINANTS



- Turbidity
- Chlorine & other disinfectants (&HPC)
- Disinfection By-Products
  - Total Trihalomethanes
  - Halocetic Acids





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SAFE DRINKING WATER ACT: MICROBIAL REGULATIONS

- Surface Water Treatment Rule
- Total Coliform Rule
- Disinfectants / Disinfection Byproduct Rule

- Filter Backwash Rule
- Groundwater Rule

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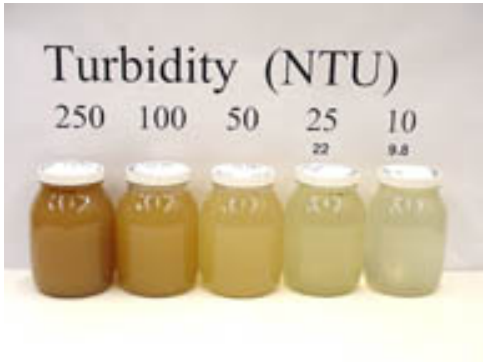
SAFE DRINKING WATER ACT: SURFACE WATER TREATMENT RULE

(SWTR, IESWTR, LT1, LT2)

- Turbidity (filter performance measure)
  - Continuous monitoring, periodic recording
  - Individual filters (>0.5 NTU (2/15))
  - Combined filter effluent
    - >0.3 NTU 36 hr/mo (non-acute)
    - > 1 NTU (acute)

(POE CL2 Residual ≥ 0.2 ppm)



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SAFE DRINKING WATER ACT: SURFACE WATER TREATMENT RULE

(SWTR, IESWTR, LT1, LT2)

- Log Removal
  - Giardia: 3-log (99.9%)
  - Virus: 4-log (99.99%)
  - Legionella: G/V
  - Crypto: 3-log (99.9%) ("bin"1)

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SAFE DRINKING WATER ACT: SURFACE WATER TREATMENT RULE

(SWTR, IESWTR, LT1, LT2)

Log Inactivation "Credit"*

	Filtration	Chlorination	UV
Giardia	2.5 log	Calc	Calc
Virus	3 log	Calc	No
Crypto	3 log	No	Calc

* Other credits include: membrane filtration, ozone, chlorine, watershed protection, etc.

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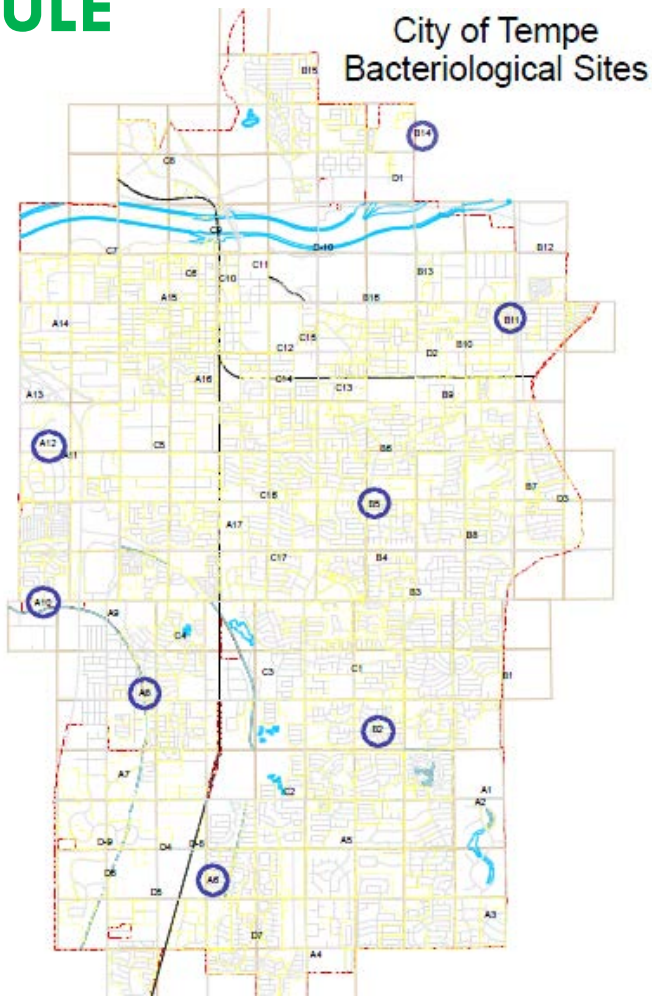
SAFE DRINKING WATER ACT: TOTAL COLIFORM RULE

- Distribution System Sampling
  - Pop-dependent (Tempe = 120/mo.)
- Total Coliform:
  - 95% (-) / (+) chlorine (non-acute)
- E. Coli
  - Tested if TC+
  - E. Coli + AND Repeat is TC+ (acute)
- Cross Connection Program



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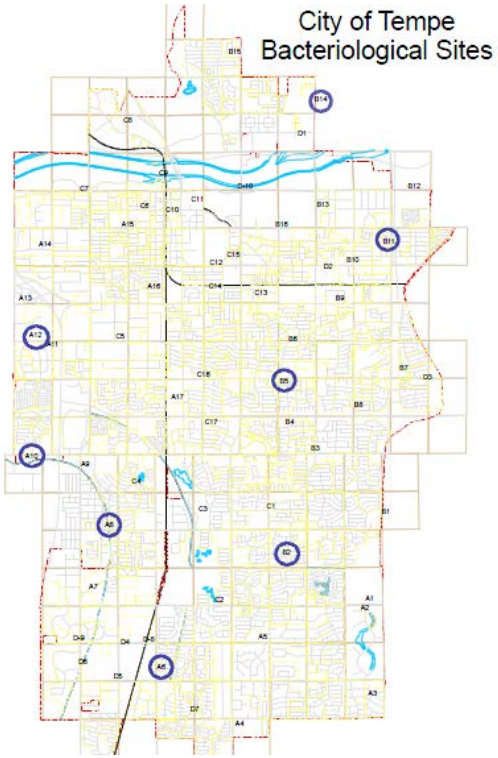
SAFE DRINKING WATER ACT: DISINFECTANTS / DISINFECTION BYPRODUCTS RULE

(Stage I, Stage II)



- Distribution System Sampling
  - Chlorine: TCR samples
    - 4.0 mg/L RAA of monthly averages
  - DBPs: Source-Dependent (Tempe = 8 sites)
    - LRAA of 1/4ly samples
    - TTHMs: 80ppb
    - HAA: 60ppb

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SAFE DRINKING WATER ACT: FILTER BACKWASH RULE

- Backwash recycle
  - Head of the plant
- Record-keeping

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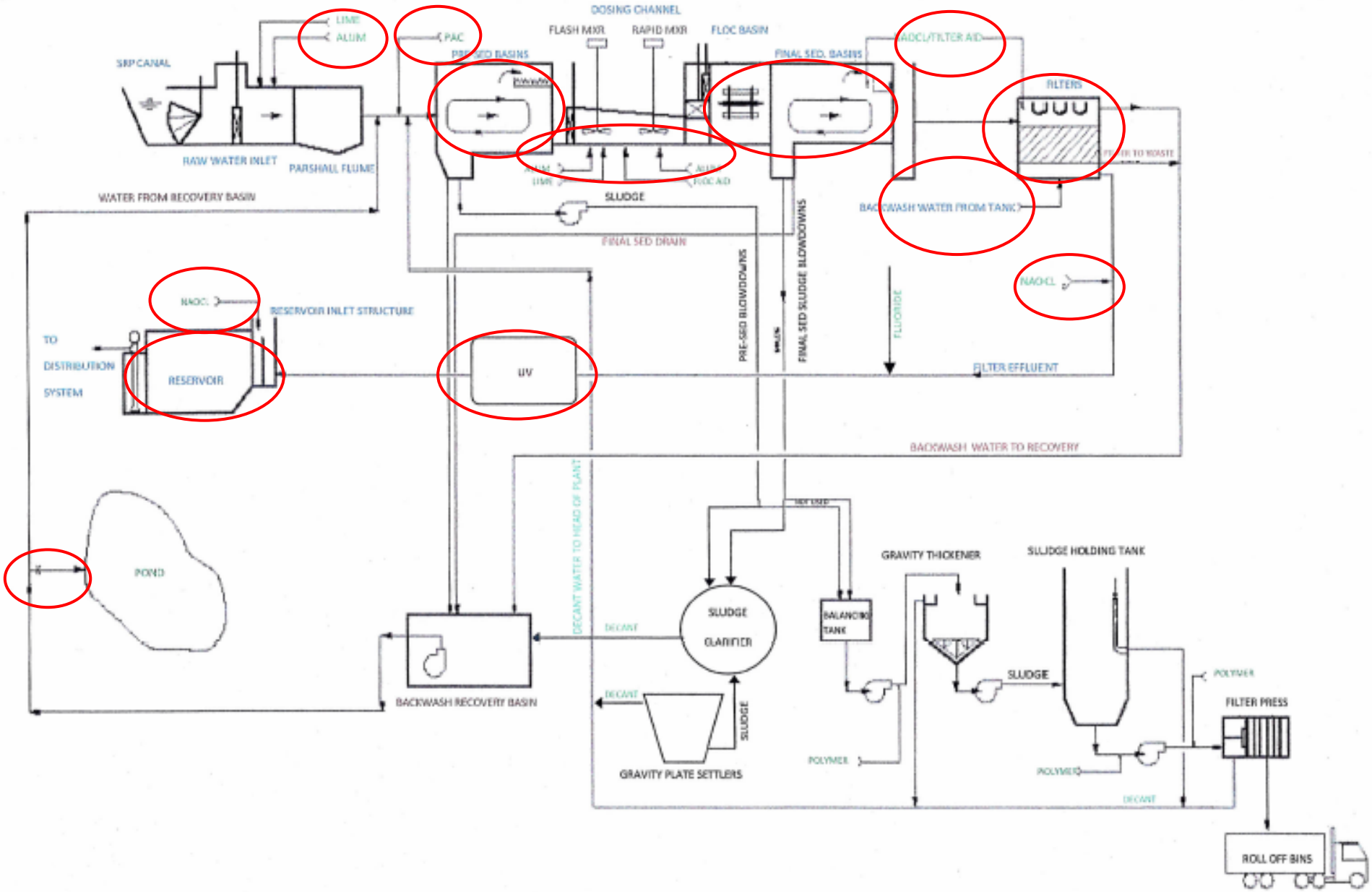
SAFE DRINKING WATER ACT: GROUNDWATER RULE

- 4-Log (99.99%) virus removal

  or

- Monitor GW Sources that were online at the time of TC+ distribution samples
  - E. coli


SRP CANAL
LIME
ALUM
PAC
DOSING CHANNEL
FLASH MIXR
RAPID MIXR
FLOC BASIN
PRE-SED BASINS
FINAL SED. BASINS
NADCL/FILTER AID
FILTERS
FILTER TO WASTE
RAW WATER INLET
PARSHALL FLUME
WATER FROM RECOVERY BASIN
SLUDGE
FINAL SED DRAIN
BACKWASH WATER FROM TANK
PRE-SED BLOWDOWNS
FINAL SED SLUDGE BLOWDOWNS
FLUORIDE
NAOCL
NAOCL
RESERVOIR INLET STRUCTURE
TO
DISTRIBUTION
SYSTEM
RESERVOIR
UV
FILTER EFFLUENT
BACKWASH WATER TO RECOVERY
DECANT WATER TO HEAD OF PLANT
POND
SLUDGE
CLARIFIER
BALANCING TANK
GRAVITY THICKENER
SLUDGE HOLDING TANK
DECANT
SLUDGE
POLYMER
FILTER PRESS
BACKWASH RECOVERY BASIN
DECANT
SLUDGE
GRAVITY PLATE SETTLERS
POLYMER
POLYMER
DECANT
ROLL OFF BINS

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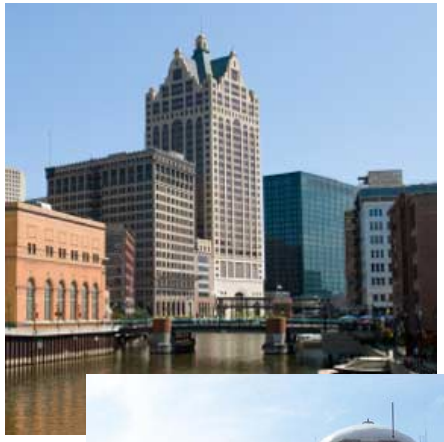
MICROBIAL CONTAMINATION: PREPAREDNESS



- Lessons learned
  - Milwaukee 1993
  - Arizona 2005

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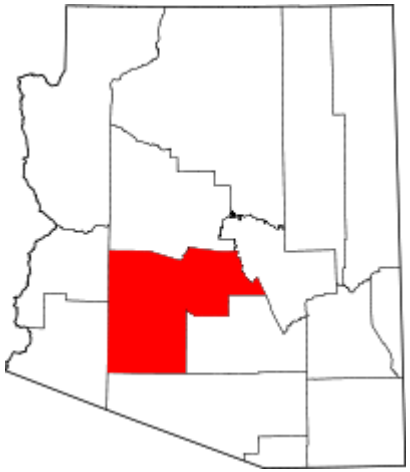
MICROBIAL CONTAMINATION: PREPAREDNESS



- Regional
  - Maricopa County Waterborne Disease Task Force
    - Action Response Plan (last revision Feb 2009)
      - Consistent Response
      - Interagency coordination and communication
  - State-Wide, 2012

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MICROBIAL CONTAMINATION: PREPAREDNESS: TEMPE

- Water Quality Process and Planning Coordinator
- Emergency Preparedness Plan: Goals/Action Items Include:
  - Development of Emergency Capacity (wells)
  - High Turbidity (e.g., "Fire Water") treatment protocol
  - Revise Emergency Response Plan
  - Interconnects
  - Chemical preparedness
  - Well preparedness

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DAVID McNEIL

ENVIRONMENTAL SERVICES MANAGER

CITY OF TEMPE

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SOUTH TEMPE WATER TREATMENT PLANT UV LOG REMOVAL DAILY RECORD

Date: Thu, 07/05/2012

Operator Initials	DW	DW	DW	DW	DW	DW	DW	RWR	RWR	RWR	RWR	RWR	RWR	RWR	RWR	DM	DM	DM	DM	DM	DM	DM	DM	DW
Time	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Actual Time	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	11:50	13:20	14:10	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
UV Transmittance (%)	95.4	95.5	95.4	95.4	95.2	94.9	94.7	94.6	94.5	94.7	94.8	94.8	95.0	95.2	95.3	95.3	95.4	95.5	95.5	95.5	95.5	95.5	95.6	95.5
Reactor 1: Flow (mgd)	7.4	7.6	7.4	7.5	7.8	7.4	7.7	7.7	6.9	7.3	7.6	7.5	7.7	6.6	6.6	7.5	7.8	7.4	7.9	7.3	7.3	7.4	7.7	7.7
Reactor 1: RED (mJ/cm^2)	55.4	57.0	55.7	56.0	56.6	54.6	54.6	53.0	54.0	55.5	53.0	56.0	55.4	54.0	54.0	56.0	56.7	55.4	56.6	55.2	55.3	56.1	57.3	57.1
Reactor 2: Flow (mgd)	6.7	7.5	7.1	7.1	6.3	6.8	7.1	7.1	6.8	7.6	6.2	6.4	7.2	6.6	6.2	6.9	6.5	7.2	6.5	7.3	7.0	6.7	6.3	7.0
Reactor 2: RED (mJ/cm^2)	53.4	56.1	53.9	54.1	52.4	52.7	53.7	54.0	53.0	54.0	52.0	52.0	54.6	54.0	52.0	53.5	52.4	55.0	52.5	55.0	53.8	53.0	52.3	53.8
Reactor 3: Flow (mgd)	5.8	6.3	6.1	5.8	6.0	6.2	5.8	5.8	6.1	5.8	6.1	6.1	6.2	5.1	6.3	6.1	5.6	6.0	6.2	5.8	6.4	6.0	6.2	6.1
Reactor 3: RED (mJ/cm^2)	52.2	52.2	52.1	52.2	52.1	52.3	52.1	52.0	52.0	52.0	52.0	52.0	52.0	81.0	52.0	52.1	52.1	52.1	52.1	52.0	52.4	52.1	52.0	52.1
Reactor 4: Flow (mgd)	6.5	6.4	6.5	5.8	6.8	6.7	6.2	5.7	6.3	7.1	6.8	6.9	6.7	5.6	5.8	6.6	6.9	6.6	6.7	6.5	6.4	6.9	6.2	6.3
Reactor 4: RED (mJ/cm^2)	48.9	48.4	49.2	52.1	49.3	49.5	48.2	48.0	49.0	51.0	50.0	52.0	50.0	53.0	53.0	50.8	51.9	51.0	51.7	51.9	51.9	53.7	51.5	51.8
Minimum RED of on-line reactors	49	48	49	52	49	49	48	48	49	51	50	52	50	53	52	51	52	51	52	52	52	52	52	52
Validated Range Compliance: Flow	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Validated Range Compliance: UVT	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Giardia: Required Log Removal	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Giardia: Required RED (mJ/cm^2)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Giardia RED Compliance Ratio	7.4	7.3	7.5	7.9	7.5	7.5	7.3	7.3	7.4	7.7	7.6	7.9	7.6	8.0	7.9	7.7	7.9	7.7	7.8	7.9	7.9	7.9	7.8	7.9
Approx. Giardia Log Removal	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log
Approx. Crypto Log Removal	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log	>3-log
Total Flow (mgd)	26.4	27.8	27.0	26.1	26.8	27.1	26.9	26.3	26.1	27.8	26.7	26.9	27.8	23.9	24.9	27.1	26.8	27.2	27.3	26.9	27.1	27.0	26.4	27.1
Number of Reservoirs Online	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Finished Water Temperature (deg C)	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	23	23	23	23	23	23	23	23	23
Finished Water Temperature (deg F)	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	74	74	74	74	74	74	74	74	74
South Reservoir (#1) Chlorine Residual	0.55	0.54	0.53	0.53	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.45	0.45	0.46	0.44	0.42	0.42	0.41	0.41	0.41	0.43	0.43	0.44
Finished Water pH	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Reservoir Level (ft)	18.6	18.6	18.5	18.4	18.3	18.1	17.6	16.9	16.7	16.6	16.6	16.8	17.2	17.5	17.6	17.9	18.5	18.5	18.6	18.6	18.6	18.2	18.1	18.0
Assumed Reservoir Baffling Factor:	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Reservoir Effluent Flow (mgd)	27.2	27.1	28.8	28.9	29.1	40.9	41.2	41.0	29.0	24.7	17.4	17.0	14.3	18.0	17.9	18.2	18.3	17.6	25.4	26.8	26.8	31.2	29.9	29.9
CT Actual (min-mg/L) :	172.5	169.6	156.1	154.8	149.9	101.1	95.1	89.6	122.3	139.6	193.2	201.2	246.6	199.1	206.1	197.6	194.9	202.6	137.9	130.7	130.7	114.8	119.1	120.9
Cl^2 Log-Reduction (*Giardia lamblia*)	10.9	10.7	9.9	9.8	9.5	6.5	6.1	5.8	7.9	9.0	12.5	13.0	16.0	12.6	13.4	12.5	12.4	12.9	8.8	8.3	8.3	7.3	7.5	7.7
Cl^2 Log-Reduction (*Virus*)	318.6	311.9	287.1	286.0	275.7	186.6	175.6	166.0	226.8	257.8	358.2	373.0	457.1	363.3	382.2	352.2	347.3	361.1	245.7	232.9	232.9	204.6	212.1	217.2
Meeting Target Giardia Removal with Cl^2	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Meeting Target Virus Removal with Cl^2	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Giardia: ***Required*** Log Removal (Cl^2) *when UV not in use	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Virus: Required Log Removal (Cl^2)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Giardia Combined Log Removal (UV, Cl^2, Conv)	16.4	16	15	15	15	12	12	11	13	15	18	19	21	18	19	18	18	18	14	14	14	13	13	13
Crypto Combined Log Removal (UV, Conv)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Virus Combined Log Removal (Cl^2, Conv)	320.6	313.9	289.1	288.0	277.7	188.6	177.6	168.0	228.8	259.8	360.2	375.0	459.1	365.3	384.2	354.2	349.3	363.1	247.7	234.9	234.9	206.6	214.1	219.2
OFF Compliance Volume (mg)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ON Compliance Yes/No	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
OFF Compliance Daily Total (mg)	0.0																							

Data Entry Notes:

(Yellow highlighted cells are for data entry):

Data is collected from the "SCADA UV System Summary" screen and "Reservoir" screen.

Calculations:

Minimum RED of on-line reactors' is the minimum RED out of the reactors that have flow greater than 0

Giardia: Required RED (mJ/cm^2)' is based on lookup table from 2003 UV Disinfection Guidance Manual Proposal Draft Tier 1 Criteria and the WTP's Giardia log removal requirement

Giardia RED Compliance Ratio is 'Minimum RED of on-line reactors' / 'Giardia: Required RED (mJ/cm2)'. For disinfection complaince, this must always be equal to or greater than 1.0

Compliance:

*Giardia: **3-log** removal required. (UV, Cl^2, Conv)

*If **UV not in use**, **0.5-log** removal by CL2 required for Giardia

Crypto: **4-log** removal required (UV, Conv)

Virus: **4-log** removal required (Cl^2, Conv)

Convential Treatment Credit for **Giardia 2.5-log**

Convential Treatment Credit for **Crypto 3-log**

Convential Treatment Credit for **Virus 2-log**

Background Calculations:

# of Reservoirs	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Peak Flow : gpm	18,903	18,833	20,007	20,056	20,208	28,424	28,632	28,472	20,139	17,153	12,083	11,806	9,896	12,500	12,424	12,639	12,708	12,222	17,639	18,611	18,611	21,667	20,764	20,757
Volume : gal	16,470,963	16,429,979	16,368,550	16,276,511	16,184,600	15,960,460	15,443,772	14,761,148	14,561,741	14,462,269	14,412,591	14,661,367	15,061,421	15,363,090	15,463,958	15,767,494	16,378,784	16,378,784	16,481,213	16,481,213	16,481,213	16,072,435	15,970,632	15,848,675
Vol. Eff. : gal	5,929,547	5,914,792	5,892,678	5,859,544	5,826,456	5,745,766	5,559,758	5,314,013	5,242,227	5,206,417	5,188,533	5,278,092	5,422,112	5,530,713	5,567,025	5,676,298	5,896,362	5,896,362	5,933,237	5,933,237	5,933,237	5,786,077	5,749,428	5,705,523
T10 : min	314	314	295	292	288	202	194	187	260	304	429	447	548	442	448	449	464	482	336	319	319	267	277	275
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Truncated Pyramid Volume Equation:

$V = (1/3) \times [A_1 + (A_1 \times A_2)^{1/2} + A_2] \times h$

Reservoir Inputs

h = 24 ft

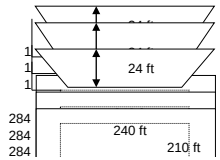
l1 = 240 ft

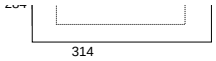
w1 = 210 ft

l2 = l1 + 2h

w2 = w1 + 2h

A1 = 192 x 312



A2 = (192 + 2 x h)(312 + 2 x h)
A2 = 236 x 356 (full reservoir condition)
m

1.54