

## REGULATORY REQUIREMENTS

1. Plan Review
  - Pilot Study
  - Approval to Construct
  - Final Approval
2. Operator Certification
  - Water Treatment 1 (Typical)
3. Monitoring
  - Chlorine/CT
  - Turbidity
4. Reporting/Recordkeeping
  - Monthly Reporting (NTU, Chlorine, CT, etc.)

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## REGULATORY REQUIREMENTS

Plan Review – OAR 333-061-0050(4)(c)(C) & (E)

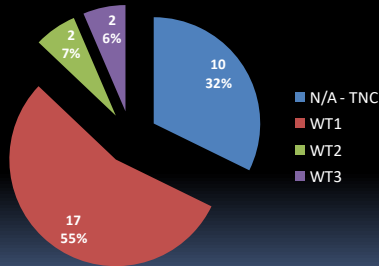
(C) Pilot studies shall be conducted by the water supplier to demonstrate the effectiveness of any filtration method other than conventional filtration. Pilot study protocol shall be approved in advance by the Authority. Results of the pilot study shall be submitted to the Authority for review and approval.

(E) All filtration systems shall be designed and operated so as to meet the requirements in OAR 333-061-0032(4) and (5) – i.e., meet turbidity limits and CT requirements. Design of the filtration system must be in keeping with accepted standard engineering references acknowledged by the Authority such as the **Ten States Standards**, technical reports by the International Reference Center for Community Water Supply and Sanitation ("IRC manual"), or publications from the World Health Organization ("WHO manual").

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## REGULATORY REQUIREMENTS – OTHER

Operator Certification Level Required for Slow Sand Filtration Systems in Oregon



N/A - TNC = Transient Non-Community water systems that are required to have their operator(s) attend a 1-time only class (0.6 CEU class).

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## REGULATORY REQUIREMENTS

Surface Water Treatment Rule (SWTR), 1989

- 40 CFR 141.70 – 141.75 (applies to all SW and GWUDI systems a.k.a. "Subpart H" systems)
- Required 3.0-log (99.9%) Giardia and 4-log (99.99%) virus removal/inactivation (filtration plus disinfection)
- Established turbidity limits ( $\leq 1$  NTU in 95% of readings w/all  $\leq 5$  NTU)
- Established disinfectant residual requirements

Interim Enhanced Surface Water Treatment Rule (IESWTR), 1998

- 40 CFR 141.170 – 141.175
- Added 2.0-log cryptosporidium treatment requirements

Long-Term 1 Enhanced Treatment Water Rule (LT1), 2002

- 40 CFR 141.500 – 141.571
- Extended IESWTR requirements for systems  $< 10,000$  pop

Long-Term 2 ESWTR (LT2), 2006

- 40 CFR 141.700 – 141.723 & 40 CFR 141.211, Appendix A to Subpart Q
- Additional *Cryptosporidium* treatment requirements depending upon source sampling and resultant bin classification (more treatment if higher than bin 2)
- Addressed uncovered finished water reservoirs

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## REGULATORY REQUIREMENTS – PATHOGEN RMVL

Applicability: PWSs that use SW or GWUDI that practice SSF, DE, or Alternative Filtration

Regulated Pathogen	Requirement
	99.99% (4-log) removal/inactivation of viruses (SWTR)
	99.9% (3-log) removal/inactivation of <i>Giardia lamblia</i> (SWTR)
	99% (2-log) removal of <i>Cryptosporidium</i> (IESWTR/LT1) ( $> 2$ -log if Bin 2 or higher under LT2)

Slow sand filtration is credited with removing:

- 2.0-log *Giardia* &
- 2-log *Cryptosporidium*

1.0-log *Giardia* inactivation is needed through disinfection, 0.5-log of which must be obtained after filtration.

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## REGULATORY REQUIREMENTS – TURBIDITY

### Turbidity Limits

Turbidity	Monitoring/Recording	CFE Turbidity Limits
	Turbidity readings are to be monitored/recorded at the combined filter effluent (CFE) at a frequency of at least once every 4 hours*	95% of CFE turbidity readings $\leq 1$ NTU ( $\leq 1.49$ NTU)
		All CFE turbidity readings $\leq 5$ NTU ( $\leq 5.49$ NTU)

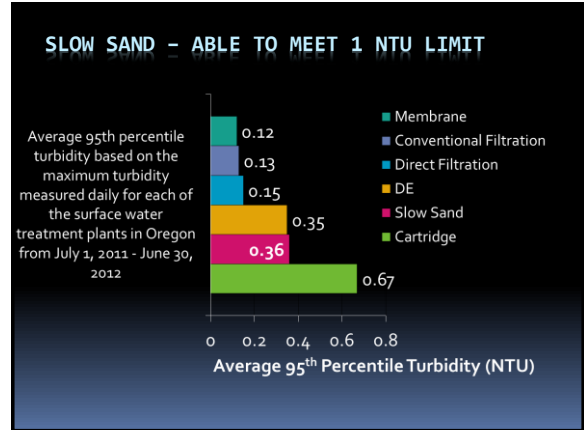
\* Frequency may be reduced by the State to once per day.

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### REGULATORY REQUIREMENTS - NTU REPORTING


Turbidity Reporting	
Turbidity reporting required within 10 days after the end of the month:	Total # of Monthly Measurements
	Number and percent less than or equal to 95 <sup>th</sup> percentile turbidity limit
Turbidity reporting required within 24 hours:	Date and Value Exceeding 5 NTU
	Exceedances of 5 NTU for CFE

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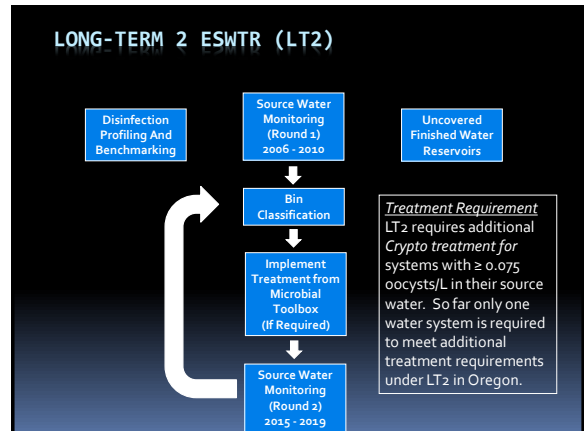
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## TURBIDIMETERS



- Turbidimeters
  - Online, portable or bench-top
  - Must be calibrated per manufacturer or at least quarterly with a primary standard
    - Formazin solution
    - StablCal® (stabilized formazin)
  - Secondary standards used for day-to-day check
  - Check is used to determine if calibration with a primary standard is necessary
    - Gelex
    - Manufacturer provided (e.g. Hach ICE-PIC)

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### LONG-TERM 2 ESWTR (LT2)

40 CFR 141.701(c) Monitoring Schedule

*Initial and second round monitoring must begin no later than the month beginning with the date listed in the table below.*

Schedule	Systems that serve...	1 <sup>st</sup> Round	2 <sup>nd</sup> Round
1	At least 100,000 people*	October 1, 2006	April 1, 2015
2	From 50,000 to 99,999 people*	April 1, 2007	October 1, 2015
3	From 10,000 to 49,999 people*	April 1, 2008	October 1, 2016
4 (E. coli)	Fewer than 10,000, not a wholesale system, and monitors for E. coli <sup>a</sup>	October 1, 2008	October 1, 2017
4 (Crypto)	Fewer than 10,000, not a wholesale system, and monitors for Cryptosporidium <sup>b</sup>	April 1, 2010	April 1, 2019

\*Also applies to wholesalers in a combined distribution system (CDS) that contains a schedule 1, 2, or 3 system.  
<sup>a</sup> Applies only to filtered systems.  
<sup>b</sup> Applies to filtered systems that meet the conditions of paragraph (a)(4) of §141.701 and unfiltered systems.

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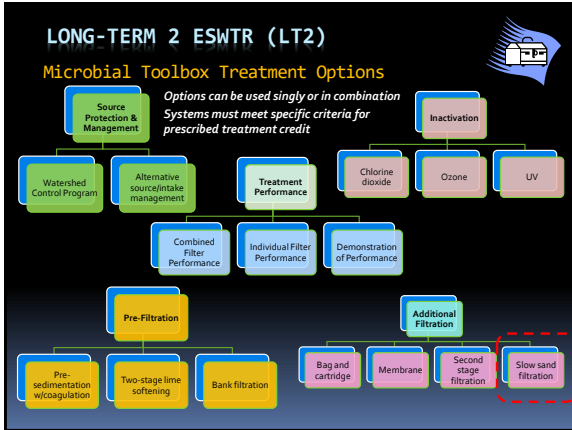
### LONG-TERM 2 ESWTR (LT2)

Filtered System Additional Cryptosporidium Treatment Requirements  
 (based on their bin classification as determined under § 141.710 and according to the schedule in § 141.713)

bin	Conventional Filtration (including softening), Slow Sand, or Diatomaceous Earth	Direct filtration	Alternative filtration technologies
Bin 1	No Additional Treatment		
Bin 2	1-log treatment	1.5-log treatment	RMVL + Inactivation ≥ 4.0-log <sup>1</sup>
Bin 3	2-log treatment	2.5-log treatment	RMVL + Inactivation ≥ 5.0-log <sup>2</sup>
Bin 4	2.5-log treatment	3-log treatment	RMVL + Inactivation ≥ 5.5-log <sup>3</sup>

<sup>1</sup>As determined by the State such that the total Cryptosporidium removal and inactivation is at least 4.0-log.  
<sup>2</sup>As determined by the State such that the total Cryptosporidium removal and inactivation is at least 5.0-log.  
<sup>3</sup>As determined by the State such that the total Cryptosporidium removal and inactivation is at least 5.5-log.

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### REGULATORY REQUIREMENTS – DISINFECTION

#### Entry Point Chlorine Residual

Entry Point Residual Disinfection Concentration  (for free chlorine measured prior to or at the first customer each day of operation)	Residual disinfectant concentration cannot be < 0.2 mg/l for more than 4 hours based on continuous monitoring (> 3,300 pop) or less frequent monitoring as allowed by the state. (SWTR)  (contact your state regulator if using a disinfectant other than chlorine or are planning to switch disinfectants)  No two consecutive daily samples should exceed 4.0 mg/l (DBPR)
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Where chlorine is used as the disinfectant, the measurement of residual chlorine shall be by the **DPD or other EPA-approved method** in accordance with Standard Methods for the Examination of Water and Waste-water, and shall measure the free chlorine residual or total chlorine residual as applicable

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### REGULATORY REQUIREMENTS – DISINFECTION

#### Distribution System Chlorine Residual

Distribution System Residual Disinfection Concentration  (for free chlorine measured with coliform samples)  (contact your state regulator if using a disinfectant other than chlorine or are planning to switch disinfectants)	Residual disinfectant concentration cannot be undetectable in greater than 5% of samples in a month, for any 2 consecutive months. (SWTR)  Not to exceed 4.0 mg/l MRDL* (DBPR)
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\*The maximum residual disinfectant level (MRDL) is regulated under the Disinfection By-Products Rules (DBPR). Compliance is based upon chlorine residuals taken at the same location and frequency as that required for total coliform monitoring in the distribution system. The running annual average of monthly averages of samples, computed quarterly, must be ≤ 4.0 mg/l.

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### REGULATORY REQUIREMENTS – CL2 REPORTING

#### Additional Distribution Residuals Monitoring 2x per week

Distribution  (records to be kept by the water system for at least 2 years)	All public water systems that add a disinfectant to the water supply at any point in the treatment process, or deliver water in which a disinfectant has been added to the water supply, must maintain a detectable disinfectant residual throughout the distribution system and shall measure and record the residual at one or more representative points at a frequency that is sufficient to detect variations in chlorine demand and changes in water flow but in no case less often than twice per week.
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### REGULATORY REQUIREMENTS – CL2 REPORTING

#### Chlorine Residual Reporting Required (within 10 days after the end of the month)

Entry Point  (reported with turbidity)	Lowest daily value for each day, the date and duration when residual disinfectant was < 0.2 mg/l, and when State was notified of events where residual disinfectant was < 0.2 mg/l.
Distribution  (reported with coliform sample results)	Number of residual disinfectant or HPC measurements taken in the month resulting in no more than 5% of the measurements as being undetectable in any 2 consecutive months.

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### CHLORINE ANALYZERS

- Chlorine analyzers
  - Handheld (HACH Colorimeter shown)
    - Follow manufacturer's instructions
  - Online
    - Check calibration against a handheld that has been calibrated
    - At least weekly
    - Follow manufacturer's instructions if out of calibration

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### REGULATORY REQUIREMENTS – OTHER

Other SWTR/IESWTR/LT1 Requirements	
Disinfection Profiling & Benchmarking	Systems must profile inactivation levels and generate a benchmark, if required due to disinfection changes (IESWTR & LT1)
Water System Surveys (State Requirement)	CWS: Every 3 years NCWS: Every 5 years (IESWTR & LT1)
Finished Water Reservoirs	New (post-1989) reservoirs must be covered under SWTR. Pre-SWTR reservoirs must be covered (or have additional treatment) under LT2
Operator Certification	Operated by Qualified Personnel as Specified by State (SWTR)

(CWS) Community Water System (NCWS) Non-community Water System

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Cyanotoxin Monitoring (OAR 333-061-0510 to -0580) Healthoregon.org/dwcyanoxtoxins	
Who does this apply to?	Affects systems who have sources susceptible to cyanobacteria blooms (not everyone). See list systems and specific rule requirements on-line at <a href="http://www.healthoregon.org/dwcyanoxtoxins">www.healthoregon.org/dwcyanoxtoxins</a>
What is required?	Raw water (intake) sampling for total microcystin and Cylindrospermopsis toxins every 2 weeks from May 1 <sup>st</sup> – October 31 <sup>st</sup> each year
What happens if detected?	<ol style="list-style-type: none"> <li>Notify your regulator</li> <li>If any toxins are greater than or equal to 0.3 µg/L in raw water or if there is a recreational use health advisory* upstream of the intake, sample raw and entry point weekly with the first EP sample taken within 1 business day. Weekly sampling continues until non-detect at EP and less than 0.3 µg/L in raw water in two consecutive samples.</li> <li>If detected at EP, sample EP daily and optimize treatment for toxin removal.</li> <li>If above Health Advisory Level (HAL) at EP, take confirmation sample within 24-hrs &amp; monitor EP daily.</li> <li>If confirmation sample is above the HAL, issue Do-Not-Drink Advisory</li> <li>Advisory may only be lifted if 2 consecutive daily EP samples taken a minimum of 24-hrs apart are ≤ HAL and two consecutive daily sets of distribution samples taken a minimum of 24 hours apart are ≤ HAL</li> </ol> <p>*Recreational use health advisory means a health advisory issued by the Oregon Health Authority for a water body when cyanotoxins are determined to be above any recreational use advisory levels.</p>
What are the DW Health Advisory Levels (HALs)?	<ul style="list-style-type: none"> <li>Total Microcystins: 0.3 µg/L for vulnerable people; 1.6 µg/L for all persons</li> <li>Cylindrospermopsis: 0.7 µg/L for vulnerable people; 3 µg/L for all persons</li> </ul> <p>*Vulnerable people means infants, children under the age of six, pregnant women, nursing mothers, those with pre-existing liver conditions, and those receiving dialysis treatment.</p>

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### REVIEW

- 2.0-log Cryptosporidium removal is required (and credited) for slow sand filtration.
- Surface Water Treatment Rule (SWTR) requires 3-log reduction of *Giardia* using a combination of disinfection and filtration and 4.0-log reduction of viruses.
- At least 2.0 -log *Giardia* removal is credited for slow sand filtration (per 1991 USEPA SWTR Manual)
- 1.0-log *Giardia* inactivation must be achieved through disinfection (0.5-log must be after filtration). 1.0-log reduction of viruses must also be achieved after filtration.

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### REPORTING FORMS

There are 4 forms:

- Conventional/Direct
- **Slow Sand / Membrane / DE / Unfiltered**
- Cartridge
- UV (if used for *Giardia credit*)

Must use correct form because each has questions that must be answered that are specific to the filtration type

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### REPORTING FORMS – CFE TURBIDITY

OHA - Drinking Water Program – Turbidity Monitoring Report Form County: \_\_\_\_\_  
Slow Sand, Membrane, Diatomaceous Earth Filtration, or Unfiltered Systems

System Name:	ID #:	WTP-:	Month/Year:				
DAY	12 AM (NTU)	4 AM (NTU)	8 AM (NTU)	NOON (NTU)	4 PM (NTU)	8 PM (NTU)	Highest Reading of the Day <sup>1</sup> (NTU)
1			0.34				0.50
2			0.24				0.66
3			0.44				
4							
5							
6							
7							
8							
9							
10							

Notify the State if NTU > 1 NTU.  
Notify the State within 24-hrs if turbidity > 5 NTU (includes after hours)

Public Health After Hours Duty Officer:  
Cell (971) 246-1789  
Pager (503) 938-6790  
Oregon Emergency Response System:  
1-800-452-0311

- Chose time closest to when daily turbidity is measured and enter result(s)
- Enter highest turbidity of all measurements for the day (e.g., on-line instrument or highest of multiple daily grab samples)

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### REPORTING FORMS – MONTHLY SUMMARY - TURBIDITY

**Slow Sand/Membrane/DE Filtration/Unfiltered**

95% of daily turbidity readings ≤ 1 NTU? <sup>2</sup>  Yes /  No

All daily turbidity readings ≤ 5 NTU?  Yes /  No

- Based on the results entered for the month, circle "yes" or "no" to the two questions at the bottom of the form.

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: \_\_\_\_\_ ID #: \_\_\_\_\_ WTP: \_\_\_\_\_ Month/Year: \_\_\_\_\_

Date / Time	Minimum Cl <sub>2</sub> Residual at 1 <sup>st</sup> User (C) <sup>2</sup> [ppm or mg/L]	Contact Time (T) [minutes]	Actual CT C X T	Temp [° C]	pH	Required CT Use tables	CT Met? <sup>3</sup> Yes / No	Peak Hourly Demand Flow [GPM]
1/9 AM								1,000
2/								
3/								
4/								
5/								
6/								
7/								
8/								
9/								
10/								

- Enter the peak hourly demand (PHD) flow and the time that the PHD flow occurred.
- This flow should not exceed 10% above the peak flows replicated at the time of the last tracer study.

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: \_\_\_\_\_ ID #: \_\_\_\_\_ WTP: \_\_\_\_\_ Month/Year: \_\_\_\_\_

Date / Time	Minimum Cl <sub>2</sub> Residual at 1 <sup>st</sup> User (C) <sup>2</sup> [ppm or mg/L]	Contact Time (T) [minutes]	Actual CT C X T	Temp [° C]	pH	Required CT Use tables	CT Met? <sup>3</sup> Yes / No	Peak Hourly Demand Flow [GPM]
1/9 AM								1,000
2/								
3/								
4/								
5/								
6/								
7/								
8/								
9/								
10/								

**Peak Hour Demand Flow:**

- The greatest volume of water passing through the system during any one hour in a consecutive 24 hr period
- Not the same as Peak Instantaneous Flow
- Report demand flow: flow leaving the clear well, not plant flow (in most cases)

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

**Method for determining peak hourly demand flow (flow meter w/rate):**

- On a daily basis, use the best available operational data to identify the hour within the 24 hr period that had the highest demand flow.
- For the hour of highest demand flow:
  - Calculate the average flow rate within the one hour period (i.e., add the flow rates and divide by the number of data points).
  - Use as many data points as possible, preferably no less than four data points taken at 15 minute intervals

**For systems that only have a flow totalizing meter:**

- Spot check throughout the day to determine the time of peak demand (e.g. 8 am or 9 pm for residential or mid-day for industrial uses)
- Then record how much water is used during that hour in gallons and divide by 60 minutes to get the peak hour demand in gpm

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

Here is an example chart, meant to represent continuous readings that shows demand flow out of a reservoir used for contact time. What would you say the peak hourly demand flow is?

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

Again, the peak hourly demand flow is the hour within the 24-hr period of the highest demand flow. The red line represents the span of 1 hour: 7:30 am to 8:30 am – the peak hour. The avg. of the 4 data points equals **4,125 gpm** - the peak hourly demand flow.

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### REPORTING FORMS – PEAK HOUR DEMAND FLOW

Think of it like a running hourly average of demand flow measurements.

Time	Demand Flow (gpm)	Running Hourly Average (gpm)
7:00 AM	2,000	
7:15 AM	2,400	
7:30 AM	3,000	
7:45 AM	5,000	3,100
8:00 AM	4,000	3,600
8:15 AM	3,500	3,875
8:30 AM	4,000	4,125
8:45 AM	3,500	3,750
9:00 AM	2,700	3,425

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### REPORTING FORMS - CHLORINE & CONTACT TIME

OHA - Drinking Water Program - Surface Water Quality Data Form

System Name: \_\_\_\_\_ ID #: \_\_\_\_\_ WTP: \_\_\_\_\_ Month/Year: \_\_\_\_\_

Date / Time	Minimum Cl <sub>2</sub> Residual at 1 <sup>st</sup> User (C) <sup>1</sup> [ppm or mg/L]	Contact Time (T) <sup>2</sup> [minutes]	Actual CT C X T	Temp [° C]	pH	Required CT Use tables	CT Met? <sup>3</sup> Yes / No	Peak Hourly Demand Flow [GPM]
1/9 AM	???	???						3,000
2/								
3/								
4/								
5/								
6/								
7/								
8/								
9/								
10/								

- The minimum chlorine residual is measured at the end of the disinfection segment.
- Contact time is the time that the disinfectant is in contact with the water within the disinfection segment.

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### HOW IS THE DISINFECTION SEGMENT DETERMINED?

The contact tank and any piping between the point of chlorine injection and the sample point used for CT determinations at or prior to the first user is considered a disinfection segment.

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### HOW IS CONTACT TIME DETERMINED?

- Tracer studies are used to determine contact time (T) which is used in calculating CT achieved, where  
 $CT = \text{chlorine Concentration} \times \text{contact Time}$
- Contact time is the time that chlorine is in contact with the water from the point of injection to the point where it is measured (sometimes referred to as the "CT segment")
  - May be at or before the 1<sup>st</sup> user
  - May be more than one CT segment
- Tracer studies are often conducted to simulate a worst-case scenario where peak hour demand flows are high and reservoir levels are low. This gives a conservative (i.e. lower) contact time than would normally be expected.

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### HOW IS CONTACT TIME DETERMINED?

- The more efficient the mixing is in a reservoir or tank, the more contact time is available for disinfection.
- Estimates of contact time based on tank or reservoir design are not allowed for calculating CT's for surface water!

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### WHAT AFFECTS MIXING EFFICIENCY?

Mixing efficiency improves with high flow path length to width ratios, found in pipelines and simulated in tanks with the use of baffles (hence the term baffling efficiency or factor).

**Perfect Circulation**  
Baffling Efficiency = 100%  
Plug flow through a length of pipe

**Superior Circulation**  
Baffling Efficiency = 70%

**Poor Circulation**  
Baffling Efficiency = 5-10%

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### Example: Tracer studies

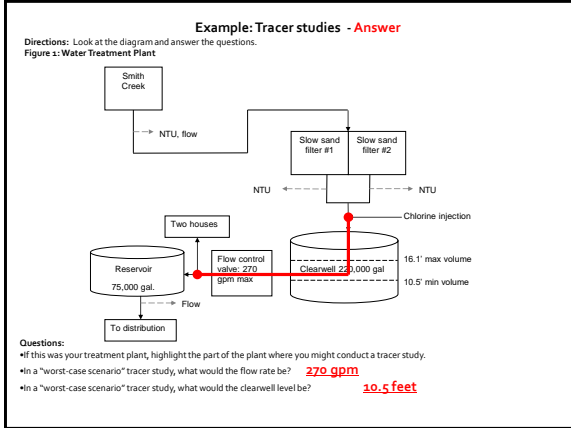
Directions: Look at the diagram and answer the questions.

Figure 2: Water Treatment Plant

Questions:

- If this was your treatment plant, highlight the part of the plant where you might conduct a tracer study.
- In a "worst-case scenario" tracer study, what would the flow rate be? \_\_\_\_\_
- In a "worst-case scenario" tracer study, what would the clearwell level be? \_\_\_\_\_

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## DO I REPORT CONTACT TIME?

- Use the time T from the tracer study on the monthly reporting form in the "Contact time (min)" column
  - Use the smallest T (highest flow) if the tracer study was done at multiple flow rates
- This may not be your exact time, but it represents your worst case (as long as the peak flow is less and clearwell volume is more than they were at the time of the tracer study)

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## REPORTING FORMS - CHLORINE & CONTACT TIME

OHA - Drinking Water Program - Surface Water Quality Data Form

Date / Time	Minimum Cl <sub>2</sub> Residual at 3' User (C) <sup>3</sup>	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? <sup>3</sup>	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[°C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100						1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

Notify the State within 24-hrs if chlorine residual < 0.2 mg/l  
Public Health After Hours Duty Officer:  
Cell (971) 246-1789  
Pager (503) 938-6790  
Oregon Emergency Response System:  
1-800-452-0311

- Enter the minimum chlorine residual at or before the first user.
- Enter the contact time (based either on the tracer study or determined from clearwell volume(s) and the peak hourly demand flow).

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## CAN I USE A BAFFLING FACTOR?

- As an alternative to using the tracer study contact time, you can use the results of the tracer study to determine the baffling factor of the clearwell
  - Baffling factor (%) =  $\frac{\text{Time (min)} \times \text{Flow During Tracer Study (gpm)}}{\text{Clearwell Volume During Tracer Study (gal)}}$
- T can be adjusted based on flow (at flow < 10% of tracer study flow) with the following equation:
  - $T = \frac{\text{Current clearwell Volume (gal)} \times \text{Baffling Factor (\%)}}{\text{Peak Hourly Demand Flow (gpm)}}$
- Contact the state for guidance on using baffling factors.

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## REPORTING FORMS - ACTUAL CT

OHA - Drinking Water Program - Surface Water Quality Data Form

Date / Time	Minimum Cl <sub>2</sub> Residual at 3' User (C) <sup>3</sup>	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? <sup>3</sup>	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[°C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60					1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- Enter the actual CT achieved that day:  
Actual CT = Chlorine Concentration (mg/l) x Contact Time (min)
- Do not confuse "CT" and "Contact Time"

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## REPORTING FORMS - TEMPERATURE & PH

OHA - Drinking Water Program - Surface Water Quality Data Form

Date / Time	Minimum Cl <sub>2</sub> Residual at 3' User (C) <sup>3</sup>	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? <sup>3</sup>	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[°C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60	12	6.8			1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- Enter the finished water temperature (°C) and pH measured at or prior to the first customer and after any storage (tank, reservoir, or pipeline) used for contact time.

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### REPORTING FORMS - REQUIRED CT

OHA - Drinking Water Program - Surface Water Quality Data Form

System Name: \_\_\_\_\_ ID #: \_\_\_\_\_ WTP: \_\_\_\_\_ Month/Year: \_\_\_\_\_

Date / Time	Minimum Cl <sub>2</sub> Residual at 1 <sup>st</sup> User (C) <sup>2</sup> [ppm or mg/L]	Contact Time (T) [minutes]	Actual CT C x T	Temp [°C]	pH	Required CT Use tables	CT Merit <sup>3</sup> Yes / No	Peak Hourly Demand Flow [GPM]
1/9 AM	0.6	100	60	12	6.8			1,000
2/								
3/								
4/								
5/								
6/								
7/								
8/								
9/								
10/								

**Actual CT must be ≥ Required CT. To determine required CT:**

- Use USEPA CT tables or
- Regression Equations (Use 1 of 2 equations - depends on °C)

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### HOW IS REQUIRED CT CALCULATED?

- We use the EPA tables (or "regression equations") to determine the CT required to inactivate *Giardia* (CT<sub>required</sub>)
  - 1-log inactivation of *Giardia* using chlorine results in at least 4.0-log inactivation of viruses.
  - To determine CT, we need to know pH, temperature, and free chlorine residual at or before the first user.
- Then we compare the CT<sub>required</sub> with the actual CT achieved in the water system (CT<sub>actual</sub>) where:
  - CT<sub>actual</sub> = chlorine concentration (mg/l) x contact time (min)
- Must keep CT<sub>actual</sub> ≥ CT<sub>required</sub>

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### USING REGRESSION EQUATIONS TO DETERMINE REQUIRED CT

Using Regression Equations to determine required CT:

- Built into the MS Excel reporting forms on-line <http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/Operations/Treatment/Pages/index.aspx>

Surface Water Monitoring and Reporting Forms for CT and Turbidity Data

If your system has more than one chlorine injection point, or if you have questions about the PDF or MS Excel versions of the monthly turbidity and surface water monitoring forms, contact the DWS technical oversight contact for your system at 971-673-0405

- Conventional or Direct Filtration: PDF -or- MS Excel
- Slow Sand, Membrane, Diatomaceous Earth Filtration or Unfiltered: PDF -or- MS Excel
- Cartridge or Bag Filtration: PDF -or- MS Excel

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### USING REGRESSION EQUATIONS, CONT.

Using Regression Equations to determine required CT:

- Regression equations can be programmed into plant SCADA or spreadsheets

**Regression Equation (for Temp < 12.5°C)**  
 $CT = (0.353 \cdot L)(12.006 + e^{(2.46 - 0.073 \cdot T + 0.125 \cdot C + 0.389 \cdot pH)})$

**Regression Equation (for Temp > 12.5°C)**  
 $CT = (0.361 \cdot L)(-2.261 + e^{(2.69 - 0.065 \cdot T + 0.111 \cdot C + 0.361 \cdot pH)})$

**Variables:**  
 CT = Product of Free Chlorine Residual and Time required  
 L = number of log inactivation for Giardia (L = 1 for slow sand)  
 T = temperature, in Celsius  
 C = chlorine residual in mg/L  
 pH = pH of water  
 e = 2.7183, base for natural log  
 (Smith, Clark, Pierce and Regli, 1995, from EPA's 1999 Guidance Manual for Disinfection Profiling and Benchmarking)

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### USING EPA CT TABLES - TEMPERATURE

- There are six EPA CT tables based on temperature
- Find the correct table based on your water temperature in degrees Celsius.
  - °C = 5/9 x (°F - 32)
- If water temp is between values, then round down
  - Example: for water temp of 12°C, use the 10°C table
  - Even if the water temp is 14.9°C, round down to 10°C
- Water gets more viscous the colder it gets and chemical reactions take longer, so rounding temp down is more conservative.

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### USING EPA CT TABLES - TEMP = 12 °C

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C

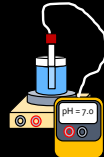
Use 10°C table for T = 10 - 14.9°C (round down for temp)

Chlorine Concentration (mg/L)	pH = 6.5						pH = 7.0						pH = 7.5					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	58	73	88	11	22	34	46	58	71
0.6	13	26	39	52	65	78	16	31	46	61	77	92	12	24	36	48	60	73
0.8	13	26	39	52	65	78	16	31	46	61	77	92	12	24	36	48	60	73
1	13	26	40	53	66	79	16	31	47	63	78	94	13	27	40	53	67	81
1.2	13	27	40	53	67	80	16	32	48	63	79	95	13	28	41	55	69	84
1.4	14	27	41	55	69	83	17	33	49	65	82	98	14	29	42	56	71	86
1.6	14	28	42	56	70	85	17	34	50	67	84	101	14	30	43	57	71	86
1.8	14	29	43	57	72	86	17	34	51	67	84	101	14	31	44	58	72	87
2	15	29	44	58	73	87	17	35	52	69	87	104	15	31	45	59	73	88
2.2	15	30	45	59	74	89	18	35	53	70	88	105	15	32	46	60	74	89
2.4	15	30	45	60	75	90	18	36	54	71	89	107	15	32	46	60	74	89
2.6	16	31	46	61	76	91	18	37	55	72	90	109	16	33	47	61	75	90
2.8	16	31	47	62	77	92	19	37	56	73	91	111	16	33	47	61	75	90
3	16	32	48	63	78	93	19	38	57	74	92	113	16	33	48	62	76	91

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### USING EPA CT TABLES - PH



- There are 7 sections for pH on each table
- Find the section that corresponds to your water's pH level
- If your pH is between the choices, then **round up** to the higher pH
  - Example: if pH of water is 6.8, use the pH 7.0 section

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### USING EPA CT TABLES - PH = 6.8

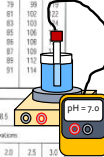
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C *10°C - 14.9°C*

*6.1 - 6.5*      *6.6 - 7.0*

Chlorine Concentration      *PH = 6*      *PH = 6.5*      *PH = 7.0*


mg/L	Log Inactivation					Log Inactivation					Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	63	73	15	29	44	59	73	88	17	35				
0.6	13	26	39	50	65	75	15	30	45	60	75	90	18	36				
0.8	13	26	39	52	66	78	15	31	46	61	77	94	19	37				
1	13	26	40	53	66	79	16	31	47	63	79	94	19	37				
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38				
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	38				
1.6	14	28	42	56	69	83	17	33	50	66	83	99	20	40				
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41				
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41				
2.2	15	30	45	59	74	89	18	35	53	70	89	105	21	42				
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43				
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44				
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45				
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46				

Use pH = 7.0 column for pH = 6.6 - 7.0 (round up for pH)



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### USING EPA CT TABLES - 1-LOG



- Use the 1-log inactivation column

(slow sand is granted 2.0-log removal credit for *Giardia*, which requires that 1.0-log *Giardia* inactivation is needed through disinfection)

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### USING EPA CT TABLES - REQUIRED LOG = 1.0


CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C *10°C - 14.9°C*

*6.1 - 6.5*      *6.6 - 7.0*

Chlorine Concentration      *PH = 6*      *PH = 6.5*      *PH = 7.0*

mg/L	Log Inactivation					Log Inactivation					Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	63	73	15	29	44	59	73	88	17	35				
0.6	13	26	39	50	65	75	15	30	45	60	75	90	18	36				
0.8	13	26	39	52	66	78	15	31	46	61	77	94	19	37				
1	13	26	40	53	66	79	16	31	47	63	79	94	19	37				
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38				
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	38				
1.6	14	28	42	56	69	83	17	33	50	66	83	99	20	40				
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41				
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41				
2.2	15	30	45	59	74	89	18	35	53	70	89	105	21	42				
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43				
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44				
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45				
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46				

For slow sand, Use the 1.0-log column



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### USING EPA CT TABLES - CHLORINE

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**Cl**  
Chlorine  
36.46

- Match your free chlorine residual on the far left column
- If in between column values, **round up**
  - Rounding chlorine residual up is more conservative because as chlorine residual increases at a given pH, more CT is required
- The point where it intersects with the log inactivation column is the CT<sub>required</sub>
  - Example: free chlorine residual is 0.6 ppm

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### USING EPA CT TABLES - CL<sub>2</sub> = 0.6 MG/L

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C *10°C - 14.9°C*

*6.1 - 6.5*      *6.6 - 7.0*

Chlorine Concentration      *PH = 6*      *PH = 6.5*      *PH = 7.0*

mg/L	Log Inactivation					Log Inactivation					Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	63	73	15	29	44	59	73	88	17	35				
0.6	13	26	39	50	65	75	15	30	45	60	75	90	18	36				
0.8	13	26	39	52	66	78	15	31	46	61	77	94	19	37				
1	13	26	40	53	66	79	16	31	47	63	79	94	19	37				
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38				
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	38				
1.6	14	28	42	56	69	83	17	33	50	66	83	99	20	40				
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41				
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41				
2.2	15	30	45	59	74	89	18	35	53	70	89	105	21	42				
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43				
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44				
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45				
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46				

Round up if measured CL<sub>2</sub> is between values in the chlorine concentration column

17  
**Cl**  
Chlorine  
36.46

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### USING EPA CT TABLES - $CL_2 = 0.6$ MG/L

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT  $10^\circ C$   $10^\circ C - 14.9^\circ C$

Chlorine Concentration:  $PH = 6$   $PH = 6.5$   $PH = 7.0$

Chlorine Concentration (mg/L)	Log Inactivations	Log Inactivations	Log Inactivations
0.5	1.0 1.5 2.0 2.5 3.0	0.5 1.0 1.5 2.0 2.5 3.0	0.5 1.0 1.5 2.0
0.8	12 24 37 49 61 73 85 97 109 121 133 145 157 169 181 193 205 217 229 241 253 265 277 289 301 313 325 337 349 361 373 385 397 409 421 433 445 457 469 481 493 505 517 529 541 553 565 577 589 601 613 625 637 649 661 673 685 697 709 721 733 745 757 769 781 793 805 817 829 841 853 865 877 889 901 913 925 937 949 961 973 985 997 1009 1021 1033 1045 1057 1069 1081 1093 1105 1117 1129 1141 1153 1165 1177 1189 1201 1213 1225 1237 1249 1261 1273 1285 1297 1309 1321 1333 1345 1357 1369 1381 1393 1405 1417 1429 1441 1453 1465 1477 1489 1501 1513 1525 1537 1549 1561 1573 1585 1597 1609 1621 1633 1645 1657 1669 1681 1693 1705 1717 1729 1741 1753 1765 1777 1789 1801 1813 1825 1837 1849 1861 1873 1885 1897 1909 1921 1933 1945 1957 1969 1981 1993 2005 2017 2029 2041 2053 2065 2077 2089 2101 2113 2125 2137 2149 2161 2173 2185 2197 2209 2221 2233 2245 2257 2269 2281 2293 2305 2317 2329 2341 2353 2365 2377 2389 2401 2413 2425 2437 2449 2461 2473 2485 2497 2509 2521 2533 2545 2557 2569 2581 2593 2605 2617 2629 2641 2653 2665 2677 2689 2701 2713 2725 2737 2749 2761 2773 2785 2797 2809 2821 2833 2845 2857 2869 2881 2893 2905 2917 2929 2941 2953 2965 2977 2989 3001 3013 3025 3037 3049 3061 3073 3085 3097 3109 3121 3133 3145 3157 3169 3181 3193 3205 3217 3229 3241 3253 3265 3277 3289 3301 3313 3325 3337 3349 3361 3373 3385 3397 3409 3421 3433 3445 3457 3469 3481 3493 3505 3517 3529 3541 3553 3565 3577 3589 3601 3613 3625 3637 3649 3661 3673 3685 3697 3709 3721 3733 3745 3757 3769 3781 3793 3805 3817 3829 3841 3853 3865 3877 3889 3901 3913 3925 3937 3949 3961 3973 3985 3997 4009 4021 4033 4045 4057 4069 4081 4093 4105 4117 4129 4141 4153 4165 4177 4189 4201 4213 4225 4237 4249 4261 4273 4285 4297 4309 4321 4333 4345 4357 4369 4381 4393 4405 4417 4429 4441 4453 4465 4477 4489 4501 4513 4525 4537 4549 4561 4573 4585 4597 4609 4621 4633 4645 4657 4669 4681 4693 4705 4717 4729 4741 4753 4765 4777 4789 4801 4813 4825 4837 4849 4861 4873 4885 4897 4909 4921 4933 4945 4957 4969 4981 4993 5005 5017 5029 5041 5053 5065 5077 5089 5101 5113 5125 5137 5149 5161 5173 5185 5197 5209 5221 5233 5245 5257 5269 5281 5293 5305 5317 5329 5341 5353 5365 5377 5389 5401 5413 5425 5437 5449 5461 5473 5485 5497 5509 5521 5533 5545 5557 5569 5581 5593 5605 5617 5629 5641 5653 5665 5677 5689 5701 5713 5725 5737 5749 5761 5773 5785 5797 5809 5821 5833 5845 5857 5869 5881 5893 5905 5917 5929 5941 5953 5965 5977 5989 6001 6013 6025 6037 6049 6061 6073 6085 6097 6109 6121 6133 6145 6157 6169 6181 6193 6205 6217 6229 6241 6253 6265 6277 6289 6301 6313 6325 6337 6349 6361 6373 6385 6397 6409 6421 6433 6445 6457 6469 6481 6493 6505 6517 6529 6541 6553 6565 6577 6589 6601 6613 6625 6637 6649 6661 6673 6685 6697 6709 6721 6733 6745 6757 6769 6781 6793 6805 6817 6829 6841 6853 6865 6877 6889 6901 6913 6925 6937 6949 6961 6973 6985 6997 7009 7021 7033 7045 7057 7069 7081 7093 7105 7117 7129 7141 7153 7165 7177 7189 7201 7213 7225 7237 7249 7261 7273 7285 7297 7309 7321 7333 7345 7357 7369 7381 7393 7405 7417 7429 7441 7453 7465 7477 7489 7501 7513 7525 7537 7549 7561 7573 7585 7597 7609 7621 7633 7645 7657 7669 7681 7693 7705 7717 7729 7741 7753 7765 7777 7789 7801 7813 7825 7837 7849 7861 7873 7885 7897 7909 7921 7933 7945 7957 7969 7981 7993 8005 8017 8029 8041 8053 8065 8077 8089 8101 8113 8125 8137 8149 8161 8173 8185 8197 8209 8221 8233 8245 8257 8269 8281 8293 8305 8317 8329 8341 8353 8365 8377 8389 8401 8413 8425 8437 8449 8461 8473 8485 8497 8509 8521 8533 8545 8557 8569 8581 8593 8605 8617 8629 8641 8653 8665 8677 8689 8701 8713 8725 8737 8749 8761 8773 8785 8797 8809 8821 8833 8845 8857 8869 8881 8893 8905 8917 8929 8941 8953 8965 8977 8989 9001 9013 9025 9037 9049 9061 9073 9085 9097 9109 9121 9133 9145 9157 9169 9181 9193 9205 9217 9229 9241 9253 9265 9277 9289 9301 9313 9325 9337 9349 9361 9373 9385 9397 9409 9421 9433 9445 9457 9469 9481 9493 9505 9517 9529 9541 9553 9565 9577 9589 9601 9613 9625 9637 9649 9661 9673 9685 9697 9709 9721 9733 9745 9757 9769 9781 9793 9805 9817 9829 9841 9853 9865 9877 9889 9901 9913 9925 9937 9949 9961 9973 9985 9997 10009 10021 10033 10045 10057 10069 10081 10093 10105 10117 10129 10141 10153 10165 10177 10189 10201 10213 10225 10237 10249 10261 10273 10285 10297 10309 10321 10333 10345 10357 10369 10381 10393 10405 10417 10429 10441 10453 10465 10477 10489 10501 10513 10525 10537 10549 10561 10573 10585 10597 10609 10621 10633 10645 10657 10669 10681 10693 10705 10717 10729 10741 10753 10765 10777 10789 10801 10813 10825 10837 10849 10861 10873 10885 10897 10909 10921 10933 10945 10957 10969 10981 10993 11005 11017 11029 11041 11053 11065 11077 11089 11101 11113 11125 11137 11149 11161 11173 11185 11197 11209 11221 11233 11245 11257 11269 11281 11293 11305 11317 11329 11341 11353 11365 11377 11389 11401 11413 11425 11437 11449 11461 11473 11485 11497 11509 11521 11533 11545 11557 11569 11581 11593 11605 11617 11629 11641 11653 11665 11677 11689 11701 11713 11725 11737 11749 11761 11773 11785 11797 11809 11821 11833 11845 11857 11869 11881 11893 11905 11917 11929 11941 11953 11965 11977 11989 12001 12013 12025 12037 12049 12061 12073 12085 12097 12109 12121 12133 12145 12157 12169 12181 12193 12205 12217 12229 12241 12253 12265 12277 12289 12301 12313 12325 12337 12349 12361 12373 12385 12397 12409 12421 12433 12445 12457 12469 12481 12493 12505 12517 12529 12541 12553 12565 12577 12589 12601 12613 12625 12637 12649 12661 12673 12685 12697 12709 12721 12733 12745 12757 12769 12781 12793 12805 12817 12829 12841 12853 12865 12877 12889 12901 12913 12925 12937 12949 12961 12973 12985 12997 13009 13021 13033 13045 13057 13069 13081 13093 13105 13117 13129 13141 13153 13165 13177 13189 13201 13213 13225 13237 13249 13261 13273 13285 13297 13309 13321 13333 13345 13357 13369 13381 13393 13405 13417 13429 13441 13453 13465 13477 13489 13501 13513 13525 13537 13549 13561 13573 13585 13597 13609 13621 13633 13645 13657 13669 13681 13693 13705 13717 13729 13741 13753 13765 13777 13789 13801 13813 13825 13837 13849 13861 13873 13885 13897 13909 13921 13933 13945 13957 13969 13981 13993 14005 14017 14029 14041 14053 14065 14077 14089 14101 14113 14125 14137 14149 14161 14173 14185 14197 14209 14221 14233 14245 14257 14269 14281 14293 14305 14317 14329 14341 14353 14365 14377 14389 14401 14413 14425 14437 14449 14461 14473 14485 14497 14509 14521 14533 14545 14557 14569 14581 14593 14605 14617 14629 14641 14653 14665 14677 14689 14701 14713 14725 14737 14749 14761 14773 14785 14797 14809 14821 14833 14845 14857 14869 14881 14893 14905 14917 14929 14941 14953 14965 14977 14989 15001 15013 15025 15037 15049 15061 15073 15085 15097 15109 15121 15133 15145 15157 15169 15181 15193 15205 15217 15229 15241 15253 15265 15277 15289 15301 15313 15325 15337 15349 15361 15373 15385 15397 15409 15421 15433 15445 15457 15469 15481 15493 15505 15517 15529 15541 15553 15565 15577 15589 15601 15613 15625 15637 15649 15661 15673 15685 15697 15709 15721 15733 15745 15757 15769 15781 15793 15805 15817 15829 15841 15853 15865 15877 15889 15901 15913 15925 15937 15949 15961 15973 15985 15997 16009 16021 16033 16045 16057 16069 16081 16093 16105 16117 16129 16141 16153 16165 16177 16189 16201 16213 16225 16237 16249 16261 16273 16285 16297 16309 16321 16333 16345 16357 16369 16381 16393 16405 16417 16429 16441 16453 16465 16477 16489 16501 16513 16525 16537 16549 16561 16573 16585 16597 16609 16621 16633 16645 16657 16669 16681 16693 16705 16717 16729 16741 16753 16765 16777 16789 16801 16813 16825 16837 16849 16861 16873 16885 16897 16909 16921 16933 16945 16957 16969 16981 16993 17005 17017 17029 17041 17053 17065 17077 17089 17101 17113 17125 17137 17149 17161 17173 17185 17197 17209 17221 17233 17245 17257 17269 17281 17293 17305 17317 17329 17341 17353 17365 17377 17389 17401 17413 17425 17437 17449 17461 17473 17485 17497 17509 17521 17533 17545 17557 17569 17581 17593 17605 17617 17629 17641 17653 17665 17677 17689 17701 17713 17725 17737 17749 17761 17773 17785 17797 17809 17821 17833 17845 17857 17869 17881 17893 17905 17917 17929 17941 17953 17965 17977 17989 18001 18013 18025 18037 18049 18061 18073 18085 18097 18109 18121 18133 18145 18157 18169 18181 18193 18205 18217 18229 18241 18253 18265 18277 18289 18301 18313 18325 18337 18349 18361 18373 18385 18397 18409 18421 18433 18445 18457 18469 18481 18493 18505 18517 18529 18541 18553 18565 18577 18589 18601 18613 18625 18637 18649 18661 18673 18685 18697 18709 18721 18733 18745 18757 18769 18781 18793 18805 18817 18829 18841 18853 18865 18877 18889 18901 18913 18925 18937 18949 18961 18973 18985 18997 19009 19021 19033 19045 19057 19069 19081 19093 19105 19117 19129 19141 19153 19165 19177 19189 19201 19213 19225 19237 19249 19261 19273 19285 19297 19309 19321 19333 19345 19357 19369 19381 19393 19405 19417 19429 19441 19453 19465 19477 19489 19501 19513 19525 19537 19549 19561 19573 19585 19597 19609 19621 19633 19645 19657 19669 19681 19693 19705 19717 19729 19741 19753 19765 19777 19789 19801 19813 19825 19837 19849 19861 19873 19885 19897 19909 19921 19933 19945 19957 19969 19981 19993 20005 20017 20029 20041 20053 20065 20077 20089 20101 20113 20125 20137 20149 20161 20173 20185 20197 20209 20221 20233 20245 20257 20269 20281 20293 20305 20317 20329 20341 20353 20365 20377 20389 20401 20413 20425 20437 20449 20461 20473 20485 20497 20509 20521 20533 20545 20557 20569 20581 20593 20605 20617 20629 20641 20653 20665 20677 20689 20701 20713 20725 20737 20749 20761 20773 20785 20797 20809 20821 20833 20845 20857 20869 20881 20893 20905 20917 20929 20941 20953 20965 20977 20989 21001 21013 21025 21037 21049 21061 21073 21085 21097 21109 21121 21133 21145 21157 21169 21181 21193 21205 21217 21229 21241 21253 21265 21277 21289 21301 21313 21325 21337 21349 21361 21373 21385 21397 21409 21421 21433 21445 21457 21469 21481 21493 21505 21517 21529 21541 21553 21565 21577 21589 21601 21613 21625 21637 21649 21661 21673 21685 21697 21709 21721 21733 21745 21757 21769 21781 21793 21805 21817 21829 21841 21853 21865 21877 21889 21901 21913 21925 21937 21949 21961 21973 21985 21997 22009 22021 22033 22045 22057 22069 22081 22093 22105 22117 22129 22141 22153 22165 22177 22189 22201 22213 22225 22237 22249 22261 22273 22285 22297 22309 22321 22333 22345 22357 22369 22381 22393 22405 22417 22429 22441 22453 22465 22477 22489 22501 22513 22525 22537 22549 22561 22573 22585 22597 22609 22621 22633 22645 22657 22669 22681 22693 22705 22717 22729 22741 22753 22765 22777 22789 22801 22813 22825 22837 22849 22861 22873 22885 22897 22909 22921 22933 22945 22957 22969 22981 22993 23005 23017 23029 23041 23053 23065 23077 23089 23101 23113 23125 23137 23149 23161 23173 23185 23197 23209 23221 23233 23245 23257 23269 23281 23293 23305 23317 23329 23341 23353 23365 23377 23389 23401 23413 23425 23437 23449 23461 23473 23485 23497 23509 23521 23533 23545 23557 23569 23581 23593 23605 23617 23629 23641 23653 23665 23677 23689 23701 23713 23725 23737 23749 23761 23773 23785 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25789 25801 25813 25825 25837 25849 2586		

## FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

- Not calculating CT's daily
  - Don't wait until the end of the month to do the calculations because if you discover you didn't meet CT's, it's too late!
- If adjusting contact time according to flow rate, use the demand flow, not the plant flow.
- Failure to answer questions at bottom of form correctly (or at all)
- Always answering "Yes" to the questions at the bottom of the form without actually looking at the numbers

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## FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

- Rounding errors when using EPA tables to determine  $CT_{required}$ 
  - Must round down for temperature
  - Must round up for pH
  - Must round up for free chlorine residual
- Bad CT formulas in excel spreadsheets:
  - Make sure you understand your formula
  - Wilkes Equation not allowed, must use Regression Equation

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## FILLING OUT THE MONTHLY REPORT – AVOIDING MISTAKES

- Check how T is calculated at your plant
- Do all treatment plant operators understand it?
- Review spreadsheet equation for CTs (if applicable)
- Write an SOP for CT determination
- Arrange for a tracer study if necessary
- Calculate CT and fill out monthly report daily
- Know what to do and who to call when things go wrong (contact State regulator & refer to Emergency Response Plan)

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## STRIVE TO IMPROVE DATA QUALITY

- Make data reliability a plant goal
- Only collect data used for process control or compliance reporting
- Establish protocols for collection and recording of data
- Establish a data verification process that can be routinely used to confirm data integrity
- Turn data into information (e.g., draw the graph).



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## O&M MANUALS



Keep written procedures on:

- Instrument calibration methods and frequency
- Data handling/reporting
- Chemical dosage determinations
- Filter operation and cleaning
- CT determinations
- Responding to abnormal conditions (emergency response plan)

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## DISINFECTION

- Types of disinfectants
  1. Radiation (UV)
  2. Chemical (chlorine, chloramines, chlorine dioxide, ozone)
- Forms of chlorine
- NSF/ANSI Standard 60



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### TYPES OF DISINFECTANTS - UV

- Works by subjecting water to ultraviolet (UV) light rays as water passes through a tube
- Drawbacks:
  - Interfering agents such as turbidity can screen pathogens from the UV light
  - Effective against *Giardia* and *Cryptosporidium* but not viruses at normal doses
  - No residual is present throughout the distribution system
  - For this reason, chlorination for residual maintenance is required when UV is used



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### TYPES OF DISINFECTANTS - CHEMICAL

1. Chlorine
2. Chloramines
3. Chlorine dioxide
4. Ozone

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### TYPES OF DISINFECTANTS - CHLORINE

- The most widely used form of disinfection
- Also used as an oxidizing agent for iron, manganese and hydrogen sulfide and for controlling taste and odors
- Effectiveness as a disinfecting agent depends on factors such as pH, temperature, free chlorine residual, contact time and other interfering agents

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### FORMS OF CHLORINE

- Sodium Hypochlorite
- Onsite generated sodium hypochlorite
- Calcium Hypochlorite
- Chlorine Gas

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### FORMS OF CHLORINE - SODIUM HYPOCHLORITE

- The liquid form of chlorine
- Clear and has a slight yellow color
- Ordinary household bleach (~5% chlorine by solution) is the most common form
- Industrial strength: 12% and 15% solutions
- Can lose up to 4% of its available chlorine content per month; should not be stored for more than 60 to 90 days
- Very corrosive; should be stored and mixed away from equipment that can be damaged by corrosion

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### FORMS OF CHLORINE - SODIUM HYPOCHLORITE



Diaphragm pump with chlorine solution tank

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### ON-SITE GENERATED SODIUM HYPOCHLORITE

- 0.8% sodium hypochlorite is produced on demand by combining salt, water & electricity
- Electrolysis of brine solution produces sodium hydroxide and chlorine gas, which then mix to form sodium hypochlorite
- Hydrogen gas byproduct; vented to atmosphere
- Alleviates safety concerns associated w/ hauling and storing bulk chlorine
- Higher initial cost, high power cost
- Mixed oxidants (proprietary)

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### ON-SITE GENERATED SODIUM HYPOCHLORITE



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### FORMS OF CHLORINE - CALCIUM HYPOCHLORITE

- The solid form of chlorine
- Usually tablet or powder form (see photo below)
- Contains ~65% chlorine by weight
- White or yellowish-white granular material and is fairly soluble in water
- Important to keep in a dry, cool place
- More stable than liquid
- Common in small systems w/ low flows or no power



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### FORMS OF CHLORINE - CALCIUM HYPOCHLORITE



Erosion chlorinator



Inside Hopper =&gt;

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### FORMS OF CHLORINE - CHLORINE GAS

- 99.5% pure chlorine
- yellow-green color 2.5x heavier than air
- Liquefied at room temperature at ~107 psi – hence the pressurized cylinders actually contain liquefied chlorine gas.
- Liquefied  $\text{Cl}_2$  is released from tanks as chlorine gas, which is then injected into the water stream.
- usually used only by large water systems
- Smaller systems may find initial cost of operation prohibitive

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### FORMS OF CHLORINE - CHLORINE GAS



150-lb cylinders

Note security chain spare tank & labeling.

Below: 1 ton cylinders. Note scale used to monitor product use.



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### FORMS OF CHLORINE – CHLORAMINES

- Chlorine + ammonia = chloramination
- Two advantages to regular chlorination:
  1. produce a longer lasting chlorine residual (helpful to systems with extensive distribution systems)
  2. may produce fewer by-products depending on the application
- Disadvantage:
  1. Need a lot of contact time to achieve CTs compared to free chlorine (300 times more) which is why not used for primary disinfection
  2. Requires specific ratio of chlorine to ammonia or else potential water quality problems

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### CHLORINE DIOXIDE - ADVANTAGES

#### Advantages:

1. More effective than chlorine and chloramines for inactivation of viruses, *Cryptosporidium*, and *Giardia*
2. Oxidizes iron, manganese, and sulfides
3. May enhance the clarification process
4. Controls T&O resulting from algae and decaying vegetation, as well as phenolic compounds
5. Under proper generation conditions halogen-substituted DBPs are not formed
6. Easy to generate
7. Provides residual

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### CHLORINE DIOXIDE - DISADVANTAGES

#### Disadvantages

1. Forms the DBP chlorite
2. Costs associated with training, sampling, and laboratory testing for chlorite and chlorate are high
3. Equipment is typically rented, and the cost of the sodium chlorite is high
4. Explosive, so it must be generated on-site
5. Decomposes in sunlight
6. Can lead to production noxious odors in some systems.

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### OZONE

- Colorless gas ( $O_3$ )
- Strongest of the common disinfecting agents
- Also used for control of taste and odor
- Extremely Unstable; Must be generated on-site
- Manufactured by passing air or oxygen through two electrodes with high, alternating potential difference



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### OZONE - ADVANTAGES

#### Advantages:

1. Short reaction time enables microbes (including viruses) to be killed within a few seconds
2. Removes color, taste, and odor causing compounds
3. Oxidizes iron and manganese
4. Destroys some algal toxins
5. Does not produce halogenated DBPs

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### OZONE - DISADVANTAGES

#### Disadvantages:

1. Overfeed or leak can be dangerous
2. Cost is high compared with chlorination
3. Installation can be complicated
4. May produce undesirable brominated byproducts in source waters containing bromide
5. No residual effect is present in the distribution system, thus post-chlorination is required
6. Much less soluble in water than chlorine; thus special mixing devices are necessary

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### NSF/ANSI STANDARD 60 - CHEMICALS

- Addresses the health effects implications of treatment chemicals and related impurities.
- The two principal questions addressed are:
  - Is the chemical safe at the maximum dose, and
  - Are impurities below the maximum acceptable levels?



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### NSF/ANSI STANDARD 60 - CHEMICALS

<http://info.nsf.org/Certified/PwsChemicals/>

NSF/ANSI 60  
Drinking Water Treatment Chemicals - Health Effects

Morton Salt, Inc.  
123 North Wacker Drive  
Chicago, IL 60606-1743  
United States  
312-807-2000

Facility : 0111 Glendale, AZ

Sodium Chloride [1] [CL]  
Trade Designation  
Bulk White Crystal Solar Salt  
Bulk w/Crystal Cras. Sol. Salt  
Fine Solar Salt  
Morton® Commercial Grade Water Softening Pellets  
Morton® System Saver® B Formula Pellets  
White Crystal Solar Salt  
White Crystal Water Softening Solar Salt

Product Function  
Other  
Other  
Other  
Other  
Other

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### NSF/ANSI STANDARD 61 - COMPONENTS & MEDIA

<http://info.nsf.org/Certified/PwsComponents/index.asp?standard=o61>

Cemex  
5380 Golden Foothill Parkway  
Suite 200  
El Dorado Hills, CA 95762  
United States  
925-426-8787

Facility : Marina, CA

Size  
.2 mm - 3 mm



Trade Designation	Size	Water Contact Temp	Water Contact Material
Sand Leak Lure Sand	.2 mm - 3 mm	CLD 23	SLOOX

[1] Certified products include F-101 through F-112.  
NOTE: Certified for water treatment plant applications.  
This product has not been evaluated for point-of-use applications.

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### RESOURCES FOR OPERATORS

- For surface water systems:  
[www.healthoregon.gov/dwp](http://www.healthoregon.gov/dwp)  
Click on "Water System Operations" on left-side menu list, then "Surface Water Treatment"
  - Monthly Surface Water Quality Report form template
  - Tracer Study form
- Surface Water Treatment Rule guidance manual, Appendix C: Determination of Disinfectant Contact Time

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### RESOURCES FOR OPERATORS

- EPA Rules  
<http://water.epa.gov/lawsregs/rulesregs/sdwa/currentregulations.cfm>
- AWWA <http://www.pnws-awwa.org/Index.asp>
- OAWU <http://www.oawu.net/>
- Circuit Rider  
<http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/Operations/Pages/circuitrider.aspx>

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### RESOURCES FOR OPERATORS

Oregon Drinking Water Services

Working to keep drinking water safe for Oregonians

Access to safe drinking water is essential to human health. Each person on Earth requires drinking, cooking and crop-irrigating freshwater. Oregon Drinking Water Services will engage drinking water utilities (DWUs) administrators and officials drinking water quality and DWU. Drinking water is the single largest public health benefit and economic activity in the state. DWU also emphasizes protection of communities through various water protection and water conservation programs.

Services:
 

- Water Conservation & Reuse Programs
- Emergency Preparedness & Security
- Contaminant & Source Water Protection
- Monitoring & Reporting
- Operational Certification
- Public Inquiries
- State Resource Fund (SRF)

Resources:
 

- Access & Development (Single Point Resources)
- 1004 System
- Drinking Water Safety Program
- Drinking Water Advisory Committee (DWAC)
- For Customers
- State & Departmental Guidelines
- Training Opportunities

News and Hot Topics:
 

- NEW 2018 WATER INSPECTOR LICENSE FEE ONLINE
- Customer Resources for Water System Operators
- 2018 Drinking Water Source Protection Grants
- 2018 Water System for Customers April 20 - May 3, 2018
- Start-Up for new water systems
- Water System Operations

Contact Us

[www.healthoregon.gov/dwp](http://www.healthoregon.gov/dwp)

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System Classification

**OR41 00731 SALEM PUBLIC WORKS** Classification: COMMUNITY

<p><b>Contact:</b> DWAYNE BARNES PO BOX 14300 SALEM, OR 97309</p> <p><b>Population:</b> 199,820</p> <p><b>Operating Period:</b> January 1 to December 31</p> <p><b>Certified Operators:</b></p> <p>Required: Y Distribution class: 4 Treatment class: 3 Filtration Endorsement Required: No</p>	<p><b>Phone:</b> 503-588-6483</p> <p><b>County:</b> MARION</p> <p><b>Activity Status:</b> ACTIVE - History</p> <p><b>Number of Connections:</b> 55,970</p> <p><b>Regulating Agency:</b> REGION 1</p> <p><b>Owner Type:</b> LOCAL GOVERNMENT</p> <p><b>Licensed By:</b> N/A</p> <p><b>Approved Drinking Water Protection Plan:</b> No</p> <p><b>Source Water Assessment:</b> Yes</p> <p><b>Last Survey Date:</b> Jul 25, 2023 - Outstanding Performer</p>
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All written correspondence goes to this person (e.g., violation notices, general mailings, etc.)

[View a list of Certified Operators](#)

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More information for this water system:

System Info : [Report for Lenders](#) : [Alerts - Violations - Compliance & Enforcement](#) : [Contacts & Advisories](#) : [Site Visits](#) : [Public Notice](#)

[Coliform Summary](#) : [Coliform Results](#) : [Coliform Schedules](#) : [LTZ](#) : [GW/GWUDI Source Details](#) : [Plan Review](#) : [Annual Fee](#)

[Chemical Summary](#) : [Chemical Results](#) : [Chemical Schedules](#) : [Chemical Schedule Summary](#) : [Arsenic RAA](#) : [Cyanotoxins](#) : [PFAS](#)

[Lead & Copper](#) : [Corrosion Control \(ICR\)](#) : [DBP Sample Sites](#) : [FANs](#) : [MRDL](#) : [GWR-4 Log](#) : [Turbidity](#) : [SWTR](#) : [LBA](#)

1. Alerts, Violations, & Compliance
2. Contacts, Advisories, & Public Notices
3. Site Visits
4. Plan Review
5. Coliform and Chemical Sampling Schedules
6. Sampling Results


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## MORE QUESTIONS?

- Call your technical services contact at the State.

State Drinking Water Services


- General Info: (971) 673-0405



TIMELESS  
TECHNOLOGY  
FOR  
MODERN  
APPLICATIONS

Slow Sand Filtration Workshop

Sponsored by the Oregon Department of Environmental Quality  
in partnership with the Oregon Water Resources Institute  
www.oregon.gov/DEQ/OWRI



Astoria, OR: MGD plant (photo taken by Frank Wolf)

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