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.)

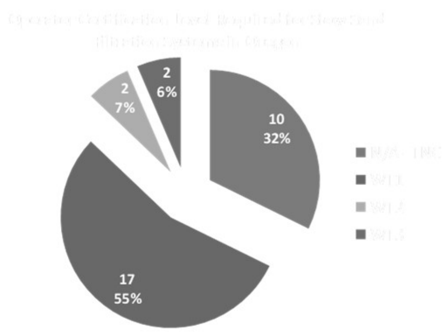
REGULATORY REQUIREMENTS

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").

REGULATORY REQUIREMENTS – OTHER



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).

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 (≤ 1 NTU in 95% of readings w/all ≤ 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

REGULATORY REQUIREMENTS –PATHOGEN RMVL

Applicability: PWSs that use SW or GWUDI that practice SSF, DE, or Alternative Filtration	
Regulated Pathogen	99.99% (4-log) removal/inactivation of viruses (SWTR)
	99.9% (3-log) removal/inactivation of *Giardia lamblia* *(SWTR)*
	99% (2-log) removal of Cryptosporidium (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.

REGULATORY REQUIREMENTS – TURBIDITY

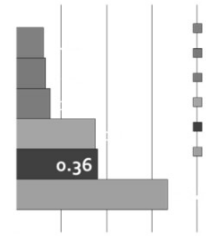
Turbidity Limits		
Turbidity	Turbidity readings are to be monitored/recorded at the combined filter effluent (CFE) at a frequency of at least once every 4 hours*	95% of CFE turbidity readings ≤ 1 NTU (≤ 1.49 NTU) All CFE turbidity readings ≤ 5 NTU (≤ 5.49 NTU)

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

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 95th percentile turbidity limit
	Date and Value Exceeding 5 NTU
Turbidity reporting required within 24 hours:	Exceedances of 5 NTU for CFE

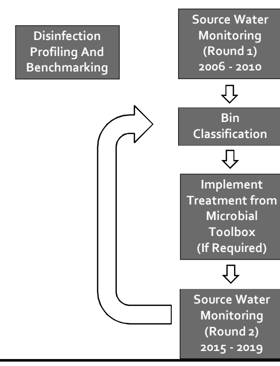
SLOW SAND – ABLE TO MEET 1 NTU LIMIT



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)

LONG-TERM 2 ESWTR (LT2)



Treatment Requirement
LT2 requires additional *Crypto treatment for* systems with ≥ 0.075 oocysts/L in their source water. So far only one water system is required to meet additional treatment requirements under LT2 in Oregon.

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…	1st Round	2nd 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* [a]	October 1, 2008	October 1, 2017
4 (*Crypto*)	Fewer than 10,000, not a wholesale system, and monitors for *Cryptosporidium* [b]	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
[a] Applies only to filtered systems.
[b] Applies to filtered systems that meet the conditions of paragraph (a)(4) of §141.701 and unfiltered systems.

LONG-TERM 2 ESWTR (LT2)

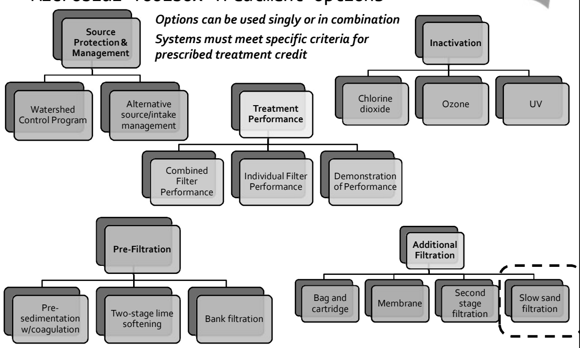
Filtered System Additional Cryptosporidium Treatment Requirements
(based on their bin classification as determined under § 141.710
and according to the schedule in § 141.713)

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[1]
Bin 3	2-log treatment	2.5-log treatment	RMVL + Inactivation ≥ 5.0-log[2]
Bin 4	2.5-log treatment	3-log treatment	RMVL + Inactivation ≥ 5.5-log[3]

[1] As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 4.0-log.
[2] As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 5.0-log.
[3] As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 5.5-log.

LONG-TERM 2 ESWTR (LT2)

Microbial Toolbox Treatment Options



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)

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

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)

**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.*

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.

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.

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

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

Cyanotoxin Monitoring (OAR 333-061-0510 to -0580) Healthoregon.org/dwcyanotoxins	
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 www.healthoregon.org/dwcyanotoxins
What is required?	Raw water (intake) sampling for total microcystin and Cylindrospermopsin toxins every 2 weeks from May 1st – October 31st each year
What happens if detected?	1. Notify your regulator 2. 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. 3. If detected at EP, sample EP daily and optimize treatment for toxin removal. 4. If above Health Advisory Level (HAL) at EP, take confirmation sample within 24-hrs & monitor EP daily. 5. If confirmation sample is above the HAL, issue Do-Not-Drink Advisory 6. 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 "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.
What are the DW Health Advisory Levels (HALs)?	• Total Microcystins: 0.3 µg/L for vulnerable people; 1.6 µg/L for all persons • Cylindrospermopsin: 0.7 µg/L for vulnerable people; 3 µg/L for all persons "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.

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.

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

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 [1] [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)

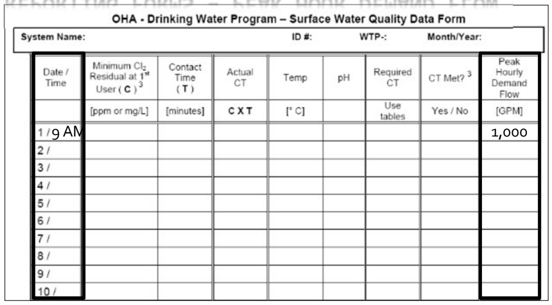
REPORTING FORMS – MONTHLY SUMMARY - TURBIDITY

Slow Sand/Membrane/DE Filtration/Unfiltered

95% of daily turbidity readings ≤ 1 NTU? [2] 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.

REPORTING FORMS – PEAK HOUR DEMAND FLOW



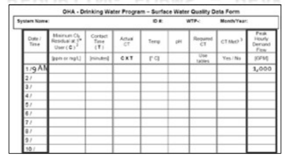
OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: ID #: WTP-: Month/Year:

Date / Time	Minimum Cl_2 Residual at 1st User (C) 3	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? 3	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[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.

REPORTING FORMS – PEAK HOUR DEMAND FLOW



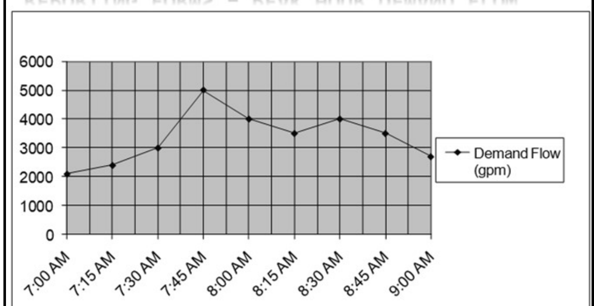
Peak Hour Demand Flow:
- The greatest volume of water passing through the system during any one hour in a consecutive 24 hr period
- Not the same as Peak Instantaneous Flow
- Report demand flow: flow leaving the clear well, not plant flow (in most cases)

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

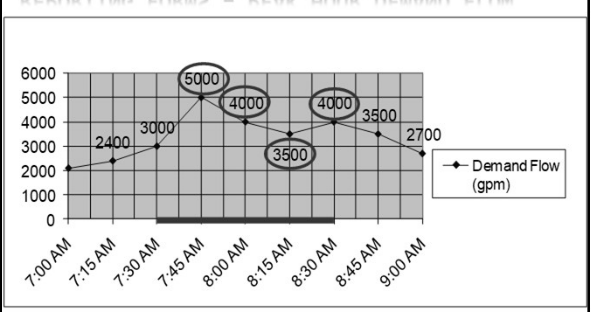
For systems that only have a flow totalizing meter:
- Spot check throughout the day to determine the time of peak demand (e.g. 8 am or 9 pm for residential or mid-day for industrial uses)
- Then record how much water is used during that hour in gallons and divide by 60 minutes to get the peak hour demand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

REPORTING FORMS – PEAK HOUR DEMAND FLOW



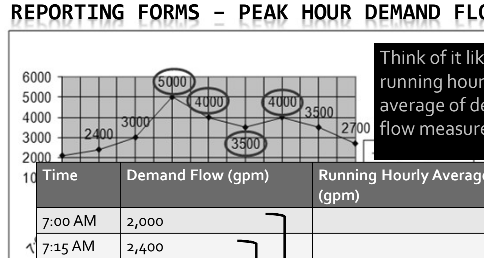
Here is an example chart, meant to represent continuous readings that shows demand flow out of a reservoir used for contact time. What would you say the peak hourly demand flow is?

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.**

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

REPORTING FORMS – CHLORINE & CONTACT TIME

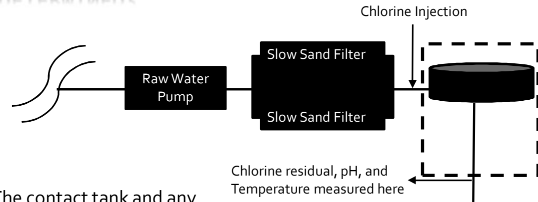
OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: ID #: WTP-: Month/Year:

Date / Time	Minimum Cl_2 Residual at 1st User (C) 3	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? 3	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	???	???						1,000
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.

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.

HOW IS CONTACT TIME DETERMINED?

- Tracer studies are used to determine contact time (T) which is used in calculating CT achieved, where

  CT = chlorine Concentration x contact Time.

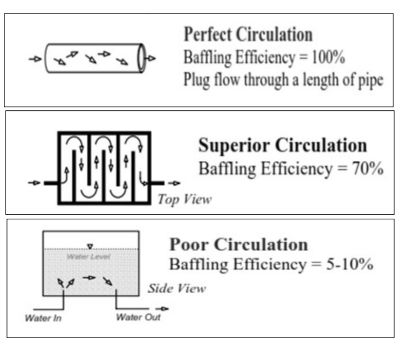
- Contact time is the time that chlorine is in contact with the water from the point of injection to the point where it is measured (sometimes referred to as the "CT segment")
  - May be at or before the 1st user
  - May be more than one CT segment
- Tracer studies are often conducted to simulate a worst-case 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.

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!

WHAT AFFECTS MIXING EFFICIENCY?

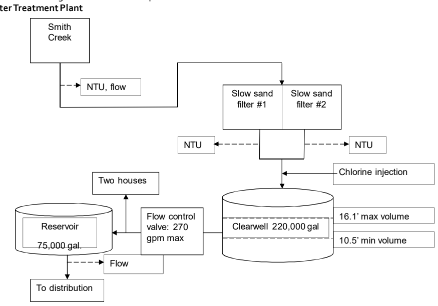
Mixing efficiency improves with high flow path length to width ratios, found in pipelines and simulated in tanks with the use of baffles (hence the term baffling efficiency or factor).



Example: Tracer studies

Directions: Look at the diagram and answer the questions.

Figure 1: Water Treatment Plant



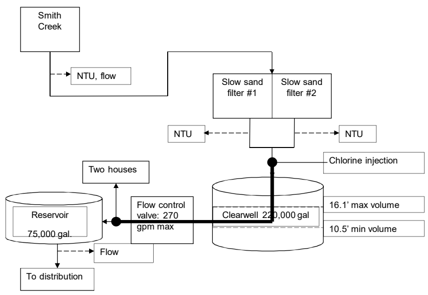
Questions:

- 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? ____________

Example: Tracer studies - Answer

Directions: Look at the diagram and answer the questions.

Figure 1: 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? **270 gpm**
- In a "worst-case scenario" tracer study, what would the clearwell level be? **10.5 feet**

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)

REPORTING FORMS – CHLORINE & CONTACT TIME

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: **ID #:** **WTP-:** **Month/Year:**

Date / Time	Minimum Cl_2 Residual at 1st User (C) 3	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? 3	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).

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 (%) = $\frac{\text{Time (min) x Flow During Tracer Study (gpm)}}{\text{Clearwell Volume During Tracer Study (gal)}}$
- T can be adjusted based on flow (at flow < 110% of tracer study flow) with the following equation:
  - T = $\frac{\text{Current clearwell Volume (gal) x Baffling Factor (\%)}}{\text{Peak Hourly Demand Flow (gpm)}}$
- Contact the state for guidance on using baffling factors.

REPORTING FORMS – ACTUAL CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: **ID #:** **WTP-:** **Month/Year:**

Date / Time	Minimum Cl_2 Residual at 1st User (C) 3	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? 3	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 **C**oncentration (mg/l) x Contact **T**ime (min)
- Do not confuse "CT" and "Contact Time"

REPORTING FORMS – TEMPERATURE & PH

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: **ID #:** **WTP-:** **Month/Year:**

Date / Time	Minimum Cl_2 Residual at 1st User (C) 3	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? 3	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.**

REPORTING FORMS – REQUIRED CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: ID #: WTP-: Month/Year:

Date / Time	Minimum Cl_2 Residual at 1st User (C) [3]	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? [3]	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 /								

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

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

HOW IS REQUIRED CT CALCULATED?

- We use the EPA tables (or "regression equations") to determine the CT required to inactivate *Giardia* ($CT_{required}$)
  - 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 $CT_{required}$ with the actual CT achieved in the water system (CT_{actual}) where:

  CT_{actual} = chlorine concentration (mg/l) x contact time (min)
- Must keep $CT_{actual} \geq CT_{required}$

USING REGRESSION EQUATIONS TO DETERMINE REQUIRED CT

Using Regression Equations to determine required *CT:*

1. **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

USING REGRESSION EQUATIONS, CONT.

Using Regression Equations to determine required CT:

2. **Regression equations can be programmed into plant SCADA or spreadsheets**

<u>Regression Equation (for Temp < 12.5°C)</u>

$$CT = (0.353^{*}L)(12.006 + e^{(2.46-0.073^{*}T+0.125^{*}C+0.389^{*}pH)})$$

<u>Regression Equation (for Temp > 12.5°C)</u>

$$CT = (0.361^{*}L)(-2.261 + e^{(2.69-0.065^{*}T+0.111^{*}C+0.361^{*}pH)})$$

<u>Variables:</u>

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)

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 <u>Celsius</u>.
  - °C = 5/9 x (°F – 32)
- If water temp is between values, then round <u>down</u>
  - 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.*

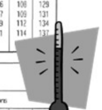
USING EPA CT TABLES - TEMP = 12 °C

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

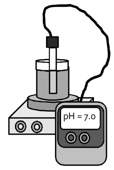
Use 10°C table for T = 10 – 14.9°C (round down for temp)

Chlorine Concentration mg/L <=	PH < 6 (6.1 – 6.5) Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	PH = 6.5 (6.1 – 6.5) Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	PH = (6.6 –) Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	87	104
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	61	81	102	122
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	62	83	103	124
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	64	85	106	127
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	65	86	108	129
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	67	89	112	134
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46	69	91	114	137

Chlorine Concentration mg/L <=	PH < 7.5 (7.1 – 7.5) Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	PH = 8.0 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	PH = 8.5 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	M	102	128	153	31	61	92	122	153	183

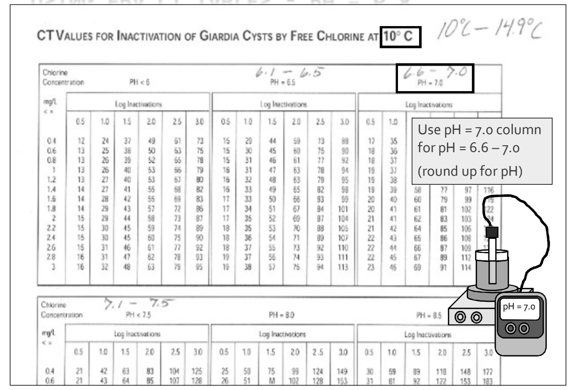


USING EPA CT TABLES - PH



- 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

USING EPA CT TABLES - PH = 6.8

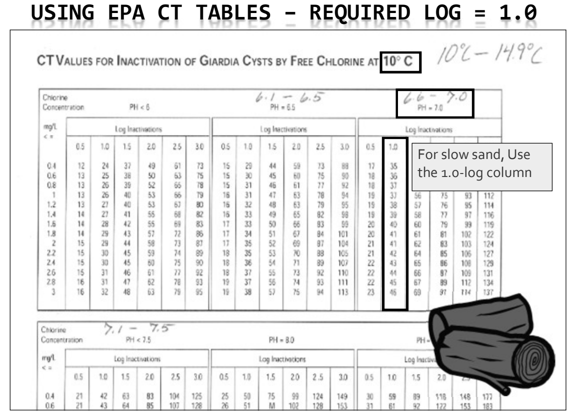


USING EPA CT TABLES – 1-LOG

- 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)

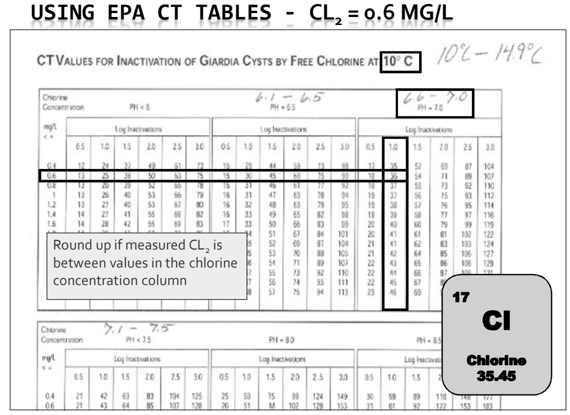
USING EPA CT TABLES – REQUIRED LOG = 1.0



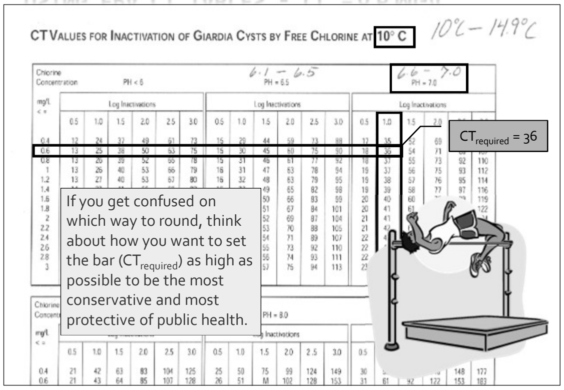
USING EPA CT TABLES - CHLORINE

- 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 $CT_{required}$
  - Example: free chlorine residual is 0.6 ppm

USING EPA CT TABLES - CL_2 = 0.6 MG/L



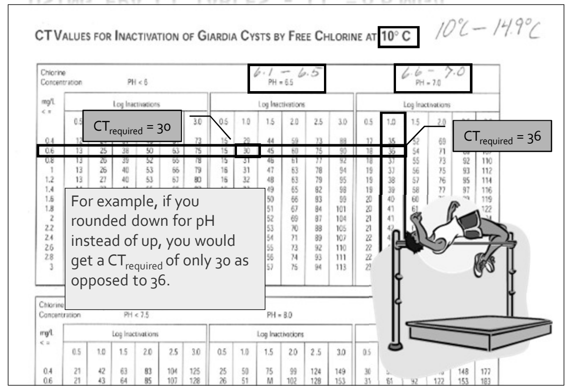
USING EPA CT TABLES - CL_2 = 0.6 MG/L



$CT_{required}$ = 36

If you get confused on which way to round, think about how you want to set the bar ($CT_{required}$) as high as possible to be the most conservative and most protective of public health.

USING EPA CT TABLES - CL_2 = 0.6 MG/L

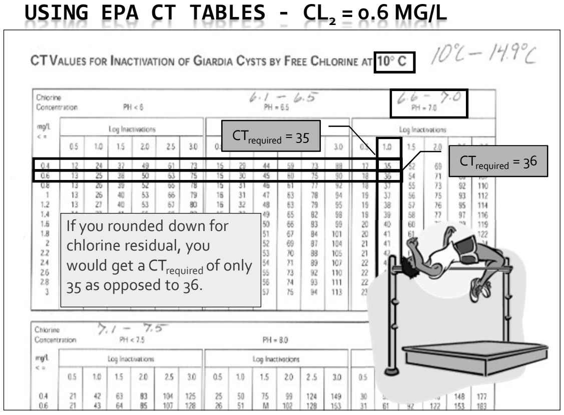


$CT_{required}$ = 30

$CT_{required}$ = 36

For example, if you rounded down for pH instead of up, you would get a $CT_{required}$ of only 30 as opposed to 36.

USING EPA CT TABLES - CL_2 = 0.6 MG/L



$CT_{required}$ = 35

$CT_{required}$ = 36

If you rounded down for chlorine residual, you would get a $CT_{required}$ of only 35 as opposed to 36.

REPORTING FORMS – REQUIRED CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name: ID #: WTP-: Month/Year:

Date / Time	Minimum Cl_2 Residual at 1st User (C) [3]	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? [3]	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	36	Yes	1,000
2 /								

Notify the State within 24-hrs if CT was not met.
Public Health After Hours Duty Officer:
Cell (971) 246-1789
Pager (503) 938-6790
Oregon Emergency Response System:
1-800-452-0311

1. Enter Required CT (CT tables or Regression Equations)
2. Was CT Met? Yes if Actual CT $\geq$ Required CT
3. Actual CT must be $\geq$ Required CT

REPORTING FORMS – MONTHLY SUMMARY – CT & CL_2

Everyone needs to fill out the CT section of the Monthly Summary

Monthly Summary (Answer Yes or No)	
CT's met everyday? (see back) (Yes) No	All Cl_2 residual at entry point ≥ 0.2 mg/l? (Yes) No
PRINTED NAME:	
SIGNATURE:	DATE:
PHONE #: ( )	CERT #:

MONTHLY REPORT

Slow Sand/Membrane/ DE Filtration/Unfiltered		Monthly Summary (Answer Yes or No)	
95% of daily turbidity readings ≤ 1 NTU? [2]	Yes / No	CT's met everyday?	All Cl2 residual at entry point ≥ 0.2 mg/l?
All daily turbidity readings ≤ 5 NTU?	Yes / No	Yes / No	Yes / No
Notes:		PRINTED NAME:	
		SIGNATURE:	DATE:
		PHONE #: ( )	CERT #:

DAY	12 AM [NTU]	4 AM [NTU]	8 AM [NTU]	Noon [NTU]	4 PM [NTU]	8 PM [NTU]	Highest Reading of the Day [NTU]
1			0.34				0.50

Date & Time	Minimum Cl_2 Residual at 1st User (C) [mg/L]	Contact Time (T) [min]	Actual CT C x T	Temp [° C]	pH	Required CT (Use CT tables)	CT Met? (Yes / No)	Peak Hourly Demand Flow (GPM)
1 /9 AM	0.6	100	60	12	6.8	36	Yes	1,000

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

FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

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

FILLING OUT THE MONTHLY REPORT – <u>AVOIDING</u> 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)

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).

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)

DISINFECTION

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

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

TYPES OF DISINFECTANTS - CHEMICAL

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

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

FORMS OF CHLORINE

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

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

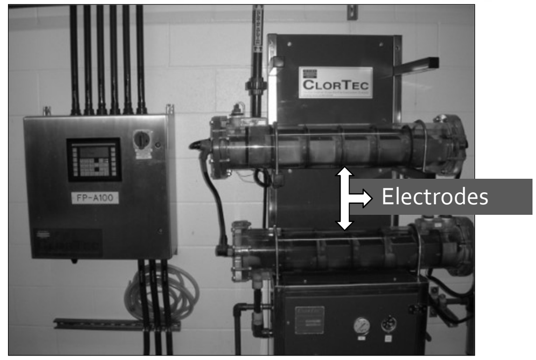
FORMS OF CHLORINE – SODIUM HYPOCHLORITE

Diaphragm pump with chlorine solution tank

ON-SITE GENERATED SODIUM HYPOCHLORITE

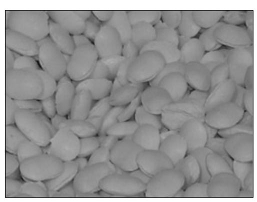
- 0.8% sodium hypochlorite is produced on demand by combining salt, water & electricity
- Electrolysis of brine solution produces sodium hydroxide and chlorine gas, which then mix to form sodium hypochlorite
- Hydrogen gas byproduct; vented to atmosphere
- Alleviates safety concerns associated w/ hauling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

ON-SITE GENERATED SODIUM HYPOCHLORITE



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



FORMS OF CHLORINE - CALCIUM HYPOCHLORITE

Erosion chlorinator

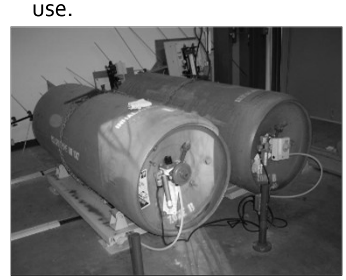
Inside Hopper =>

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 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

FORMS OF CHLORINE – CHLORINE GAS

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



150-lb cylinders
Note security chain
spare tank & labeling.

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

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

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.

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

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

OZONE - DISADVANTAGES

Disadvantages:

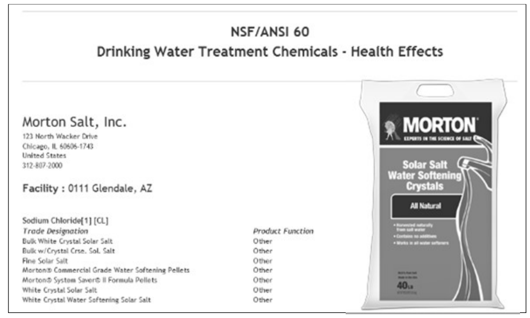
1. Overfeed or leak can be dangerous
2. Cost is high compared with chlorination
3. Installation can be complicated
4. May produce undesirable brominated byproducts in source waters containing bromide
5. No residual effect is present in the distribution system, thus post-chlorination is required
6. Much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

NSF/ANSI STANDARD 60 - CHEMICALS

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

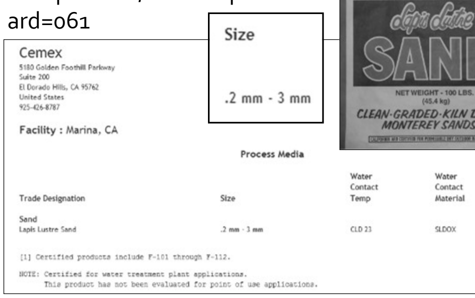
NSF/ANSI STANDARD 60 - CHEMICALS

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



NSF/ANSI STANDARD 61 – COMPONENTS & MEDIA

http://info.nsf.org/Certified/PwsComponents/index.asp?standard=061



RESOURCES FOR OPERATORS

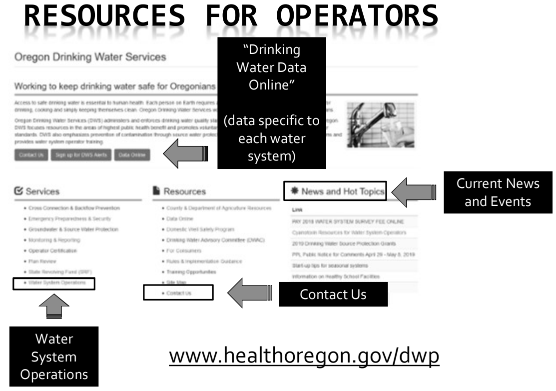
- For surface water systems: www.healthoregon.gov/dwp

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

RESOURCES FOR OPERATORS

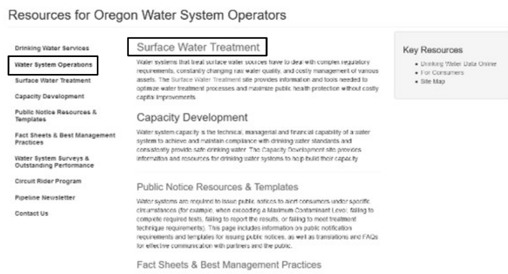
- EPA Rules http://water.epa.gov/lawsregs/rulesregs/sdwa/currentregulations.cfm
- AWWA http://www.pnws-awwa.org/Index.asp
- OAWU http://www.oawu.net/
- Circuit Rider http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/Operations/Pages/circuitrider.aspx

RESOURCES FOR OPERATORS

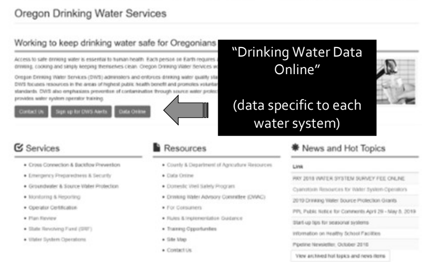


www.healthoregon.gov/dwp

RESOURCES FOR OPERATORS



RESOURCES FOR OPERATORS



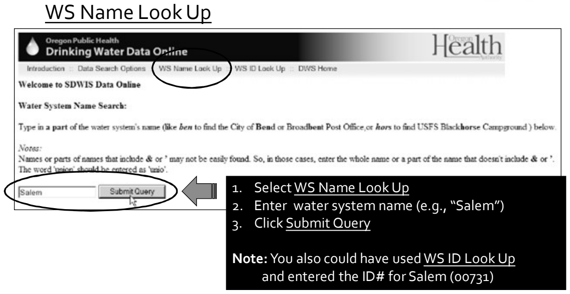
www.healthoregon.gov/dwp

DATA FOR EACH SYSTEM ON-LINE

Many data search options are available

DATA FOR EACH SYSTEM ON-LINE

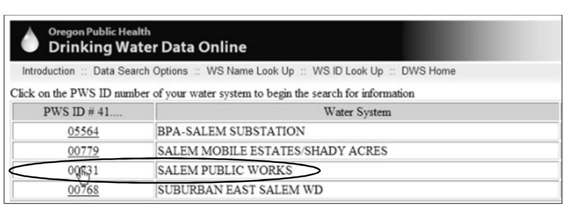
WS Name Look Up

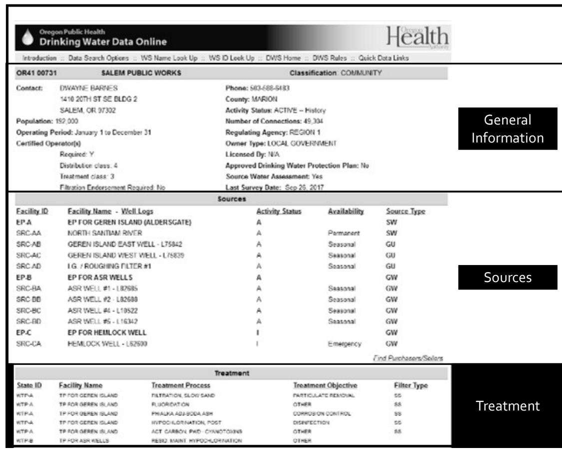


DATA FOR EACH SYSTEM ON-LINE

Select the Water System by

Clicking on the PWS ID#





System Classification

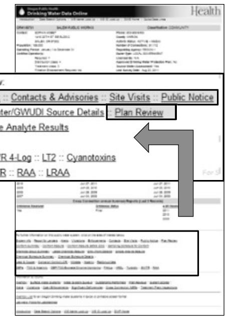
OR41 00731	SALEM PUBLIC WORKS	Classification: COMMUNITY

Contact: DWAYNE BARNES
1410 20TH ST SE BLDG 2
SALEM, OR 97302
Population: 192,000
Operating Period: January 1 to December 31
Certified Operator(s)
Required: Y
Distribution class: 4
Treatment class: 3
Filtration Endorsement Required: No

Phone: 503-588-6483
County: MARION
Activity Status: ACTIVE -- History
Number of Connections: 49,304
Regulating Agency: REGION 1
Owner Type: LOCAL GOVERNMENT
Licensed By: N/A
Approved Drinking Water Protection Plan: No
Source Water Assessment: Yes
Last Survey Date: Sep 26, 2017

All written correspondence goes to this person (e.g., violation notices, general mailings, etc.)

View a list of Certified Operators



For further information on this public water system, click on the area of interest below:
System Info :: Report for Lenders :: Alerts :: Violations :: Compliance & Enforcement :: Contacts & Advisories :: Site Visits :: Public Notice
Coliform Summary :: Coliform Results :: Sampling Schedule for Coliform :: Groundwater/GWUDI Source Details :: Plan Review
Chemical Group Summary :: Latest Chemical Results :: Entry Point Detects :: Single Analyte Results
Chemical Schedule Summary :: Chemical Schedule Details
Lead & Copper :: Corrosion Control (LCR) :: Nitrate :: Arsenic :: Radionuclides :: GWR 4-Log :: LT2 :: Cyanotoxins
DBPs :: TOC & Alkalinity :: DBP Sample Sites :: FANLs :: MRDL :: Turbidity :: SWTR :: RAA :: LRAA

1. Sampling Schedules
2. Results
3. Violations
4. Enforcements
5. Site Visits/Contacts
6. Plan Review

MORE QUESTIONS?

- Call your technical services contact at the State. State Drinking Water Services
  - General Info: (971) 673-0405

Astoria, OR 5 MGD plant (photo taken by Frank Wolf)