

CT Studies for Ground Water Plants

Presented by Jack C. Schulze, P.E.
Public Drinking Water Section
jschulze@tceq.state.tx.us 512/239-6046

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GWDR CT Study Template

- A one-page form used to evaluate the disinfection protocol at plants treating Ground Water (NOT under the direct influence of surface water)
- Available in MS Excel, MS Word, and Adobe pdf
- Applicable at most plants that:
 - utilize free chlorine for disinfection, and
 - use storage tanks that have (both) inlets and outlets.



GWDR CT Study Template (cont)

Entry Point Analysis Worksheet for Groundwater Systems That Use Free Chlorine and Desire a Minimum Specified Residual			
1	Total capacity (maximum) of all storage tanks at this site	[Yellow bar]	gallons
2	Minimum volume/water level	[Yellow bar]	gallons (or feet)
3	Maximum volume/water level	[Yellow bar]	gallons (or feet)
4	Actual Min/Max Ratio (line 2 divided by line 3)	[Orange bar]	
5	Maximum allowable ratio	0.50	
6	Allowable ratio (minimum of line 4 and line 5)	[Orange bar]	
7	Allowable Volume (line 1 times line 6)	[Orange bar]	gallons
8	Baffling Factor	0.1	
9	Effective Volume (line 7 times line 8)	[Orange bar]	gallons
10	Total capacity (maximum) of the wells feeding these tanks	[Yellow bar]	gpm
11	Total capacity (maximum) of all the service pumps fed by these tanks	[Yellow bar]	gpm
12	Flow rate (minimum of line 10 and line 11)	[Orange bar]	gpm
13	T ₁₀ for this site (line 9 divided by line 12)	[Orange bar]	minutes
14	CT required for a 4-log viral inactivation if the water temperature is at least 10°C and the pH is not greater than 9.5.	6.0	mg/L-min
Assuming that you are using free chlorine, your water temperature does not drop below 10°C (60°F), and the pH is always below 9.5 . . . The Minimum Specified Residual For This Entry Point will be: (line 13 divided by line 14)			mg/L
If the T ₁₀ is less than 1.5 minutes, the TCEQ cannot approve a Minimum Specified Residual for this site because it would be greater than 4.0 mg/L under worst-case operating conditions.			



The CT Study Template for Groundwater Systems is also referred to as the Minimum Specified Residual (MSR) calculator.

It can only be used at a plant (or site) that:

- utilizes free chlorine as a primary disinfectant,
- has at least one ground storage tank,
- has a separate inlet and outlet on each of its ground storage tanks,
- operates its ground storage tanks (if there is more than one) in a parallel configuration. Parallel operation means that the inlets for each the tank are fed by a common influent header and the outlets for each tank are connected to a common effluent header.

and

- has at least 30 gallons of storage for every gpm of pump capacity. For example, at least 30,000 gallons of storage at a site with a 100 gpm well.

You may not use the template if the site only has pressure tanks and you may not use the template if the site only has tanks with a single line that serves as both the tank inlet and outlet.

GWDR CT Study Template (cont)

1	Total capacity (maximum) of all storage tanks at this site	gallons
2	Minimum volume/water level	gallons (or feet)
3	Maximum volume/water level	gallons (or feet)
4	Actual Min/Max Ratio (line 2 divided by line 3)	
5	Maximum allowable ratio	0.50
6	Allowable ratio (minimum of line 4 and line 5)	
7	Allowable Volume (line 1 times line 6)	gallons
8	Baffling Factor	0.1
9	Effective Volume (line 7 times line 8)	gallons

- **Yellow Area/Cell:** A place where you must enter data
- **(Burnt) Orange Area/Cell:** A calculated value



Total Capacity = the total usable volume of water that can be stored in all of the ground storage tanks at this entry point. You must exclude any volumes located above the overflow elevation in the tank(s) because water cannot be stored between the overflow and the tank roof. You may not claim credit for the volume of water contained in a pressure tank and you may not claim credit for tanks that have a single line that serves as both the inlet and the outlet.

Minimum volume/water level = the lowest operating level that you will allow in these tanks under normal operating conditions. This “low water level” usually occurs during peak demand periods. If you change the low operating level on a seasonal basis, record the lowest of the seasonal settings.

Maximum volume/water level = the highest water level that you will maintain in these tanks under normal operating conditions. This “max water level” occurs when the tanks are completely full and the service pumps are off. If you change the max operating level on a seasonal basis, record the highest of the seasonal settings.

Actual Min/Max Ratio = the percentage of the total usable volume (divided by 100) that you maintain under normal operating conditions.

Maximum allowable ratio = the maximum ratio we generally allow you to claim credit for.

Allowable volume = the volume of water that you will usually maintain during normal operating conditions.

Baffling factor = a factor used to compensate for the short-circuiting that occurs in ground storage tanks that contain no internal baffles.

Effective volume = the equivalent amount of water that the tank would be holding if we could completely eliminate any short circuiting.

GWDR CT Study Template (cont)

1	Total capacity (maximum) of all storage tanks at this site		78,750 gallons
2	Minimum volume/water level	12.0	gallons (or feet)
3	Maximum volume/water level	22.5	gallons (or feet)
4	Actual Min/Max Ratio (line 2 divided by line 3)	0.56	
5	Maximum allowable ratio	0.50	
6	Allowable ratio (minimum of line 4 and line 5)	0.50	
7	Allowable Volume (line 1 times line 6)		39,375 gallons
8	Baffling Factor		0.1
9	Effective Volume (line 7 times line 8)		3,938 gallons



At this site, the system has two 42,000 gallon ground storage tanks that share a common inlet header and share a common outlet header. Although the tanks have a total nominal capacity of 84,000 gallons, they only have a usable capacity of 78,750 gallons because there is 1.5 feet of space between the overflow and the tank roof.

The wells come on when the water level falls to 16 feet (about 70% of maximum usable volume). However, during peak hour the water level typically falls another 4 feet before consumption drops to a point where the (continuous) well output matches the (intermittent) service pump discharge rate.

Since the actual min/max ratio exceeds 0.50, the site will only get credit for 39,375 gallons (or 50% of the maximum usable volume).

Since the tanks are unbaffled, there is a lot of short-circuiting and the effective volume of the tanks is 3,938 gallons (or 10% of the allowable volume).

GWDR CT Study Template (cont)

9	Effective Volume (line 7 times line 8)		gallons
10	Total capacity (maximum) of the wells feeding these tanks	[Yellow Box]	gpm
11	Total capacity (maximum) of all the service pumps fed by these tanks	[Yellow Box]	gpm
12	Flow rate (minimum of line 10 and line 11)	[Orange Box]	gpm
13	T_{10} for this site (line 9 divided by line 12)	[Orange Box]	minutes
14	CT required for a 4-log viral inactivation if the water temperature is at least 10°C and the pH is not greater than 9.5.		6.0 mg/L-min
Assuming that you are using free chlorine, your water temperature does not drop below 10°C (60°F), and the pH is always below 9.5 . . . The Minimum Specified Residual for this Entry Point will be: (line 13 divided by line 14)			mg/L



Effective volume = (see previous slide)

Total well capacity = the combined output of all the wells that feed this storage tank (or tank battery). This is the maximum possible flow rate of the water entering tank(s) during peak flow rate conditions.

Total service pump capacity = the combined output of all the service pumps that draw from this storage tank (or tank battery). This is the maximum possible flow rate of the water leaving the tank(s) during peak flow rate conditions.

Flow rate = the flow rate that will be used to calculate the amount of time that water remains in the tank. This value will be the lower of the influent and effluent flow rates because influent and effluent flow rates will be identical when the tank is operating a minimum water level. If the water is flowing in faster than it flow out, level will rise (above minimum). If the water flows out faster than it flows in, the level will drop . . . but it can't because we're at minimum level. It won't matter if the actual service pump capacity exceeds the actual well capacity because over a 1 – 2 hour period, the service pumps will be running intermittently while the wells will be running continuously.

T_{10} = the amount of time it takes for 10% of the water entering the tank(s) to make its way to the tank outlet. We base disinfectant contact time on the T_{10} value to ensure that all of the water has been adequately disinfected (even if that means that 90% of the water has received more disinfection that required).

CT required = the product of the disinfectant concentration (C) and the contact time (T, or T_{10}). The CT needed to achieve a 4-log viral inactivation depends on the water temperature and pH and the type of disinfectant used. We selected the operational limits (a 10°C, or 50°F, minimum temperature and maximum pH of 9.5) because we think these are about the worst possible combination of conditions that will ever exist at a system treating groundwater. If you can make it there, you can make it anywhere.

Entry Point MSR = the minimum residual that you will have to maintain at the plant's high service pumps to meet the 4.0-log inactivation requirement under worst-case conditions. It is important to note that you will probably (in almost all cases) be required to maintain a much higher residual at the entry point so that you can maintain the required residual in the far end of the distribution system.

GWDR CT Study Template (cont)

9	Effective Volume (line 7 times line 8)		3,938 gallons
10	Total capacity (maximum) of the wells feeding these tanks	240 gpm	
11	Total capacity (maximum) of all the service pumps fed by these tanks	800 gpm	
12	Flow rate (minimum of line 10 and line 11)		240 gpm
13	T_{10} for this site (line 9 divided by line 12)		16.4 minutes
14	CT required for a 4-log viral inactivation if the water temperature is at least 10°C and the pH is not greater than 9.5.		6.0 mg/L-min
Assuming that you are using free chlorine, your water temperature does not drop below 10°C (60°F), and the pH is always below 9.5 . . . The Minimum Specified Residual for this Entry Point will be: (line 13 divided by line 14)			0.4 mg/L



Continuing from the previous example.

The system we were using in the previous example has two wells that feed the storage tanks at this site. One well produces 147 gpm and the other well produces 93 gpm (for a total of 240 gpm).

There are also two 400 gpm service pumps that take suction from the discharge header of the tanks.

Since the well capacity is less than the service pump capacity, we know that it is the wells that control the water level in the tank. Furthermore, since the well capacity is only 30% of the total service pump capacity, we know that (during the one hour period before the water level began to rise) the well ran for 60 minutes while the service pumps ran a total of 18 minutes (or 36 minutes if only one pump was running).

Based on the effective volume of the tanks and the flow rate through them, the site provides a minimum of 16.4 minutes of disinfectant contact time. Since they are using free chlorine as their disinfectant, they will only need to maintain a free chlorine residual of 0.4 mg/L at the entry point to distribution . . . even under worst case operating conditions.

Surface Water CT Study Template

- An Excel 2003 spreadsheet that is used to evaluate the disinfection protocol at plants treating Surface Water or Groundwater under the Direct Influence of Surface Water.
- Ground Water plants can use this spreadsheet to claim credit for:
 - Contact time in pipelines
 - Tanks with internal baffles
 - Tanks in series



Submitting a CT Study

- Any PWS representative can submit the CT Study
 - Consulting engineer
 - Utility Director
 - Plant Operator
 - even the Mayor
- Send it to:
 - TCEQ/PDWS/DWPT (MC-155)
 - P.O. Box 13087
 - Austin, Texas 78711-3087
 - Attn: Groundwater CT Study



Thank You

Jack C. Schulze, P.E.

TCEQ/WSD/PDWS (MC-155)

PO Box 13087

Austin, TX 78711-3087

Phone: 512-239-6046

Fax: 512-239-6050

e-mail: jschulze@tceq.state.tx.us

