Water Contaminant Information Tool
Pathogen Contaminant Profile - *Comprehensive Report Format*

➢ Data Package for *Francisella tularensis*

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Introduction

The Water Contaminant Information Tool (WCIT) was developed in support of the June 12, 2002 Public Health Security and Bioterrorism Preparedness and Response Act. The Act amends the Safe Drinking Water Act (SDWA), and specifies actions community water systems and the United States Environmental Protection Agency (EPA) must take to improve the security of the nation's drinking water infrastructure.

WCIT is a password-protected, online database for tracking and managing information and research on priority traditional and nontraditional water contaminants of concern to water security. Nontraditional contaminants are those that are not significant from a regulatory or operational perspective, but that could have substantial adverse consequences on the public or utility if accidentally or intentionally introduced into the drinking water.

The purpose of WCIT is to assist in planning for, and responding to, drinking water contamination threats and incidents. As a planning tool, WCIT can be used to support vulnerability assessments, emergency response plans, and the development of site-specific response guidelines. As a response tool, WCIT can provide real-time information about specific water contaminants to inform decision makers about appropriate response actions. A secondary objective of WCIT will be to identify knowledge gaps for priority contaminants, which will in turn, inform future research efforts.

WCIT contains information on more than 800 chemical, biological, and radiochemical contaminants. A number of contaminants are only linked to field and laboratory methods. The contaminants with profiles generally have the following information, when available:

- Contaminant summary, with key information on the fate and transport
- Name and forms including synonyms, degradation products, and by-products
- Physical property measurements and chemical formulas
- Availability of the contaminant and where it is likely to be found
- Properties and processes related to fate and transport
- Basic medical information (for example, treatment, vulnerable subpopulations, and exposure route)
- Lethal doses and other toxicity data
- Analytical methods, field tests, and sampling information
- Data on the treatment of contaminated drinking water
- Early warning signs that might indicate a contaminant's presence in a water system, including color, odor, pH, and toxicity tests

- Early warning signs in the environment when water is contaminated, including impact on local wildlife
- Contaminated wastewater treatment
- Infrastructure decontamination

Pathogen Data Provided

Data supplied in this package covers information about *Francisella tularensis* related to fate and transport in the environment, and information on inactivating it in drinking water.

The tables in this data package are in the same order as the tables listed in the WCIT Contaminant Profile - Comprehensive Report Format. The sections suggested for updates or new data are indicated in the headings for each page or in the tables.

Data and citations from primary scientific research papers are provided. In some cases, some references already had codes assigned by WCIT. When a search of all WCIT references (as of March 26, 2015) did not reveal that a source was included, a notation of "NEW REFERENCE – needs new code" has been included.

Because there have been no studies on inactivating *Francisella tularensis* in wastewater or infrastructure (including biofilms), no data have been provided in this update.

***FRANCISELLA TULARENSIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes

Properties Relevant to Fate and Transport		**References**
Other Information (Water)	Forsman et al. (2000) reported that it **required 70 days for *F. tularensis* subsp. *holarctica* LVS to decrease to an undetectable level (as determined by plate counts) in sterile tap water at 8° C**. In addition, Forsman et al. (2000) stated: the "analysis showed that approximately **30% of the cells stored for 140 days in cold water increased in size** …, while none of the formalin-killed cells increased in size. Taken together, the results showed that at least 30% of the 140-day starved cells could be defined as VBNC …. Nevertheless, if only 30% of the population were viable, this would have been more than sufficient to elicit tularemia in mice." No signs or symptoms of tularemia were observed in the mice.	Forsman, M., Henningson, E.W., Larsson, E., Johansson, T., Sandstrom, G. 2000. *Francisella tularensis* Does Not Manifest Virulence in Viable but Nonculturable State. *FEMS Microbiology Ecology,* 31(3):217–224. **NEW CODE**
Other Information (Water)	Gilbert and Rose (2012) used culture-based procedures to determine the viability of *F. tularensis* subsp. *holarctica* NY98 and *F. tularensis* subsp. *holarctica* LVS in sterile tap water. ***Ft* NY98 persisted for at least 28 days** and ***Ft* LVS persisted for 14 days, up to 21 days in sterile tap water at 8 °C**, but **not at 25 °C or 5 °C**.	Gilbert, S.E. and Rose, L.J., 2012. Survival and Persistence of Nonspore-forming Biothreat Agents in Water. *Letters in Applied Microbiology*, 55(3):189-194. **NEW CODE**
Other Information (Water)	Berrada and Telford (2011) reported that *F. novicida* U112, *F. tularensis* subsp. *tularensis* SSTR9 10 7 (Type A) and *F. tularensis* subsp. *holarctica* LVS (Type B) were able to survive in **filter-sterilized brook water stored at room temperature (approximately 21° C) for 7 to 10 days**. In **brackish water, Type A and *F. novicida* were culturable for at least 28 days and Type B for at least 34 days**. **In saline, Type B and *F. novicida* were culturable between 18 and 21 days and Type A was culturable between 21 and 28 days.** The sulfur residues in brackish water are theorized to enhance *Ft* survival.	Berrada, Z. L. and Telford, III, S.R., 2011. Survival of *Francisella tularensis* Type A in Brackish-water. *Archives of Microbiology*, 193(3):223-226. **NEW CODE**

***FRANCISELLA TULARENSIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes
continued

Properties Relevant to Fate and Transport		**References**
Other Information (Water; mud)	Parker et al. (1951) reported that natural bodies of water (potentially contaminated from carcasses or excreta of infected animals) have been implicated as primary sources of contamination. Stored at 7 °C, *Pasturella tularensis* [1] **survived for at least 23 days, but not more than 35 days.** Naturally contaminated mud samples stored under these same conditions gave varying results, with **persistence lasting over a 4 to 10 week period.** Parker et al. (1951) also isolated the organism from ice formed from naturally contaminated water. Frozen contaminated water in the laboratory showed that the organism **survived for a period of not less than 12 days but not 14 days.** Parker et al. (1951) remarked: "There seems to be no escaping the conviction that the factors governing persistence are residence in the water or the mud or both. One hesitates to suggest the possibility of the multiplication of *P. tularensis* in a water-mud medium yet present information suggests such a hypothesis."	Parker, R.R., Steinhaus, E.A., Kohls, G.M, and Jellison, W.L. 1951. Contamination of Natural Waters and Mud with *Pasturella tularensis* and Tularemia in Beavers and Muskrats in the Northwestern United States. *National Institutes of Health Bulletin,* No. 193. U.S. Government Printing Office: Washington, D.C., 61 pp. **NEW CODE**
Other Information (Water; mud)	Jellison et al. (1942) reported contamination of pond water with *P. tularensis* for **at least 31 days**. The final date of water collection was 33 days after any beaver were present in the pond. The agent was also present in the mud on the last day of water sample collection. "**The survival of virulent *P. tularensis* in one of the water samples was demonstrated for a period of at least 16 days and in the mud sample for at least 31 days."**	Jellison, W.L., Kohls, G. M., Butler, W.J., and Weaver, J.A. 1942. Epizootic Tularemia in the Beaver, *Castor canadensis*, and the Contamination of Stream Water with *Pasturella tularensis*. *American Journal of Hygiene*, 36:168-182. **NEW CODE**

[1] *Pasturella tularensis* is an earlier name for *Francisella tularensis.*

***FRANCISELLA TULARENSIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes
continued

Properties Relevant to Fate and Transport		**References**
Other Information (Amoeba)	Abd et al. (2003) reported that coculture of *F. tularensis* subsp. *holarctica* LVS with *Acanthamoeba castellanii* (free-living amoeba) resulted in *Ft* cells being found intracellularly in vacuoles in the amoeba. The *Ft* was able to multiply within the vacuoles. Ft was found in both the cysts (formed by *Acanthamoeba* spp. under adverse conditions) and the active trophozoite stage.	Abd, H., Johansson, T., Golovliov, I., Sandström, G., and Forsman, M. 2003. Survival and Growth of *Francisella tularensis* in *Acanthamoeba castellanii*. *Applied and Environmental Microbiology,* 69(1):600-606. **NEW CODE**
Other Information (Amoeba)	El-Etr et al. (2009) cocultured a variety of *F. tularensis* subsp. (one was the less virulent LVS strain, one was the opportunistic human pathogen subsp. *F. novicida,* and 11 were the more virulent Type A strains) with *Acanthamoeba castellanii* (free-living amoeba). In culture media, most virulent strains responded differently than the vaccine strain (LVS), which is "least efficient at both association and entry, consistent with the nonpathogenic nature of this isolate". The amoeba host rapidly encysted in response to *F. tularensis* infection, did not replicate in large numbers, but survived for a period of 3 weeks. "…we conducted a detailed characterization of the interaction of multiple *F. tularensis* strains with the amoeba *A. castellanii* and have demonstrated for the first time the ability of fully virulent strains to enter and survive in amoebae." Further: "*F. tularensis* strains in general replicated at much lower rates in *A. castellanii* than other amoeba-resistant bacteria, such as *M. avium* and *L. pneumophila…* The variation in the ability of clinical *F. tularensis* strains to associate with and survive in *A. castellanii* suggests that more than one environmental host may exist for *F. tularensis*."	El-Etr, S.H., Margolis, J. J., Monack, D., Robison, R.A., Cohen, M., Moore, E., and Rasley, A. 2009. *Francisella tularensis* Type A Strains Cause the Rapid Encystment of *Acanthamoeba castellanii* and Survive in Amoebal Cysts for Three Weeks Postinfection. *Applied and Environmental Microbiology*, 75(23):7488-7500. **NEW CODE**

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**
Table: Treatment Process Performance Summary – CHLORINE (recommend replacing current WCIT contents with the following information)

Disinfection – *Chlorine* [Rose, L. J., Rice, E.W., Jensen, B., Murga, R., Peterson, A., Donlan, R.M., and Arduino, M.J. 2005. Chlorine Inactivation of Bacterial Bioterrorism Agents. *Applied and Environmental Microbiology,* 71(1): 566-568.] [2] **JAEM2**	
Drinking Water Treatment Performance	Ct values for a 3-$\log_{10}$ reduction of *F. tularensis* ranged from 1.0 to 10.3 (extrapolated number). *F. tularensis* NY98 showed a Ct value of 10.3 for a 3-$\log_{10}$ reduction at 5 °C and a Ct value of 3.9 for a 3-$\log_{10}$ reduction at 25 °C. *F. tularensis* LVS showed a Ct value of 2.4 for a 3-$\log_{10}$ reduction at 5° C and a Ct value of 1.0 at 25 °C. *Ft* NY98 was slightly more resistant to chlorine than *Ft* LVS. The pH was 7 for this bench scale study.
Study Conditions Summary	The initial inoculum ($\log_{10}$ CFU) was 6.5 for *F. tularensis* NY98 at 5 ° and 6.6 at 25 °C; for *F. tularensis* LVS it was 7.0 at 5° C and 6.8 at 25 °C. The effect of each chlorine concentration was tested in triplicate by using chlorine demand-free buffer (0.05 M KH2PO4; pH 7) and maintained at 5 °C and 25 °C. Free available chlorine (FAC) and total chlorine were monitored by using DPD colorimetric analysis. The reported Ct values represent the mean of the Ct values calculated for each chlorine concentration. [3]
Process Performance Considerations	A 1992 survey of samples from 283 water utilities using chlorine reported a median residual of 1.1 mg/liter, and a median contact time of 45 min from the first point of use - from treatment facility to first access point in the water distribution system (median Ct value = 49.5) [Water Quality Disinfection Committee. 1992. Survey of water utility disinfection practices. *J. Am. Water Works Assoc.* 84(9): 1-128 **NEW REFERENCE – needs new code**]. ….This study shows that viable *F. tularensis* would be reduced by more than 3 orders of magnitude under these median conditions, if pH (7) and temperatures were similar to those in the present study.
Contaminant Byproducts	None mentioned
Rating [4]	**Note: This needs to be assigned.**

[2] WCIT Reference "JAEM2" (Do not use "AEM7" or "JAEM-9" – they are incorrect variations on the "JAEM2" citation)

[3] Decay curves were generated for each organism by using the $\log_{10}$-transformed data of the mean CFU counts at each time, temperature, and chlorine concentration. Linear regressions…were performed to estimate the time needed for a 99 or 99.9% reduction in viable counts. The Ct values were calculated by multiplying inactivation times for a given temperature and percent inactivation by the chlorine concentration at that time. The reported Ct values represent the mean of the Ct values calculated for each chlorine concentration.

[4] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-$\log_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-$\log_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-$\log_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**
Table: Treatment Process Performance Summary – CHLORINE
NEW REFERENCE – needs new code

Disinfection – *Chlorine* [O'Connell, H.A., Rose, L.J., Shams, A.M., Arduino, M.J., and Rice, E.W. 2011. Chlorine Disinfection of *Francisella tularensis. Letters in Applied Microbiology,* 52(1): 84-86.] NEW REFERENCE – needs new code.	
Drinking Water Treatment Performance	In this bench scale study: a 4 $\log_{10}$ reduction of viable *F. tularensis* counts occurred most rapidly at pH 7 °C and 25 °C, with no statistical difference between the Ct values (0.7 – 1.7 mg-min/L) for all tested strains. Disinfection occurred most slowly at pH 8 and 5 °C, with Ct values ranging from 53.5 to 103.4 mg-min/L …. for the wild-type strains, all of which had Ct values at least double of those for LVS, 24.3 mg-min/L. ANOVA analyses of the Ct values required for a 4 $\log_{10}$ reduction in culturable cell numbers showed that for all conditions other than pH 7 and 25 °C, *F. tularensis* LVS was more sensitive to FAC than any of the wild-type strains ($P \leq 0.029$).
Study Conditions Summary	FAC solutions at 0.5 mg/L were made by adding a 1:100 dilution of reagent-grade NaOCl to 50 mmol/L KH2PO4 (phosphate buffer) adjusted to pH 7 or 8. FAC, and total chlorine levels were monitored using the N,N- diethyl-p-phenylenediamine colorimetric method (DPD: APHA, AWWA and WEF. 2005. Standard Methods for the Examination of Water and Wastewater). [5]
Process Performance Considerations	Based on a survey of water treatment plants in the United States that revealed a mean FAC residual of 1.1 mg/L and a residence time of 45 min, [Water Quality Disinfection Committee. 1992. Survey of water utility disinfection practices. *J. Am. Water Works Assoc.* 84(9): 1-128 **NEW REFERENCE – needs new code**] water at the most favorable temperature and pH combination (25 °C, pH 7) would reduce planktonic populations of the most sensitive *F. tularensis* strain by 4 $\log_{10}$ in less than 1 minute. The least favorable temperature and pH conditions (5 °C, pH 8) would require up to 1.7 h to reduce planktonic populations of the most tolerant strain by 4 $\log_{10}$. The decreased efficacy of FAC at pH values greater than 7 is relevant to utilities using increased pH to reduce pipe corrosion and leaching from lead and copper.
Contaminant Byproducts	None mentioned.
Rating [6]	**Note: This needs to be assigned.**

[5] The $\log_{10}$ values of the average CFU counts for each exposure time point were used to construct decay curves. Linear regression was used to calculate the mean contact concentration time values (Ct, mg-min/L, for 4 $\log_{10}$ reductions in viable cell counts.

[6] "**Highly effective**" means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$] or greater inactivation of pathogens. "**Effective**" means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-$\log_{10}$] inactivation of pathogens. "**Minimally effective**" means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-$\log_{10}$] inactivation of pathogens. "**Not effective**" represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-$\log_{10}$] inactivation of pathogens. "**Unknown**" means unknown.

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness
Table: Treatment Process Performance Summary – CHLORINE DIOXIDE
NEW REFERENCE – needs new code

Disinfection – *Chlorine Dioxide* [Shams, A.M., O'Connell. H., Arduino, M.J., and Rose, L.J. 2011. Chlorine dioxide inactivation of bacterial threat agents. *Letters in Applied Microbiology,* 53(2):225-230.] NEW REFERENCE – needs new code.	
Drinking Water Treatment Performance [7]	Two strains of *F. tularensis* were inoculated (10^6 CFU/ml) into a ClO_2 solution with an initial concentration of 0.25 mg/L at pH 7 or 8 at 5 °C or 25 °C. At 0.25 mg/L in potable water, both strains were inactivated by at least three orders of magnitude within 10 min. These strains "would be inactivated by at least 3-log_{10} while still in the treatment plant under the temperature and pH conditions used in this study.
Study Conditions	Test solutions were prepared by adding an appropriate aliquot of concentrated ClO_2 stock solution to chlorine demand-free buffer (0.05 mol KH_2PO_4, adjusted to either pH 7 or 8 with 1 mol NaOH). ClO_2 test solutions (99 ml) were dispensed into three sterile amber glass flasks (250 ml) with glass stoppers. A positive control of 100 ml ClO_2 test solution and a negative control of 99 ml 0.05 mol KH2PO4 were prepared. All solutions were allowed to adjust to the required temperatures (5 °C or 25 °C) before testing began. Test solutions were inoculated by the addition of 1.0 ml of the bacterial suspension to each test flask and the negative control flask for a final test concentration of 10^6 CFU/ml.
Process Performance Considerations	These strains "would be inactivated by at least 3-log_{10} while still in the treatment plant under the temperature and pH conditions used in this study." Even with the efficacy reduced at 5 °C, the disinfectant was sufficiently effective…. FAC Ct values at pH 8 for *F. tularensis* LVS were previously tested under identical conditions as this study, and ClO_2 was found to be superior to FAC in efficacy against this strain. (FAC data from: O'Connell, H.A., Rose, L.J., Shams, A.M., Arduino, M.J., and Rice, E.W. 2011. Chlorine disinfection of *Francisella tularensis. Lett. Appl. Microbiol*. 52(1): 84-86. **NEW REFERENCE – needs new code**.)
Contaminant Byproducts	"Some disadvantages to the use of ClO_2 are the formation of the by-products chlorite and chlorate (maximum limit < 1.0 mg/L), a higher production cost than chlorine and the need for specialized equipment on site, and it can cause unpleasant odors in homes near the treatment plant."
Rating [8]	**Note: Needs to be assigned.**

[7] Decay curves were generated for each organism, temperature and pH tested using the log10-transformed data of the mean CFU counted at each sampling time. The time required to reduce viability of each organism by 2- and 3-log_{10} was estimated by linear regression of the appropriate segments of the decay curves. Because ClO_2 concentrations are expected to decline over the course of the experiment, the ClO_2 concentration at the time of a given log10 reduction was estimated by linear regression. The Ct values were calculated by multiplying the inactivation times by the estimated ClO_2 concentration at the specific inactivation time. Ct values for a 3-log10 reduction were compared using the Student's t-test and ⁄ or ANOVA with a significant $P \leq 0.05$.

[8] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-log_{10}] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-log_{10}] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-log_{10}] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-log_{10}] inactivation of pathogens. **"Unknown"** means unknown.

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness

Table: Treatment Process Performance Summary – MONOCHLORAMINE (recommend replacing current WCIT contents with the following information)

Disinfection – *Monochloramine* [Rose, L.J., Rice, E.W., Hodges, L., Peterson, A., and Arduino, M.J. 2007. Monochloramine Inactivation of Bacterial Select Agents. *Applied Environmental Microbiology*, 73(10): 3437-3439.] [9] AEM-22	
Drinking Water Treatment Performance	*F. tularensis* isolates demonstrated a 2-$\log_{10}$ inactivation at Ct values of 26.3 to 31.3 (at 25 °C) and a 3-$\log^{10}$ inactivation at Ct values of 30.4 to 37.1 (at 25 °C). *F. tularensis* can be reduced by 3-$\log_{10}$ within 45 min if the water temperature is 15 °C or higher and the pH is maintained at 8.
Study Conditions Summary	In the present bench scale study, …. strains of *F. tularensis* were exposed to preformed monochloramine, and Ct values were calculated for 2-$\log_{10}$ and 3-$\log_{10}$ inactivation. These studies were conducted at three temperatures representative of a range found within water distribution systems, 5 °C, 15 °C, and 25 °C at pH 8 for all temperatures. Decay curves were generated using the mean $\log_{10}$ of the CFU counts at each sample time. The time each organism was inactivated by 99.0% or 99.9% was determined by linear regression of the appropriate segment of the decay curve. Disinfectant concentrations at the times of interest were estimated by linear regression. The Ct values for each inactivation level and test temperature were then determined by multiplying the inactivation time by the estimated mono- chloramine concentration.
Process Performance Considerations	The American Water Works Association found the median time to the first point of use to be 45 min for the 283 distribution systems responding to a survey [Water Quality Disinfection Committee. 1992. Survey of water utility disinfection practices. *J. Am. Water Works Assoc.* 84(9): 1-128 **NEW REFERENCE – needs new code**] A second survey indicated that the median (and target) concentration was 2 mg/liter monochloramine at the average residence time in the responding distribution systems [Seidel, C.J., McGuire, M.J., Summers. R.S., and Via, S. 2005. Have utilities switched to chloramines? *J. Am. Water Works Assoc.* 97(10): 87-97 **NEW REFERENCE – needs new code**] … The study estimates that an organism with a 3-$\log_{10}$ Ct of 90 would be inactivated by 3 $\log_{10}$ before the median first point of use (45 min) if introduced early in the distribution system when the monochloramine concentration is at least 2 mg/liter. *F. tularensis* can be reduced by 3 $\log_{10}$ within 45 min if the water temperature is 15 °C or higher and the pH is maintained at 8.
Contaminant Byproducts	Monochloramine, though a less effective disinfectant than free chlorine, is being used increasingly as a secondary disinfectant because it is effective against microbial regrowth in the distribution systems and because of the tendency to form lower levels of the disinfection by-products (DBPs) closely regulated by the Disinfectants and Disinfection By-Product Rules. Fewer taste and odor complaints from consumers also make monochloramine use attractive. Disadvantages include problems with controlling excess ammonia to avoid nitrification and the need to control pH for better efficacy. Many treatment facilities have opted to use chloramines for residual disinfection and to alternate between FAC and monochloramine to control nitrification problems and biofilm formation, to boost disinfection efficacy, and to reduce DBPs.
Rating [10]	**Note: This needs to be assigned.**

[9] WCIT Reference "AEM-22" (Note that "Rose" is an incomplete citation for AEM-22 listed in master WCIT reference list. Recommend deleting it.)

[10] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$]) or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness
Table: Treatment Process Performance Summary – ULTRAVIOLET
NEW REFERENCE – needs new code

Disinfection – *Ultraviolet* [Rose, L.J. and O'Connell, H. 2009. UV Light Inactivation of Bacterial Biothreat Agents. *Applied and Environmental Microbiology,* 75(9):2987-2990.] NEW REFERENCE – needs new code	
Drinking Water Treatment Performance	The inactivation results for *F. tularensis* reflect findings similar to those of other waterborne pathogenic organisms, such as *Escherichia coli*, *Shigella sonnei*, *Yersinia enterocolitica*, and *Campylobacter jejuni* … UV irradiation was performed by using a collimated beam apparatus equipped with a low-pressure lamp (254 nm): The fluence (mJ/cm^2) for 3-log$_{10}$ inactivation for *F. tularensis* LVS was 4.8 and 6.6 for 4-log$_{10}$ inactivation. The fluence (mJ/cm^2) for 3-log$_{10}$ inactivation for *F. tularensis* NY98 was 6.3 and 8.7 for 4-log$_{10}$ inactivation.
Study Conditions Summary	Two *F. tularensis* strains were adjusted to 10^8 CFU/ml in Butterfield buffer (3 mM KH_2PO_4, at pH 7.2). … The suspensions were diluted 1:100 in Butterfield buffer for final test concentrations. Five milliliters of each suspension were placed into a small petri dish (50-mm diameter) along with a small sterile stir bar, and the petri dish was placed on a stir plate…. UV irradiation was performed by using a collimated beam apparatus equipped with a low-pressure lamp (254 nm). Each irradiation test was conducted at room temperature (23 ± 2 °C) in triplicate. After 10-fold serial dilutions, the suspensions were plated and counted at 3 to 5 days…. A linear regression of the fluence response data determined the fluence required for 2-, 3-, and 4-log$_{10}$ inactivation.
Process Performance Considerations	None discussed.
Contaminant Byproducts	None mentioned.
Rating [11]	**Note: This needs to be assigned.**

log$_{10}$]) inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-log$_{10}$]) inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-log$_{10}$]) inactivation of pathogens. **"Unknown"** means unknown.

[11] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-log$_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-log$_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-log$_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-log$_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness

Table: Disinfection Values – CHLORINE (recommend replacing current WCIT contents with the following because of incorrect [C mg/L] values in the current WCIT)

Disinfection Values - *Chlorine*

Inactivation (%)	CT Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference [12]
99.00	1.5	0.23	–	5	7	LVS – initial inoculum 7.0 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	2.4	0.23	–	5	7	LVS – initial inoculum 7.0 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	0.6	0.10	–	25	7	LVS – initial inoculum 6.8 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	1.0	0.10	–	25	7	LVS – initial inoculum 6.8 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	7.8	0.20	–	5	7	NY98 - initial inoculum 6.5 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	10.3 *extrapolated*	0.20	–	5	7	NY98 - initial inoculum 6.5 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	2.0	0.30	–	25	7	NY98 - initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	3.9	0.30	–	25	7	NY98 - initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.

[12] **This is JAEM2.**

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine*

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.00	13.4	0.70	–	5	7	Schu S4 – intial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	16.8	0.70	–	5	7	Schu S4 – intial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	20.3	0.70	–	5	7	Schu S4 – intial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	0.9	0.30	–	25	7	Schu S4 – intial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	1.3	0.30	–	25	7	Schu S4 – intial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	1.7	0.30	–	25	7	Schu S4 – intial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	47.4	1.67	–	5	8	Schu S4 – intial inoculum 6.4 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	62.3	1.67	–	5	8	Schu S4 – intial inoculum 6.4 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	77.2	1.67	–	5	8	Schu S4 – intial inoculum 6.4 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	3.7	0.47	–	25	8	Schu S4 – intial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	4.5	0.47	–	25	8	Schu S4 – intial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	5.2	0.47	–	25	8	Schu S4 – intial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	13.6	0.64	–	5	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	16.9	0.64	–	5	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	20.2	0.64	–	5	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	0.9	0.41	–	25	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	1.3	0.41	–	25	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	1.6	0.41	–	25	7	MA00-2987 – initial inoculum 6.7 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	64.1	1.80	–	5	8	MA00-2987 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	83.8	1.80	–	5	8	MA00-2987 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	103.4	1.80	–	5	8	MA00-2987 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	2.7	0.45	–	25	8	MA00-2987 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	3.4	0.45	–	25	8	MA00-2987 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	4.2	0.45	–	25	8	MA00-2987 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	14.4	0.96	–	5	7	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	17.7	0.96	–	5	7	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	21.0	0.96	–	5	7	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	0.4	0.16	–	25	7	NM99-1823 – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	0.5	0.16	–	25	7	NM99-1823 – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	0.7	0.16	–	25	7	NM99-1823 – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	45.4	1.22	–	5	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	60.5	1.22	–	5	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	75.7	1.22	–	5	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	2.9	0.39	–	25	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	3.7	0.39	–	25	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	4.5	0.39	–	25	8	NM99-1823 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	14.2	0.72	–	5	7	WY96-3418 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	17.4	0.72	–	5	7	WY96-3418 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	20.8	0.72	–	5	7	WY96-3418 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	0.8	0.33	–	25	7	WY96-3418 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	1.3	0.33	–	25	7	WY96-3418 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	1.6	0.33	–	25	7	WY96-3418 – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	46.8	1.75	–	5	8	WY96-3418 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	61.7	1.75	–	5	8	WY96-3418 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	76.2	1.75	–	5	8	WY96-3418 – initial inoculum 6.5 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	3.3	0.85	–	25	8	WY96-3418 – initial inoculum 6.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	4.1	0.85	–	25	8	WY96-3418 – initial inoculum 6.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	5.0	0.85	–	25	8	WY96-3418 – initial inoculum 6.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	9.3	0.90	–	5	7	OR96-0246 – initial inoculum 6.2 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	12.9	0.90	–	5	7	OR96-0246 – initial inoculum 6.2 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	16.5	0.90	–	5	7	OR96-0246 – initial inoculum 6.2 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	0.9	0.28	–	25	**7**	OR96-0246 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	1.2	0.28	–	25	7	OR96-0246 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	1.5	0.28	–	25	7	OR96-0246 – initial inoculum 6.9 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.00	47.1	1.76	–	5	8	OR96-0246 – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.90	59.0	1.76	–	5	8	OR96-0246 – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.
99.99	70.8	1.76	–	5	8	OR96-0246 – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol*. 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE

NEW REFERENCE – needs new code

Disinfection Values - *Chlorine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	3.2	0.36	–	25	8	KY99-3387 – initial inoculum 6.8 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.99	3.8	0.36	–	25	8	KY99-3387 – initial inoculum 6.8 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.00	5.0	0.82	–	5	7	LVS – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.90	6.7	0.82	–	5	7	LVS – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.99	8.5	0.82	–	5	7	LVS – initial inoculum 6.3 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.00	0.7	0.57	–	25	7	LVS – initial inoculum 6.8 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.90	1.0	0.57	–	25	7	LVS – initial inoculum 6.8 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.99	1.2	0.57	–	25	7	LVS – initial inoculum 6.8 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.00	15.9	0.97	–	5	8	LVS – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.90	20.1	0.97	–	5	8	LVS – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.99	24.3	0.97	–	5	8	LVS – initial inoculum 6.6 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.00	2.0	0.47	–	25	8	LVS – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.90	2.7	0.47	–	25	8	LVS – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.
99.99	3.5	0.47	–	25	8	LVS – initial inoculum 7.1 (log_{10} CFU)	O'Connell, H.A., Rose, L.J. et al. *Lett. Appl. Microbiol.* 52(1): 84-86.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**

Table: Disinfection Values – CHLORINE DIOXIDE

NEW REFERENCE – needs new code

Disinfection Values – *Chlorine Dioxide*

Inactivation (%)	Ct Value (mg-min/L)	ClO_2 mg/L	T (min)	Temp (°C)	pH	Notes Inoculum 10^6 CFU/ml	Reference
99.00	0.8	0.25	–	5	7	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	1.0	0.25	–	5	7	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.2	0.25	–	25	7	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	25	7	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	1.2	0.25	–	5	7	NY98	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	1.5	0.25	–	5	7	NY98	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.2	0.25	–	25	7	NY98	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	25	7	NY98	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.8	0.25	–	5	8	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	1.0	0.25	–	5	8	LVS	Shams, A.M., O'Connell, H. et al 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.1	0.25	–	25	8	LVS	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	25	8	LVS	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.9	0.25	–	5	8	NY98	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**
Table: Disinfection Values – CHLORINE DIOXIDE
NEW REFERENCE – needs new code

Disinfection Values – *Chlorine Dioxide*
continued

Inactivation (%)	Ct Value (mg-min/L)	ClO_2 mg/L	T (min)	Temp (°C)	pH	Notes Inoculum 10^6 CFU/ml	Reference
99.90	1.1	0.25	–	5	8	NY98	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.1	0.25	–	25	8	NY98	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	25	8	NY98	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness
Table: Disinfection Values – MONOCHLORAMINE [13]

Disinfection Values - *Monochloramine*

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference [14]
99.00	76.0	–	–	5	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	97.9	–	–	5	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	61.2	–	–	15	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	71.1	–	–	15	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	26.3	–	–	25	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	30.4	–	–	25	8	LVS	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	84.0	–	–	5	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.

[13] These data were not included in a "Disinfection Values" table in the current WCIT, although some information was included in the "Table: Treatment Process Performance Summary – Disinfection – Chloramine".
[14] WCIT Reference "AEM-22" (Note that "Rose" is an incomplete citation for AEM-22 listed in master WCIT reference list. Recommend deleting it.)

FRANCISELLA TULARENSIS - Drinking Water Treatment Effectiveness
Table: Disinfection Values – MONOCHLORAMINE [15]

Disinfection Values – *Monochloramine* continued

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference
99.90	116.0	–	–	5	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	48.7	–	–	15	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	64.8	–	–	15	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	31.3	–	–	25	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	37.1	–	–	25	8	NY98	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.

[15] These data were not included in a "Disinfection Values" table in the current WCIT, although some information was included in the "Table: Treatment Process Performance Summary – Disinfection – Chloramine".

***FRANCISELLA TULARENSIS* - Drinking Water Treatment Effectiveness**
Table: Disinfection Values – ULTRAVIOLET
NEW REFERENCE – needs new code

Disinfection Values - *Ultraviolet*

Inactivation (%)	Fluence (mJ/cm^2)	C (mg/L)	T (min)	Temp (°C)	pH	Notes Inoculum 10^8 CFU/ml	Reference
99.90	4.8	–	–	–	7.2	LVS	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.99	6.6	–	–	–	7.2	LVS	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.90	6.3	–	–	–	7.2	NY98	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.99	8.7	–	–	–	7.2	NY98	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.

Francisella tularensis: New References (Need Codes)

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Rose, L.J. and O'Connell, H. 2009. UV Light Inactivation of Bacterial Biothreat Agents. *Applied and Environmental Microbiology,* 75(9):2987-2990.

[16] This particular reference is sometimes incorrectly cited as the *American Journal of Epidemiology,* which it became in 1965.

Francisella tularensis: New References (Need Codes) continued

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