Summary of Wastewater Chlorine Reduction Efforts in RI Since Meeting Secondary Treatment Standards

RIDEM Office of Water Resources

Background: In 1984, Rhode Island was delegated authority by the Environmental Protection Agency to implement the National Pollutant Discharge Elimination System (NPDES) (known as RIPDES in RI). The RIPDES program responsibilities includes developing, tracking compliance, and enforcing permit limitations that apply to municipal and industrial wastewaters, storm water and combined sewer overflows discharged directly into the waters of the State as well to industrial wastewaters discharged into publicly owned treatment facilities (Pretreatment Program). This document describes significant reductions in chlorine discharge from municipal wastewater treatment facilities (WWTF) in RI. Additional information regarding WWTF construction is available in the DEM document, History of Rhode Island Wastewater Treatment Facility Construction & Upgrades (RIDEM 2016). http://www.dem.ri.gov/programs/benviron/water/permits/wtf/pdfs/conuphis.pdf

Total Residual Chlorine (TRC) Chlorine is toxic to aquatic life and combines with organic matter to form toxic compounds. DEM has adopted the Environmental Protection Agency's TRC criteria that were developed to protect aquatic life based on toxicity testing. Accordingly, and beginning more than 20 years ago, WWTFs in RI were required to achieve chlorine discharge limits that protect aquatic life from the toxic effects of chlorine. For WWTFs that discharge to tidal waters, the discharge limits are based on meeting the water quality criteria at the edge of acute and chronic mixing zones near the point of the discharge (determined from dye studies or computer modeling). For discharges to freshwater rivers, the criteria must be met at the lowest seven consecutive day river flow expected to happen once every ten years (7Q10 flow). By September 1999 many municipal wastewater treatment facilities in RI (12 of 19) achieved a significant reduction in the amount of chlorine used and total residual chlorine (TRC) **The total amount of chlorine released from RI WWTFs in 2015 was 23 lbs./day (including CSOs captured in the NBC tunnel that receive full treatment at the WWTF), a 94% reduction from what was released in 2000. The current discharge of chlorine from WWTF represents less than one-tenth of the permitted levels (i.e., the levels that will not cause adverse impacts to aquatic organisms).** Reduction at most WWTFs was achieved by improving the chlorine addition methods to minimize the amount of chlorine used, adding sodium bisulfite to neutralize the toxic effects and reduce TRC (i.e., de-chlorination), or by switching to ultraviolet light (UV) disinfection. Three RI WWTFs eliminated the use of chlorine all together by switching to the use of UV light to disinfect their wastewaters (one of these, the NBC Bucklin Point WWTF continues to use chlorination/dechlorination at their combined sewer overflow (CSO) wet weather treatment facility).

Each WWTF completed a Facilities Plan which evaluated the cost and effectiveness of alternatives for compliance with reduced chlorine discharge limits and selected a preferred alternative. DEM approves the selected alternative provided the Facilities Plan followed proper engineering procedures. For example, in 2014 Newport decided to upgrade their existing chlorination/dechlorination system after determining that doing so would involve construction costs of $1,500,000 with annual O&M cost of $120,000 versus UV construction cost of $6,300,000 with annual O&M cost of $340,000.

Magnitude of Chlorine Reductions at RI WWTF – Since the early 2000s, the harmful effects of total residual chlorine (TRC) have been eliminated from every wastewater treatment facility (WWTF) in Rhode Island as a result of discharge limits established to protect aquatic life. **By 2001, an 85% reduction in the total amount of TRC released from all RI WWTFs, as compared to 1997 levels, was achieved (200 lbs./day in 2001 versus 1,340 lbs./day in 1997).** By 2003 the magnitude of chlorine

reduction increased to a 95 % reduction and has remained between 96% and 98% since. **In 2016 only 20.2 lbs./day was discharged, less than one-tenth of the permitted levels (i.e., the levels that will not cause adverse impacts to aquatic organisms)**. **Between January 2005 and December 2016, the monthly average TRC limit compliance rate for all RI WWTFs was 99.9%. These reduced TRC discharge rates continue today.** Completion of Phase I of the CSO tunnel (in November 2007) and Phase II (in December 2014) have substantially reduced chlorinated discharges from the Fields Point wet weather facility. In Newport, discharges from the Wellington Avenue CSO Facility were nearly eliminated after June 30, 2017, and the Washington Street CSO facility completed installation of dechlorination in June 2016. Through improvements in wastewater treatment processing and CSO stormwater capture, the amount of chlorine discharged from RI WWTF today is less than 2% of that discharged prior to the year 2000 (Figure 1).

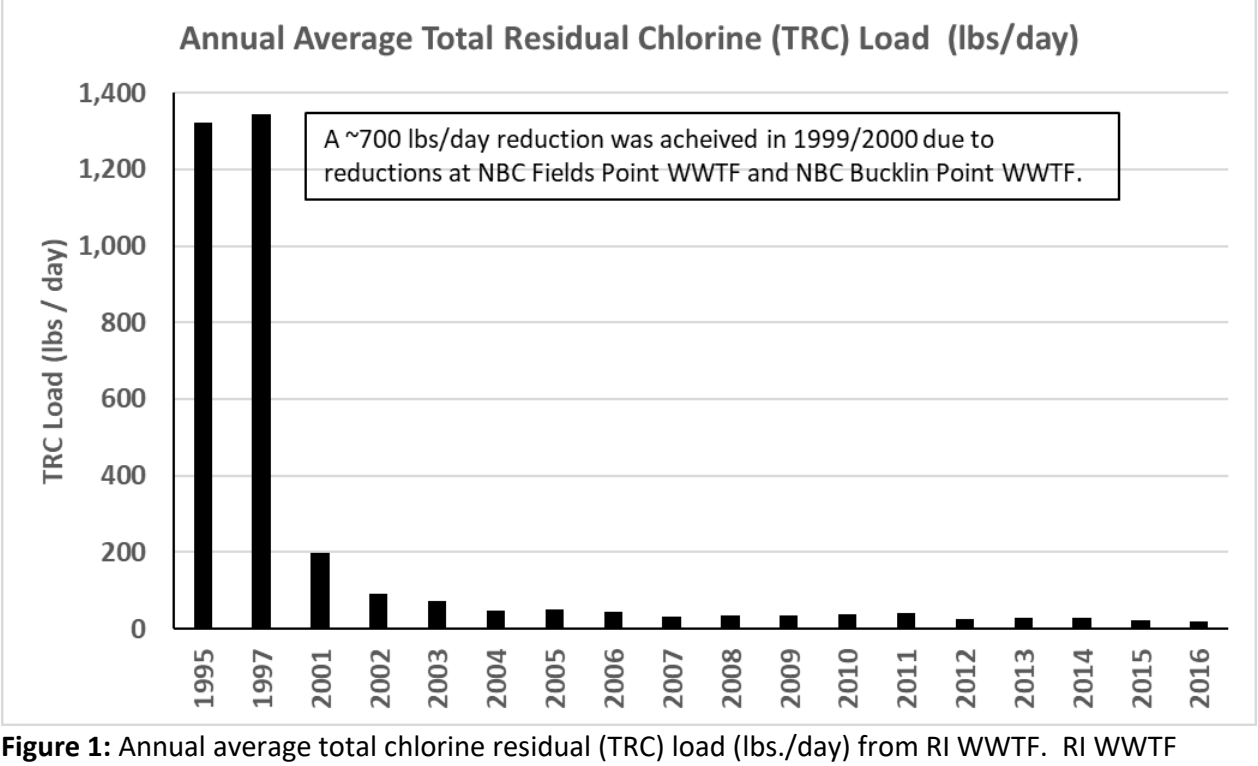

Figure 1: Annual average total chlorine residual (TRC) load (lbs./day) from RI WWTF. RI WWTF included in total: Bristol, Burrilville, East Greenwich, East Providence, Jamestown, NBC Bucklin Point, NBC Fields Point, New Shoreham, Quonset, Scarborough, Smithfield, South Kingstown, Cranston, Warren, Warwick, Westerly, West Warwick, Woonsocket.

Effluent Toxicity Testing – Since 1990 RI WWTFs have been required to test the toxicity of treated effluent by exposing aquatic organisms to samples of their discharge to determine if there are any acute or chronic effects. This technique is referred to as a bioassay test, a standard method to check whether chemicals not measured in the discharge (e.g., personal care products or pharmaceuticals) or combinations of chemicals are more toxic than the aquatic life criteria suggest. **Prior to 2003 samples collected from chlorinated effluent would need to be diluted 100 times to eliminate acute effects while dechlorinated samples show no acute effects or chronic effects**. **These impacts were eliminated more than 20 years ago. For example, from October 2014 - June 2017, RI WWTFs achieved 93% compliance with the requirement for no chronic (i.e., sub-lethal) effects beyond the mixing zone. Of the 9 violations, 6 are from one WWTF and have been traced to an industrial wastewater discharge to the WWTF.**

Dechlorination Process: Chlorination of wastewater results in the formation of hypochlorous acid, hypochlorite ion, chloramines. These combined forms of chlorine plus any free chlorine are collectively known as Total Residual Chlorine (TRC). When discharged into salt water, similar bromide compounds are formed, collectively referred to as Chlorine Produced Oxidants. The 16 RI WWTFs that dechlorinate use sodium bisulfite to neutralize the chlorine and reduce and prevent the formation of chlorinated compounds (Fam and Stenstom, 1988; USEPA, 2000). This reaction results in the formation of small amounts of sulfate and acidity (that is neutralized by the WWTF). If sodium bisulfite is added in excess, it can reduce dissolved oxygen. A concern has been voiced regarding the discharge of sulfate from the dechlorinating process. Based on a literature review the only potential concerns are the formation of small amounts of acidity that are neutralized by the wastewater and reduced dissolved oxygen if sodium bisulfite is added in excess. **The concentration of sulfate naturally occurring in seawater is 1,000 times higher than in that in wastewater effluent dechlorinated after dosing with a TRC concentration of 2 mg/l.**

As indicated above, WWTFs are required to perform whole effluent toxicity testing (WET) or bioassay tests where aquatic organisms are exposed to samples of the discharge to determine if there are any lethal (acute) or reproductive/sub lethal (chronic) effects. All testing required by a RIPDES permit, including WET, must be conducted using EPA approved methods found in 40CFR Part 136. Per EPA's Report to Congress on the Availability, Adequacy, and Comparability of Testing Procedures (USEPA, 1988; 2000), prior to adoption EPA validates the: accuracy, precision, dynamic range, detection limits, interferences, ruggedness (applicability), reporting, and representativeness/method comparability. The organisms that EPA approved for acute and chronic toxicity testing were selected since they are easily cultured in the laboratory, are sensitive to a variety of pollutants and are generally available throughout the year from commercial sources (EPA 1993).

The approved estuarine and marine whole effluent toxicity test methodologies were developed by the EPA Environmental Research Laboratory in Narragansett, RI (EPA 2002). All the approved organisms are native to RI marine and estuarine waters, including the chronic toxicity test for Sea urchin, *Arbacia punctulata*, fertilization test. This test determines whether the test substance (i.e., WWTF effluent) causes a reduction in fertilization. **Tests performed on RI WWTFs document that, as expected, chlorinated effluent was highly toxic but after implementation of dechlorination (i.e., by 2003) little to no toxic effects have been observed.** In the early 90s WET testing was conducted on wastewater prior to and after chlorination on both an invertebrate and a fish. Samples tested after chlorination were consistently more toxic than prior to chlorination. Once WWTFs achieved compliance with their TRC limit i.e., after dechlorination, acute and chronic bioassay testing has been done on samples collected from the final discharge. This testing conducted since 2003 has confirmed earlier results that samples collected after dechlorination are far less toxic that chlorinated samples. For example, of the 122 data points collected between October 2014 and June 2017, 113, or 93% of the samples, showed no in-stream toxicity beyond the mixing zone (i.e., the chronic test results complied with the chronic toxicity permit limits). Additionally, 93 data points, or 76% of the samples, showed no toxicity in the undiluted effluent itself (i.e., the chronic test result was 100%, indicating that there were no adverse effects in 100% effluent). Of the 9, violations 6 are from one WWTF and have been traced to an industrial wastewater discharge to the WWTF. This data indicates that dechlorinated effluent does not cause adverse toxic impacts. Further Details Regarding Chlorine, Dechlorination and Bioassay Testing are presented in in the RIDEM document RI Municipal WWTF Total Residual Chlorine Limits History and Status (RIDEM 2017).

Literature Cited:

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