

Chloroform Formation from Swimming Pool Disinfection: A Significant Source of Atmospheric Chloroform in Phoenix?



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Introduction

Chloroform (CHCl₃) is a well-documented disinfectant by-product (DBP) of water chlorination. Chloroform is an important atmospheric pollutant by its direct health effects as well as by its contribution to photochemical smog formation.¹ Chloroform outgassing from swimming pools is not typically considered a source of atmospheric chloroform because swimming pools are scarce compared to other sources. However, urban areas in hot climates such as Phoenix generally contain a substantial amount of swimming pools per capita,² potentially resulting in significant atmospheric fluxes. In this study, swimming pools as a source of atmospheric chloroform is investigated. Measurements of chloroform concentrations are used to estimate fluxes and determine impacts on Phoenix air pollution.

Chlorination of Swimming Pool Water

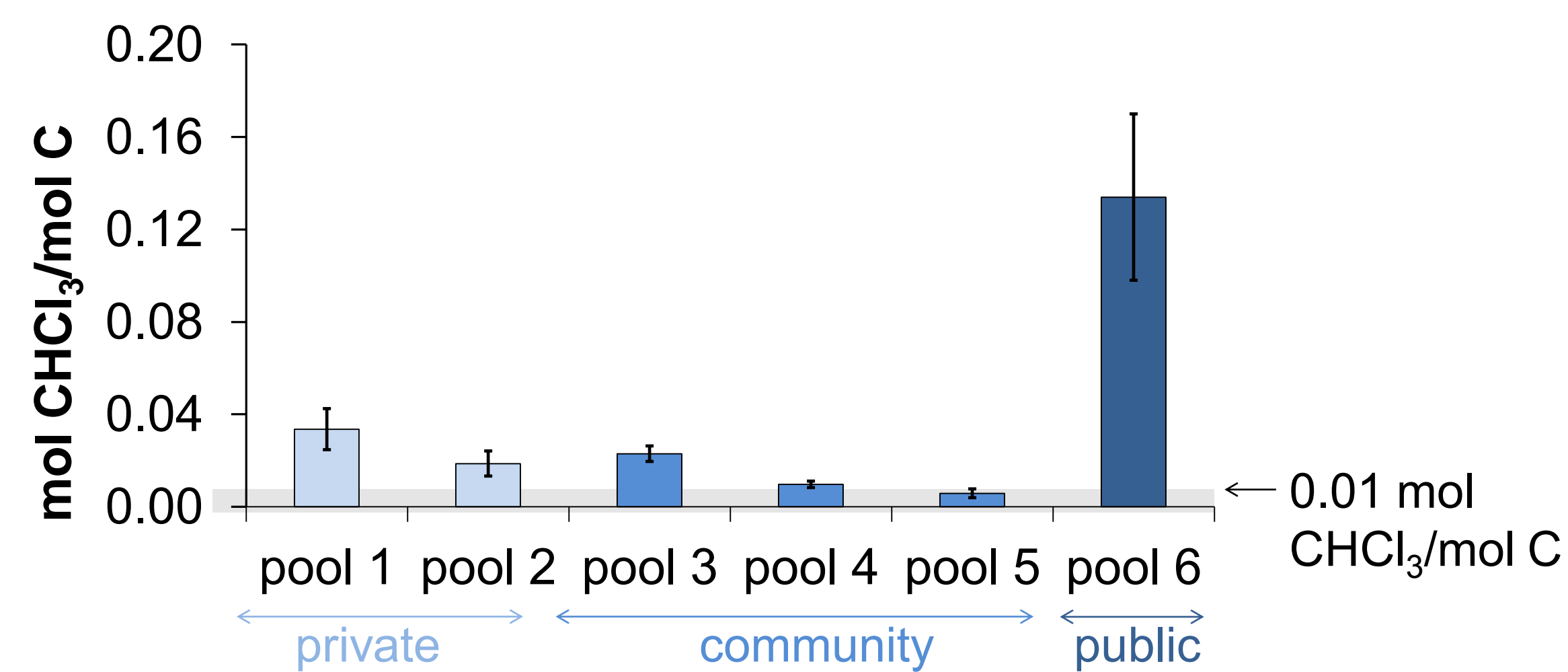


Figure 3: CHCl₃ yield per mol C after chlorination of pool water. Shaded region indicates 0.01 mol CHCl₃/mol C as measured by Lee et al. (2007).

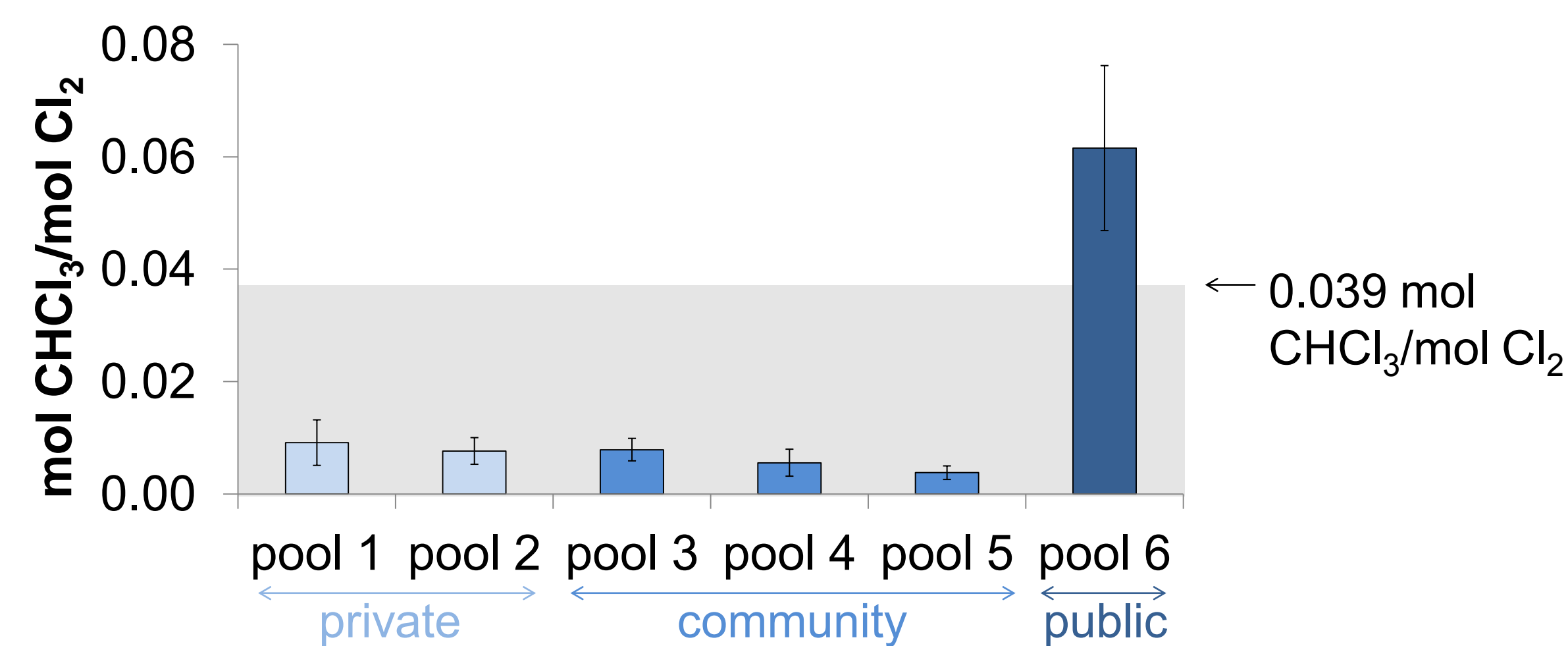


Figure 4: CHCl₃ yield per mol Cl₂ consumed after chlorination of pool water. Shaded region indicates 0.039 mol CHCl₃/mol Cl₂ as measured by Weng and Blatchley (2011).

Implications

Flux estimate yields 4 Gg CHCl₃/yr from swimming pools in Phoenix. This number is much larger than previous estimates and suggests that chlorination of swimming pools might be a significant source of CHCl₃ in Phoenix.

Other sources of CHCl₃ in Phoenix?

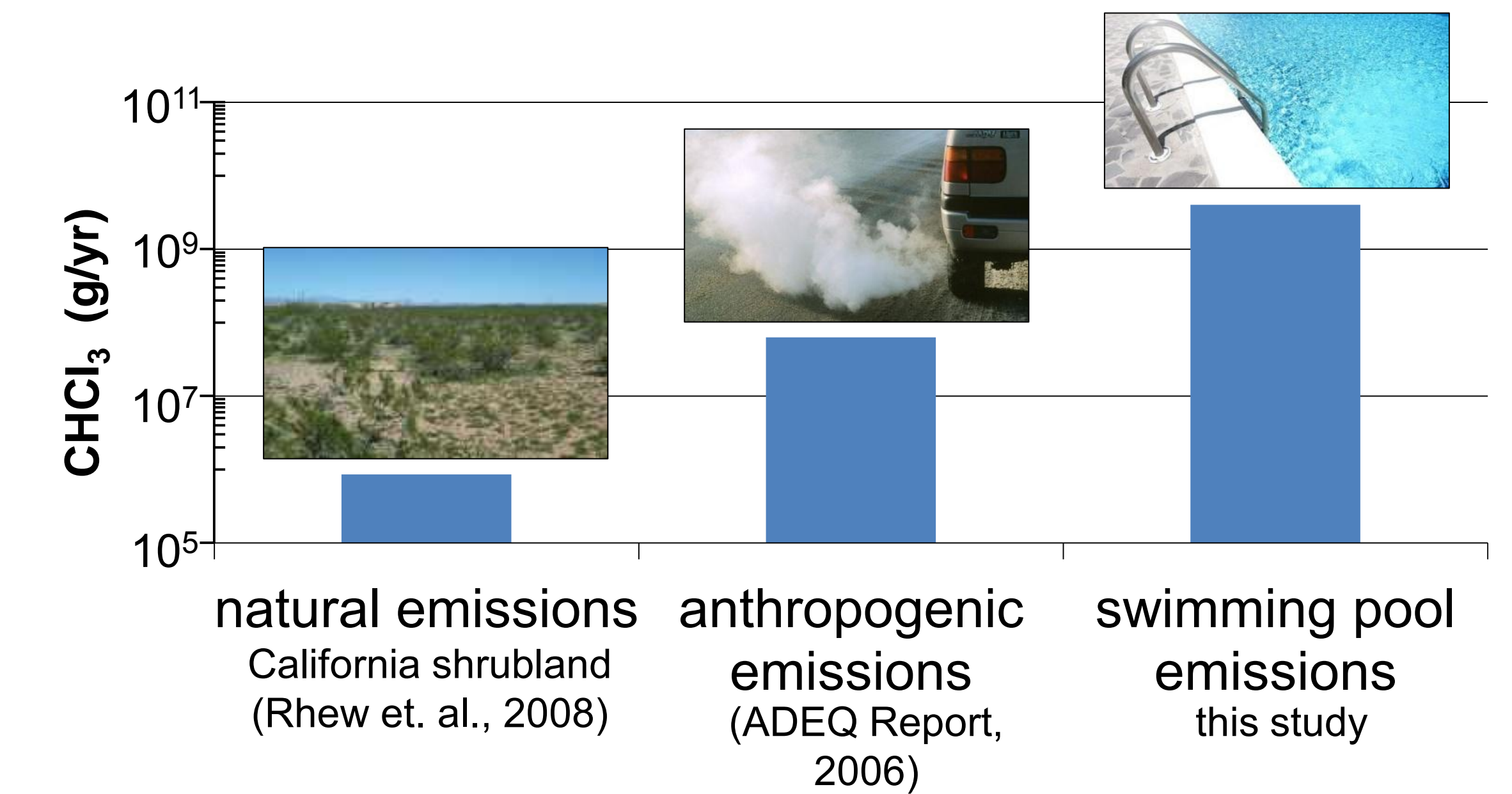


Figure 6: Phoenix CHCl₃ emission estimates

Chloroform at the National Level

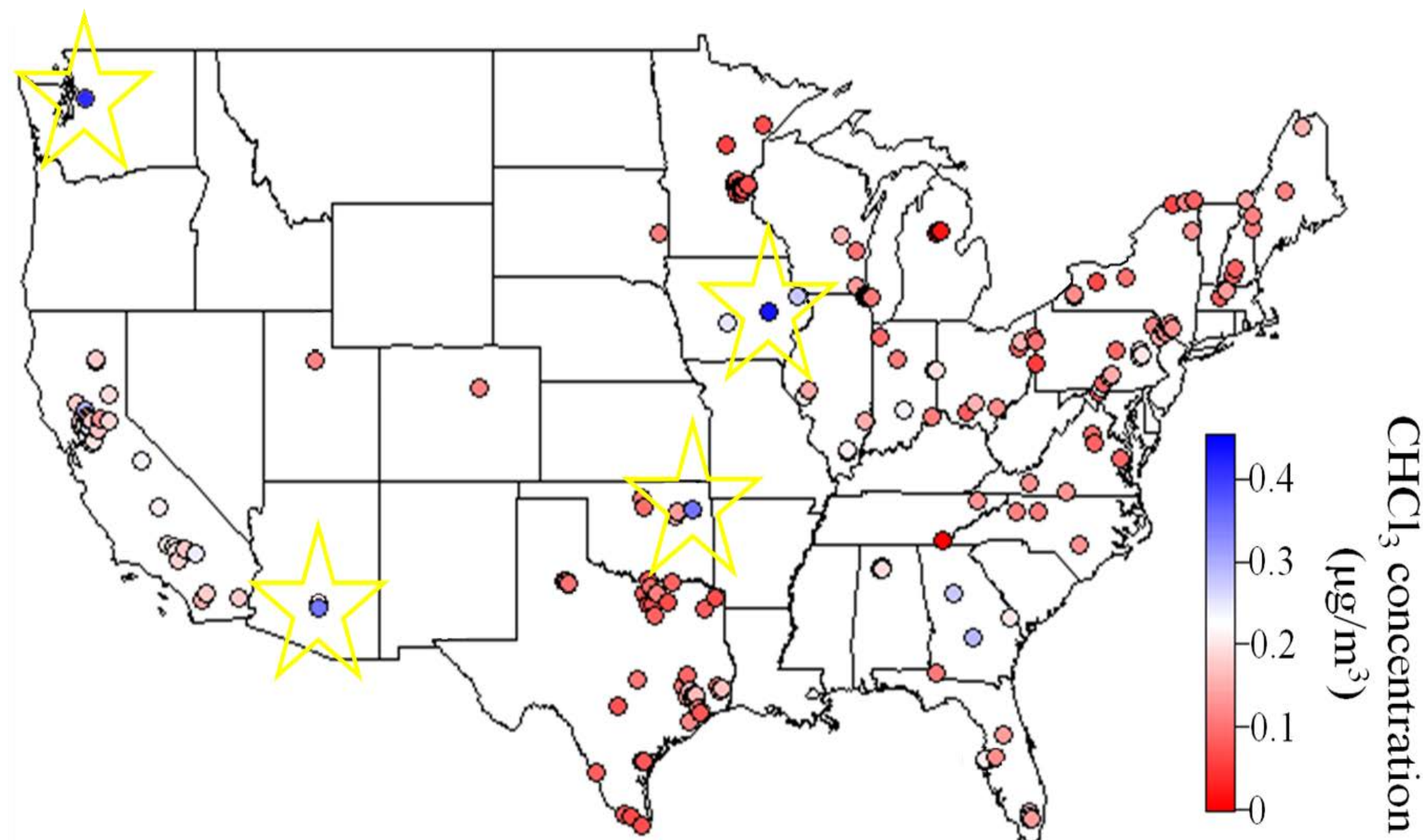


Figure 1: 2012 Average Annual Ambient CHCl₃ concentrations⁵

What causes the CHCl₃?

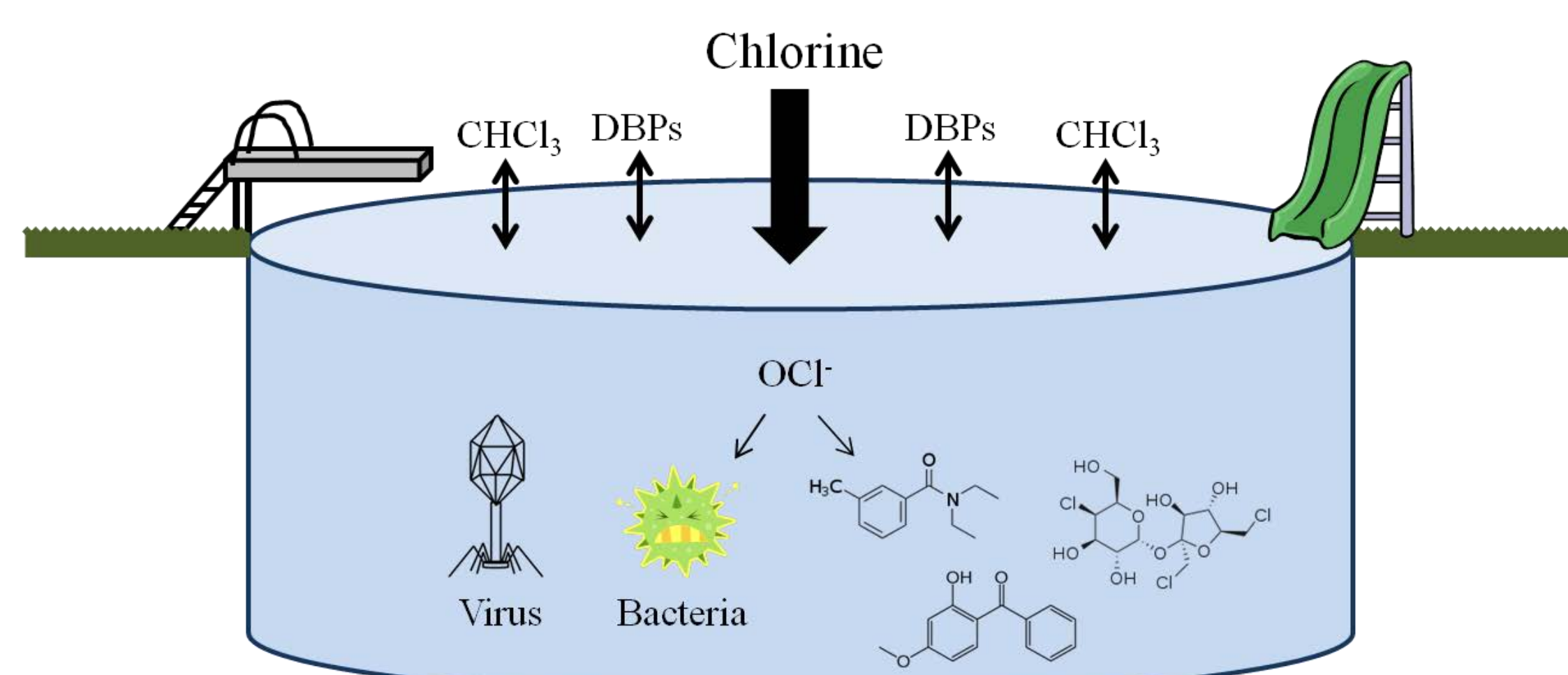


Figure 2: Illustration of chemistry occurring in swimming pool water⁴

Chloroform Flux From Pools in Phoenix

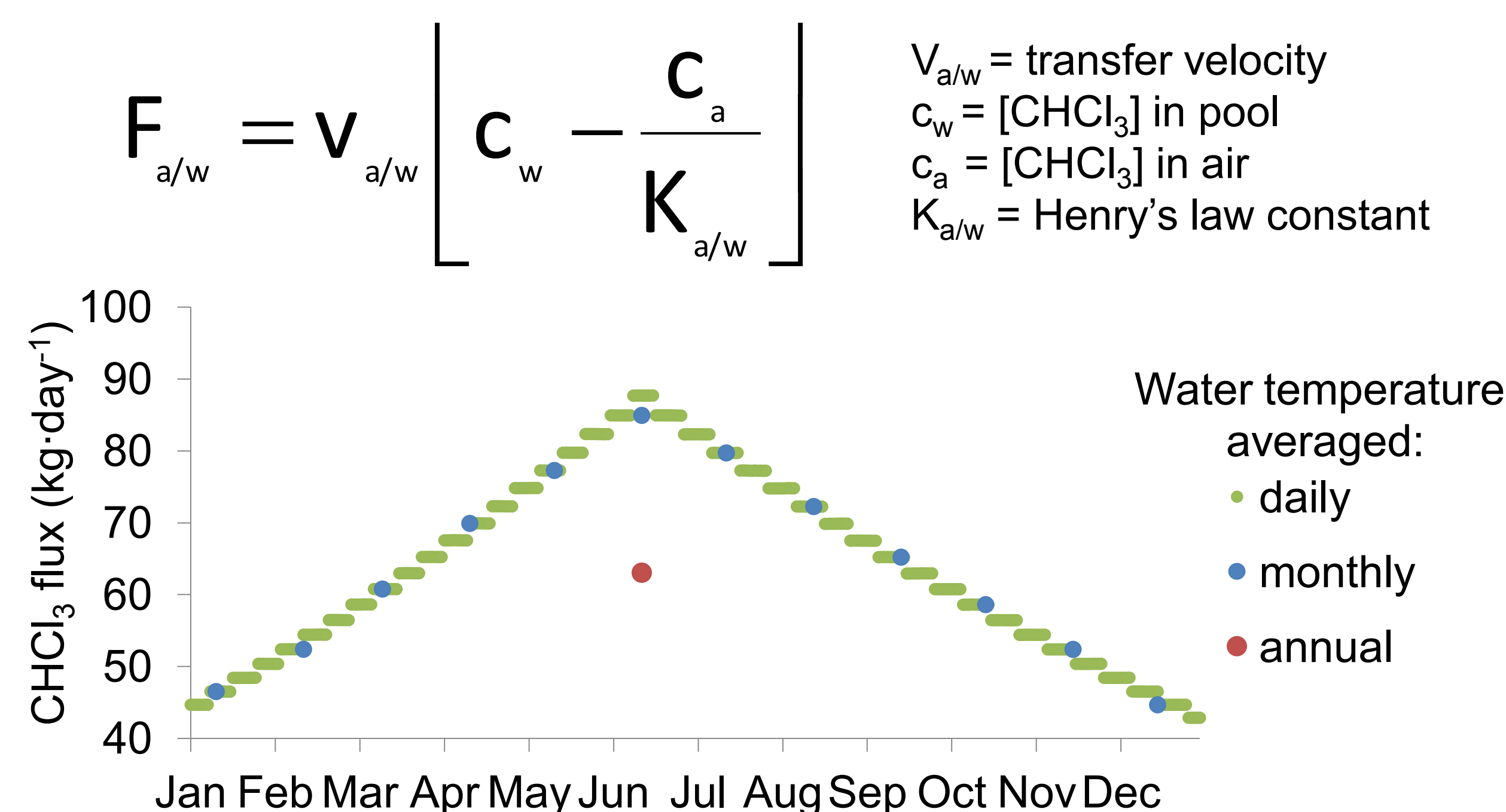
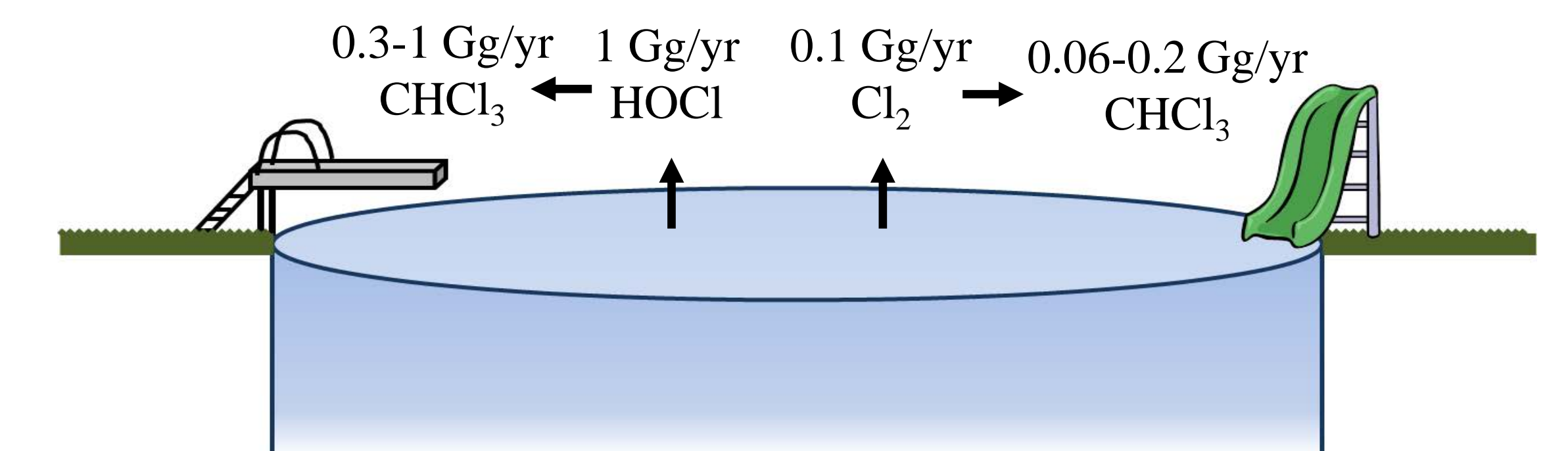


Figure 5: Phoenix CHCl₃ emission estimates when varying water temperature between 8 °C (winter) and 28 °C (summer)

Future work

- Measure CHCl₃ outgassing from pools for comparison
- Is CHCl₃ being produced in the atmosphere after outgassing of HOCl and Cl₂ from pools? Estimates from previous flux measurements suggest significant outgassing of HOCl and Cl₂. (Chang et al., 2001)



References

- ¹Richardson, S.D.; DeMarini, D.M.; Kogevinas, M.; Fernandez, P.; Marco, E.; Lourencetti, C.; Ballesté, C.; Heederik, D.; Meliefste, K.; McKague, A. B.; Marcos, R.; Font-Ribera, L.; Grimalt, J.O.; Villaneuva, C.M. (2010) What's in the Pool? A Comprehensive Identification of Disinfection By-products and Assessment of Mutagenicity of Chlorinated and Brominated Swimming Pool Water, 118, 1523-1530.
²P.K. Data, Inc. U.S. Swimming Pool and Hot Tub Market 2013. Retrieved Jan. 14, 2014 from <http://www.apsp.org/ResearchResources/content.cfm?ItemNumber=1028&navItemNumber=1083>
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⁴Forrest, N., and Williams, E. (2010) Life Cycle Environmental Implications of Residential Swimming Pools, Environmental Science and Technology, 44, 5601-5607.