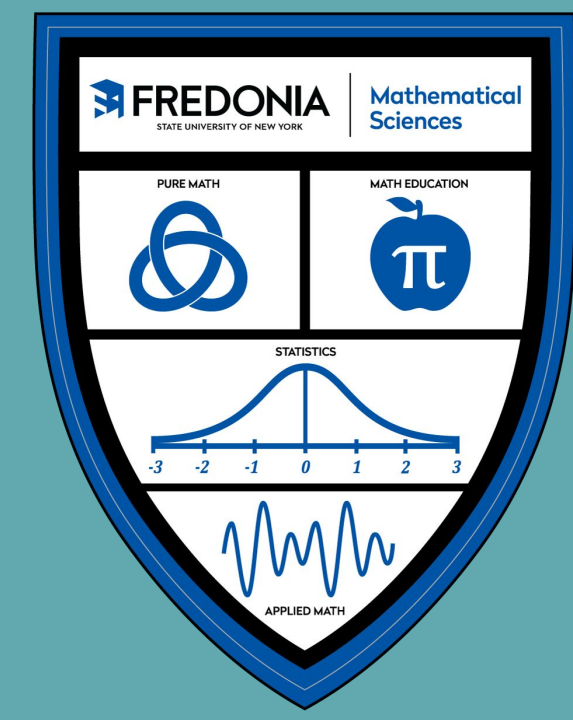
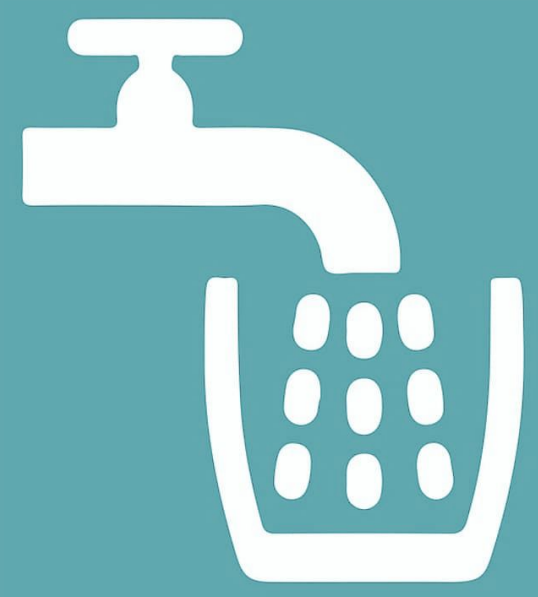


Should Every Drop Count? - An Investigation into the Fredonia Water Billing System



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Abstract

This research project focuses on analyzing the sewage charge to residents in the Village of Fredonia. Currently, the sewer is billed solely by the amount of water used, which some residents consider to be unfair due to summer water activities (watering lawns/gardens, washing cars, etc.). The objective of this study is to develop a more fair billing method for sewer charges. To achieve this, we analyzed quarterly water usage data spanning two decades from more than a dozen houses over different seasons and compared it to various characteristics of the homes, such as size and number of rooms. Based on our analysis and research we proposed several strategies that can improve the water billing system for residents in Fredonia.

Introduction

In the Village of Fredonia, the sewer is billed solely on the water usage. Currently, the quarterly sewer charge includes a base rate of \$20, and then \$6.47 for each additional thousand gallons of water used. For example, $10 \times \$6.47 + \$20 = \$84.70$ will be charged for the current quarter if a customer uses 10 thousand gallons of water. This is a common issue with sewer billing systems that rely solely on water usage as an indicator of sewer usage. During the summer months, there is often a higher demand for outdoor water usage, such as watering lawns and gardens or filling swimming pools, which does not necessarily contribute to an increase in sewer usage. As a result, residents may be overcharged for their sewer usage during these months. In this project we studied water usage from 14 selected households and suggested a new sewer billing system.



Figure 1. Water usage history (in thousands of gallons) for House 903 from the years 2000 to 2022 indicating a decrease in water usage.

Existing Sewer Billing Systems

E-meter

Typically e-meters are used to measure outdoor water usage, like lawn irrigation or garden watering. In Dinwiddie County, sewer is first billed for all water used. Customers can choose to install an e-meter if they use a significant amount of water to water their lawn or gardens. The e-meter and main water meter will be read at the same time. Customers with the e-meter installed will be given the credit on the sewer of all the water read by the e-meter.

Cap Model

Cap, an upper limit sewer charge, is based on the water usage in the winter months. For example, in Tallahassee, Florida your protective 'upper limit' sewer charge is set at your highest water usage level on bills dated December, January, February, and March. This benefits the homeowner, as they would on average pay less, but also encourages them to use less water in the winter. However, it is important for utilities to ensure that the winter usage accurately reflects typical water usage patterns for each customer. If a customer's winter water usage is unusually high due to leaks or other issues, setting the sewer usage cap based on that usage could result in them being charged unfairly for excess sewer usage during the summer. Instead, in other areas the water used over these months is averaged to determine the sewer cap.

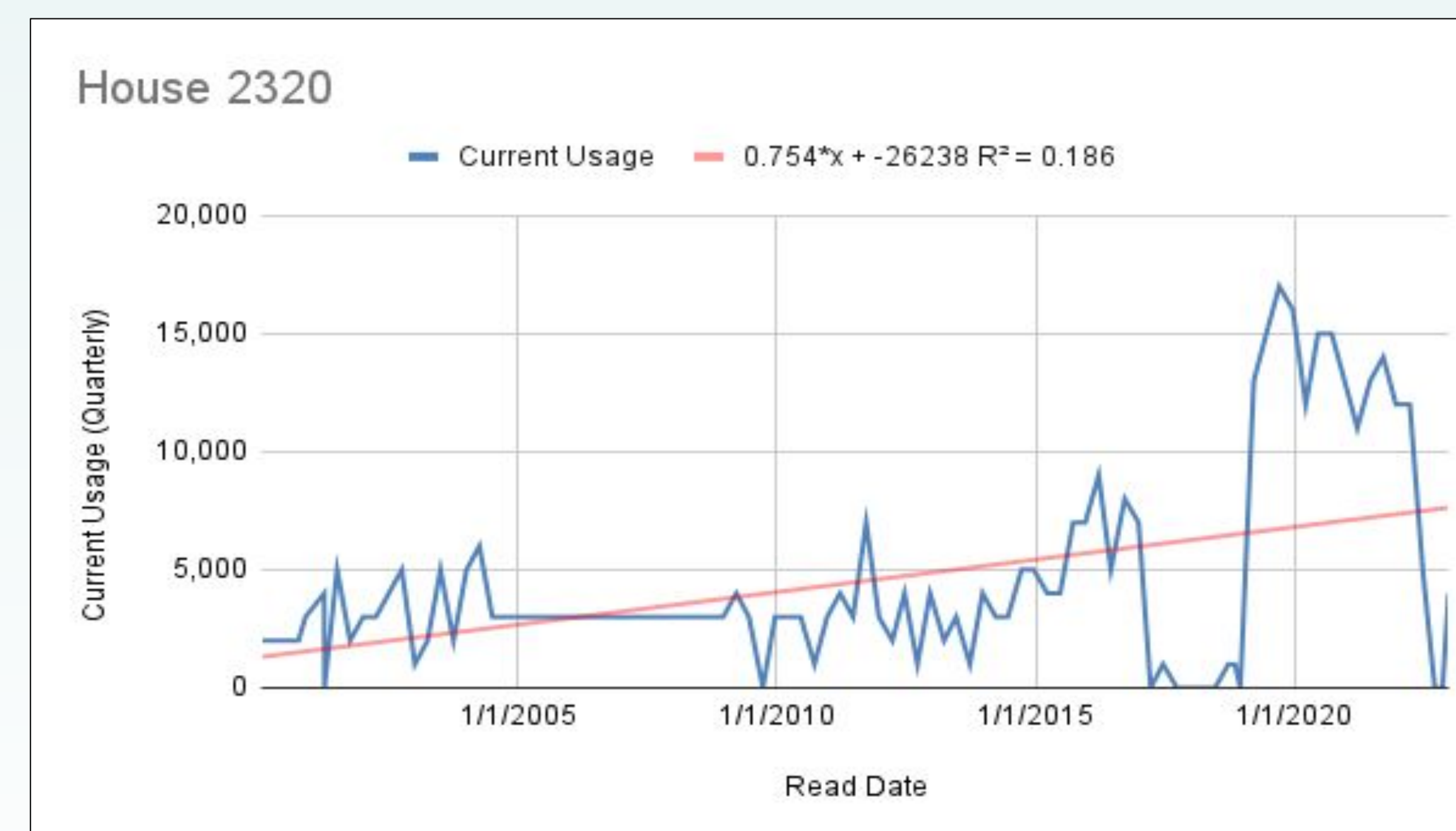


Figure 2. Water usage history for House 2320 (in thousands of gallons) from the years 2000 to 2022 indicating an increase in water usage due to different owners.

Proposed Sewer Billing System for Village of Fredonia

E-meter

E-meter can be easily adopted by Fredonia. Residents can choose to install the e-meter if they normally use lots of outdoor water, either used to water the garden or lawn, or other purposes. In 2019, it cost \$275 to install the e-meter. The current price and cost of installation would need to be further investigated.

Cap Model

Installing an e-meter will provide the most accurate reading; however, the cost is expensive and it involves a lot of infrastructure and maintenance for the government. The cap model is an easy and relatively reasonable way to solve the problem. Based on our data analysis we propose to use the average of the last two quarterly readings on February, March, or April as the cap and use the following formula to bill the water:

$$C_t = 4.80y + 6.17[\min(x,y)] + 45$$

where C_t describes the water total charge, x is the sewer cap, and y is the current water usage (thousands of gallons).

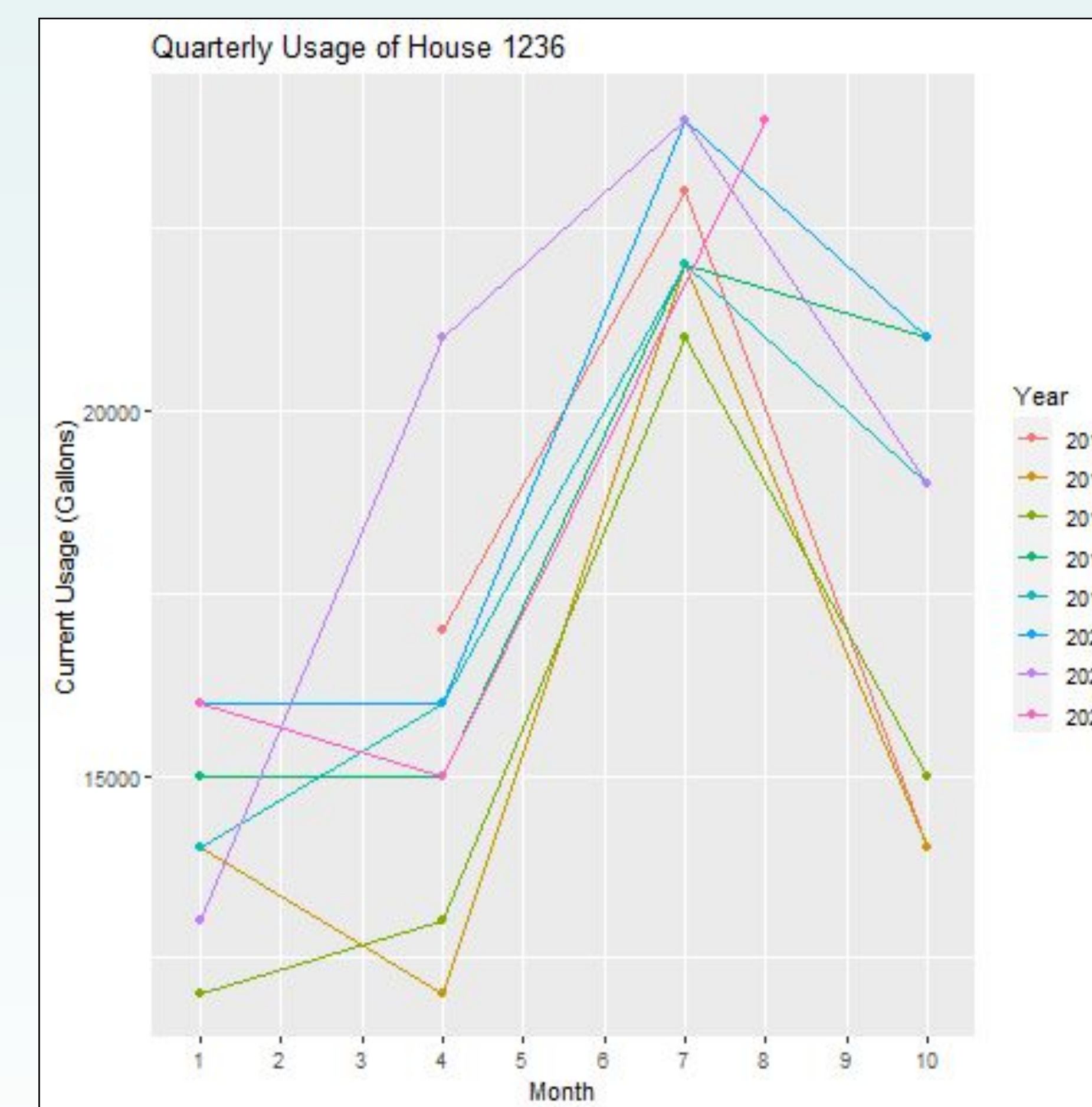


Figure 3. Water usage plot (in gallons) of House 1236 in Fredonia, NY from the years 2015 to 2022 (where January = 1, ..., December = 12).

Future Work and Limitations

- Only limited knowledge of these houses was provided by Zillow. No information of lawn watering tendencies, number of residents, or the amount of time residents stayed at home.
- We only had access to 14 houses water data. More accurate results can be obtained if we have more time to analyze water usage data.
- Our model can be improved with a better understanding of how water works, if we had time to analyze more data. It could benefit both the residents and the city more effectively.
- More models can be introduced with more research.
- With the cap model the village may not have enough money to cover their sewer expense. We could reinvestigate the cap model and evaluate the coefficient of the water charge formula if we have more information about sewer expense for the village.

Acknowledgements

Thank you to Dr. Lan Cheng for her continued support with the project and to the Village of Fredonia for working with the SUNY Fredonia Department of Mathematical Sciences. We greatly appreciate and value the knowledge and education we have received and attribute the success of this report to both parties.

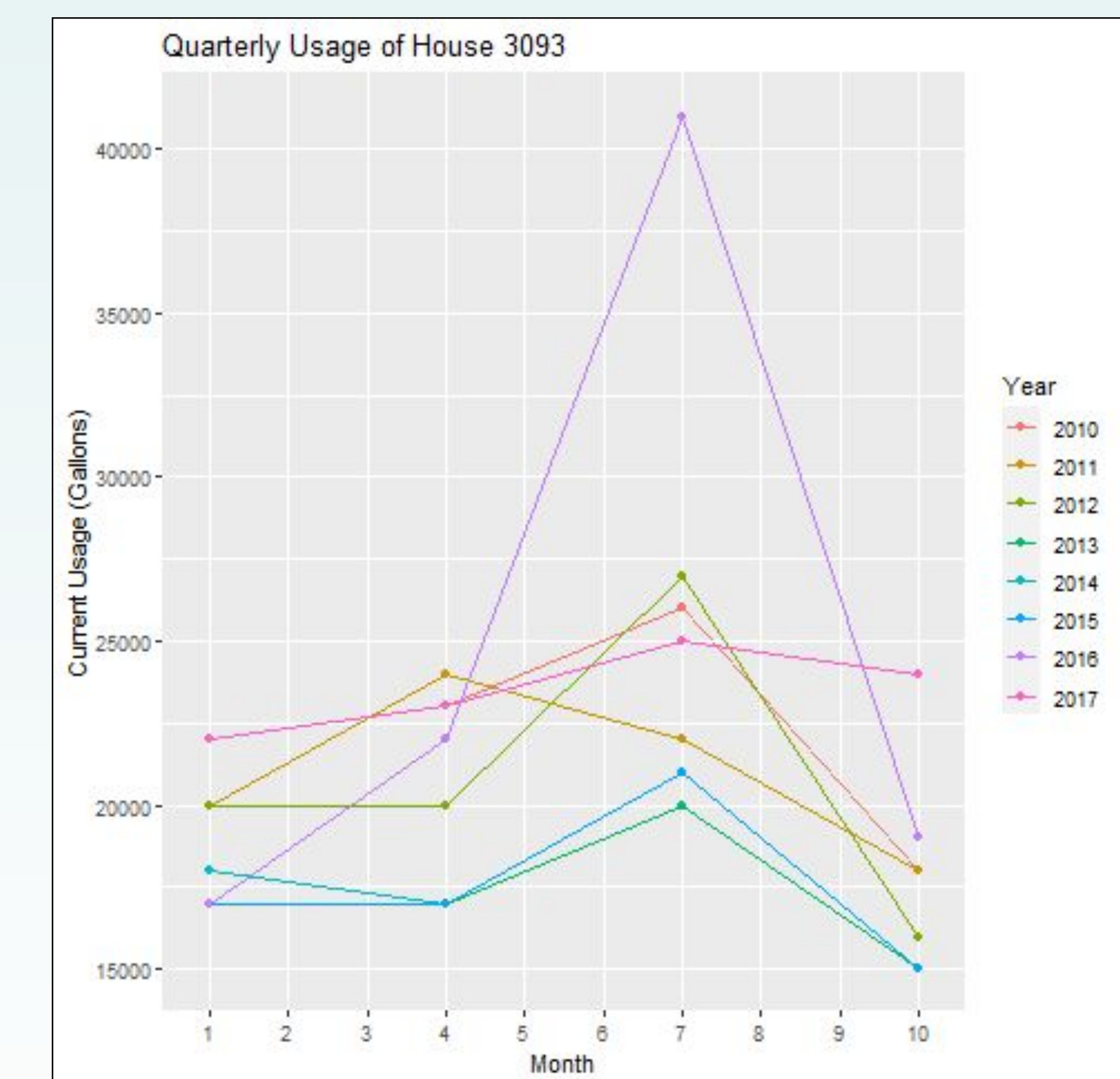


Figure 4. Water usage plot (in gallons) of House 3093 in Fredonia, NY from the years 2010 to 2017 (where January = 1, ..., December = 12).