The Effects of Source Water Protection Grants:
Evidence from the Minnesota Clean Water Fund

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ABSTRACT
Protecting drinking water sources is a growing challenge in the U.S. as local communities struggle to finance measures needed to comply with Safe Drinking Water Act standards. In November 2008, Minnesota voters approved an increase in the state's sales tax to fund the Clean Water, Land and Legacy Amendment. The Clean Water Fund (CWF) is one component of this program and provides funding to protect drinking water sources. This paper examines the impacts of CWF source water protection grants on drinking water outcomes. Leveraging the water violation records of hundreds of community water systems (CWSs) in Minnesota, we employ panel data and event study research designs to study the impact of these grants on violations. We find evidence that water systems incur less health-based violations after they receive a grant.

KEYWORDS
Source Water Protection; Drinking Water Policy; Clean Water Fund
JEL Codes: H23, H70, Q50

1 INTRODUCTION

On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment to the state's constitution. Since 2010, the programs funded by this amendment have allocated nearly 1$B for Clean Water Fund (CWF) initiatives to protect, enhance, and restore water quality in lakes, rivers, streams, and groundwater. A significant share of these funds target the protection of drinking water sources.

We explore three main research questions. First, we study the CWF grants' impact on drinking water quality violations at community water systems (CWSs) in Minnesota. We use panel data and event study research designs to test the impact of these grants. Second, we study how the effects of the CWF grants differ according to served populations and explore plausible mechanisms. Last, we compare the benefits of the CWF grants with the costs and estimate the cost-benefit ratio. The answer to this question is important for understanding who is more likely to benefit from the CWF grants and the efficiency of subsidizing the protection of source water.

This paper aims to shed light on the impacts of the CWF grants using three sets of files. These files include drinking water violation records obtained from the Minnesota Department of Health (MDH); drinking water quality analyte data from MDH, which is a plant-level data set of drinking water concentrations in Minnesota from 2003 to 2018; and, Clean Water Fund Grants Data, which includes each of the Clean Water Fund grants the state government gave each water systems.

We find suggestive evidence that CWF grants reduce health-based violations. We also find that construction projects have the largest negative impact on violations.

Our paper contributes to a considerable body of research which has sought to understand source water protection management (Timmer et al. [2007]), the vulnerability of drinking water systems (Allaire et al. [2018]), class, rurality, race, ethnicity, and justice in drinking water compliance (Switzer and Teodoro [2018]; Marcillo and Krometis [2019]), and the allocation of water system grants (Jocoy [2000]). The present work is designed to be the first to consider the impact of state source water protection grants on drinking water quality and water violations. Recent work by Jocoy [2000] provides a comprehensive analysis of the allocation of state funded programs to small water systems in Pennsylvania(PENNVEST). His paper focuses on evaluating the PENNVEST program's distribution of funds to systems of varying sizes and shows that (1) very small systems do not apply with the same frequency as systems of larger sizes, and (2) very small systems that apply do not have an equally probable chance of acquiring an award. Our study complements the existing work and examines the funding impacts on drinking water outcomes and its distributional effects. More broadly, our work will contribute to the knowledge of the governance mechanisms that improve drinking water outcomes and discuss implications for current drinking water policy decisions.

The remainder of our paper proceeds as follows. We present our econometric models in Section 2 and describe the data in Section 3. Section 4 reports results. We conclude in Section 5.

2 EMPIRICAL STRATEGY

In this section, we first estimate how CWF grants affect drinking water violations. We use panel data and event study research designs to examine the impact of CWF grants on violation outcomes. We then investigate the benefit of the CWF grants by examining how violations impact averting expenditures in Minnesota.

2.1 *CWF Grants Impact on Violations*

We first explore how the cumulative number of grants a CWS receives impacts the tnumber of violations for that facility. The main specification is:

$$V_{jt} = \gamma Grant_{jt} + \sigma_t + \gamma_j + \epsilon_{jt} \tag{1}$$

where j index community water system, t indexes year, and V_{jt} is the cumulative number of violations incurred for water system j at given year t. $Grant_j$ represents the cumulative number of CWF grants that a water system j has received by year t. We include the year fixed effects σ_t to control for all the time variant determinants across systems and water system fixed effect γ_j to control for time-invariant determinants specific to water system j. The error term ϵ_{jt} includes other determinants of water violations. The main coefficient of interest, γ, captures the impacts of an additional grant on water quality violations. We explore other specifications for V_{jt} and $Grant_j$ as robustness checks, including the duration of violations, limiting to grants for construction and not for monitoring and education, and others.

We also estimate an event-study style version of our main equation to examine how grants impact violations over time. This allows us to see if grants have a potential delayed impact on violations. It also allows us to test for differential pre-trends in violations leading up to a grant for those facilities that receive grants versus those that do not.

2.2 *Heterogeneity effects of the CWF grants*

We further examine heterogeneous responses to the CWF grants across different CWSs in Minnesota. Specifically, We interact the cumulative grant number in equation (1) with indicators for system size and rurality and then explore plausible mechanisms. The main specification is:

$$V_{jt} = \gamma Grant_{jt} + X_j + [\text{Grant}_{jt} \times \text{X}_j] + \sigma_t + \gamma_j + \epsilon_{jt} \tag{4}$$

where X_j is defined based on the CWS characteristics.

2.3 *Violation impact on Bottled Water Sales*

In this section, we examine the impact of violations on the sales of bottled water. We again utilize panel data and event study designs to estimate the effect of interest. The main specification is:

$$Q_{ct} = \alpha V_{ct} + \sigma_t + \gamma_c + \epsilon_{ct} \tag{3}$$

where c reflects an individual store in Minnesota, t indexes year, and Q_{ct} is the log of sales of bottled water in Minnesota. Following Allaire et al. (2019), V_{ct} is an indicator that is calculated by taking the portion of the county population that was served by a given water system i at county c, multiplying this by the portion of days in the month that the violation was in effect, and summing them up together at the county level. We also include the year fixed effects σ_t and store fixed effect γ_c as controls. Our coefficient of interest is α, which measures the average change in sales outcome in Minnesota due to a violation.

3 **DATA**

3.1 *Water Violation Records and Analyte Data*

Drinking water violation records for 963 Minnesota community water systems from 2003 to 2018 are obtained from the Minnesota Department of Health (MDH). The data set includes the start and end dates for each violation, the violation type (MR, MCL, TT or RPT), water system name and its characteristics. These characteristics include: primary water source (groundwater v.s. surface water), whether or not a system purchases water from another purveyor, ownership type (private v.s. public), water system size (from very small to very large), population served, and the county in which the system is located.

Table **??** shows the descriptive statistics of community water system characteristics in Minnesota and how violations are distributed between grant-funded and non-grant-funded water systems. Among the 963 CWSs in Minnesota, 269 water systems have received grants in the last decade and 694 water systems haven't received one. However, the water systems that have received grants serve around three fourths of the total population (4.4 Million). Grant-funded water systems are more likely to be public systems and use local source water.

In terms of violations, Minnesota CWSs have incurred over 3,600 violations from 2003 to 2018. Grant-funded CWSs account for 20.7% of the total violations. Health-based violations are the sum of MCL violations and TT violations that represent a threat to public health. On average, Minnesota CWSs incurred 0.1 health-based violations per year from 2003-2018 and grant-funded CWSs are more likely to have health-based violations in the study period. Among 1,500 health-based violation observations, "Radionuclides" violation was the most prevalent type of violation, representing about 49.4% of violations. DBPs and Nitrite/Nitrate violations are relatively rare, only 83 occurred during our study period. Arsenic and Total Coliform violation were also prevalent, representing about 30.0% and 12.2% of violations.

To understand how the health-based violations varied over the study period, we plot time trends in violations among Minnesota grant-funded CWSs by characteristics in Appendix Figure **??**. We find that significant time trends exist for some violation types. Arsenic violations and Radionuclides violations spike in 2007 and start to die out in the next 3 years. Both types of violations experienced a rapid drop toward the end of 2014.

3.2 *Clean Water Fund Grants Data*

The Minnesota Department of Health provides public data on all CWF grants recipients since passage of the Clean Water, Land and Legacy Amendment in 2008. The data provide characteristics of water systems and grants details, including the water system name, the exact location, the grant type, the project description, the grant start date and end date, the project status (completed or in progress). The data also include information about grant amount, dollars leveraged from other local sources, direct expenditure, and administration cost.

Clean Water Funds were first approved in 2008. The first recorded start dates and completion dates occur in 2010. Panel A describes the start and completion dates for all the CWF grants used on source water protection and panel B restricts the grants to only construction projects. We separate the Plan Implementation Grants and Competitive Grant into different groups from 2010 to 2019. Both types of grants have a high completion rate in the first several years and then drop off staring in 2013.

Appendix Table **??** gives the descriptive statistics for Minnesota CWSs and CWF grants. The average number of grants that a Minnesota CWS received is 0.54. This number increases to 1.94 if we restrict the sample to grant-funded CWSs. 72% of CWSs didn't received a grant and 16% received one grant over the study period. The average grant amount is $7,807 and ranges from $450 to $30,000. The average dollar leveraged amount is $6,287 and varies between $0 and $809,100.

4 RESULTS

4.1 *CWF Grants' Impact on Water Violations*

We have preliminary results at this point and choose not to report them here. Please contact authors if interested in these results. We find preliminary suggestive evidence that the CWF grants reduce health-based drinking water violations at CWSs.

5 CONCLUSIONS

This paper presents estimates of the impacts of CWF source water protection grants on health-based water violations. We find suggestive evidence that these grants reduce the number of health-based violations.

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APPENDIX

We only have preliminary results at this stage and choose not to report Tables and Figures here. If interested, please contact authors for tables and figures.