Are We Providing Our School Kids Safe Drinking Water?

An Analysis of California Schools Impacted by Unsafe Drinking Water

COMMUNITY WATER CENTER
EL CENTRO COMUNITARIO POR EL AGUA

Environmental Justice Coalition For Water

May 2016

ABOUT THE COMMUNITY WATER CENTER

The Community Water Center (CWC) is a non-profit environmental justice organization based in California's San Joaquin Valley, whose mission is to act as a catalyst for community-driven water solutions through organizing, education, and advocacy. CWC's fundamental goal is to ensure that all communities have access to safe, clean, and affordable water. CWC employs three primary strategies in order to accomplish this goal: 1) educate, organize, and provide assistance to low-income communities of color facing local water challenges, 2) advocate for systemic change to address the root causes of unsafe drinking water in the San Joaquin Valley, and 3) serve as a resource for information and expertise on community water challenges. CWC helps build strategic grassroots capacity to address water challenges in small, rural, low-income communities and communities of color. Since opening its doors in 2006, CWC has worked with local residents from 82 California communities (69 in the southern San Joaquin Valley) to improve access to safe, clean, and affordable water. For more information, visit CWC's website at **www.communitywatercenter.org**.

ABOUT THE ENVIRONMENTAL JUSTICE COALITION FOR WATER

In 1999, the Environmental Justice Coalition for Water (EJCW) was formed by a group of grassroots organizations and individuals interested in building a collective, community-based movement for democratic water management and policy development in California. EJCW is now a statewide, grassroots coalition working on water justice issues that impact low-income and people of color communities.

EJCW's mission is to educate, empower, and nurture a community-based coalition that serves as a public voice and an effective advocate for environmental justice issues in water policy in California. We achieve our mission through policy analysis and advocacy, community capacity building and training, and nurturing a statewide coalition of organizations that share our vision for the equitable and sustainable management of California's precious water resources. EJCW engages the power of organized communities in state-level policy work by: 1) bridging the gap between policy makers and disadvantaged communities, 2) advocating on behalf of those communities left out of the decision-making process, and 3) building capacity among impacted communities to fight for environmental justice. For more information, visit EJCW's website at **www.ejcw.org**.

ACKNOWLEDGEMENTS

This work benefited from the expertise and knowledge of many different researchers over several years. The following individuals contributed substantively to the initial and/or final study design, analysis and writing: Jenny Rempel, Elizabeth Jones, Claire Sarraille, Carolina Balazs, Esther Min, Kaitlin Toyama, Colin Bailey, Shen Huang, Ryan Jensen, Barbara Nerness, Hyeyeong Choe, Paige Norberg, Teri Greenfield, Asha Kreiling, Kelsey Hinton, and Laurel Firestone.

We extend our sincere thanks to the entire Community Water Center staff for their feedback as we developed our analysis and the final report.

Thank you to The California Endowment for the generous funding which enabled us to pursue the initial research that then became the basis for this report. We also thank The California Endowment for their investment in #Agua4All, that is, in guaranteeing safe, clean, and affordable drinking water for all Californians.

Thank you to Emily Scott for formatting and layout.

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I. Executive Summary

Schools throughout California have been unable to provide students safe water from the tap, and many schools' water supplies have repeatedly violated safe drinking water standards. This report assesses the magnitude, location, and characteristics of the impacts of unsafe water in California public schools, and provides a basis to guide further research and public policy solutions. Neither the state nor local jurisdictions maintain a record of school water system providers, so this report matches 6,974 California schools with public water systems through both direct matching and spatial correlation. It then uses spatial analysis to overlay water quality violations to assess the magnitude of water quality violations on schools. This first-of-its-kind report provides Californians with insights into a statewide problem that has gone unmeasured, untracked and unaddressed for too long.

KEY RESULTS

- 979 to 1,688 schools may have been impacted by unsafe drinking water between 2003 and 2014, representing up to 24% of the 6,974 schools reviewed in the study. That means these schools were correlated with a water system that served water that violated a primary safe drinking water standard.
- 514,269 to 1,048,222 students attended schools impacted by water systems that did not meet primary safe drinking water standards.
- The problem could be even worse if the pipes and drinking fountains in schools added lead or copper to the water supplies. These contaminants were not included in the study because there are no state-wide monitoring or tracking systems for these distribution system contaminants in schools.
- Bacterial and arsenic violations were the most common types of violations impacting schools, followed by the pesticide DBCP, disinfectant byproducts, and nitrates.
- 6–9% of schools were impacted in multiple years, some for a decade or more. 254–332 schools were impacted by recurring bacterial violations (i.e., the water systems serving them experienced bacterial violations in more than one year), and 177–207 schools were impacted by recurring arsenic violations.
- While the problem exists statewide, the Central Valley had both the greatest number and highest percentage of schools in the region impacted by unsafe drinking water.
- 1 in 4 schools in the Central Valley and 1 in 3 schools in the Tulare Lake region were impacted

by unsafe drinking water. Many of these students also suffer from other forms of pollution including some of the worst air quality in America and other environmental health hazards.

- The 320 schools that still operate their own water systems (e.g., a single well run by the school) were more likely to have a water quality violation and to have recurring violations than schools receiving water from larger community water systems.
- Schools impacted by unsafe drinking water had higher percentages of Hispanic and Latino students and socioeconomically disadvantaged students.
- State agencies do not currently have access to sufficient information to assess the magnitude of the problem and ensure that children have safe drinking water at school.

RECOMMENDATIONS

Address Immediate Needs

- Provide funding for safe water access points at schools that lack access to safe drinking water, particularly those with recurring violations where the systems lack the capacity to reliably provide safe drinking water or resolve problems in a swift manner. An investment of $10 million could provide funding for roughly 1,000 filtered water bottle filling stations, which would be enough for each of the 103–144 schools impacted in 2014 to receive 7–9 safe water access points.

Monitor and Track the Problem

- Ensure adequate tracking, transparency, and public reporting from state agencies about water quality at schools. The State Water Resources Control Board should work with the California Department of Education to develop and maintain a database that enables parents, teachers, students and school staff to search for any public school and access the most recent Consumer Confidence Report (explaining the water quality for the water system that supplies the water to the school). This database should also provide any school site-specific testing for distribution system contaminants, like lead. The state should also maintain a priority list of schools that are unable to provide safe drinking water from the tap so they can be tracked and targeted for assistance.
- Develop a statewide monitoring and reporting system for lead and copper in schools. This study could not attempt to assess the prevalence of contaminants like lead and copper, which may enter drinking water through a school's internal distribution system, because the state lacks a monitoring system to track these contaminants at school sites. Public water systems, which are already required to test for lead at a representative sample of locations within their systems, should also test for lead at all school sites. All data on school tap testing should be easily and publicly accessible.
- Require schools to report whether they provide functioning and appealing safe water access points (e.g., fountains or filling stations). We recommend this information be collected by the California Department of Education, perhaps as part of each school's annual Local Control Accountability Plans, to assess and track the scope of water access need in the state.

Promote Sustainable Community-Wide Solutions

- The best solution for schools is ensuring safe, robust and resilient community-wide water systems. Schools that operate their own water systems were more likely to be impacted by unsafe water than schools receiving water from larger community water systems. Decision-makers should target resources to schools and struggling small water systems to consolidate them into larger water systems that can more reliably provide safe water. These consolidations will enable schools to focus their limited resources on providing education rather than safe water, since a larger entity with more technical, managerial, and financial capacity would then be responsible for maintaining the public water system.

Are We Providing Our School Kids Safe Drinking Water?

The daily reality for residents in hundreds of communities throughout California is that of pervasive and constant exposure to unsafe drinking water. The threats of contaminants reach many residents in every environment they enter — their homes, workplaces, public spaces, places of worship, and schools. While it is known that children are highly vulnerable to the health consequences of water contamination, little to no information has been collected on the scope and nature of unsafe drinking water in schools. For years, the Community Water Center and our partner organizations have worked with local school administrators who have been forced to shut off water fountains and dedicate portions of their limited budget resources to purchase bottled water for their students and staff. In this working paper, the Community Water Center (CWC) and the Environmental Justice Coalition for Water (EJCW) investigate how these local conditions in our communities are connected to a broader landscape of unsafe water in schools across the state. This report aims to assess the magnitude, location, and characteristics of the impacts of unsafe water in California public schools, as well as to provide a basis to guide further research and solutions.

Neither the state nor local jurisdictions maintain a record of school water system providers, so our results are based on spatial correlations and thus only provide estimates for the magnitude of the problem. This study does not attempt to assess the prevalence of contaminants like lead and copper, which are likely to enter drinking water through a school's internal distribution system, rather than through source water, nor does this study assess whether schools have working drinking water fountains. For these reasons, we refer to this report as a "working paper," intended to analyze the best available data to understand the magnitude and characteristics of the problem of unsafe drinking water in California schools and focus attention on the need for better data and additional research to further understand the scope of the problem.

II. Objectives

The objectives of this study are to identify:

1. Schools that were impacted by unsafe drinking water, and
2. Contaminants that are present in the water delivered to these schools.

III. Methods

Study Population, Definitions, Data Sources and School Groupings

This study focuses on public schools in California that were active from 2003 to 2014 and had geographic coordinates available in the California Department of Education's (CDE's) dataset of public schools. Within this category, we included the following types of public schools: preschool, community day, K–8, elementary, junior/middle, continuation, and high schools.* Using the California Department of Education's list of public schools, the study population consisted of 6,974 schools that could be directly matched or spatially correlated with a public water system.

Our measure for schools "impacted by unsafe drinking water" is based on schools that were served by a public water system that violated a primary Maximum Contaminant Level (MCL) for a contaminant regulated by the State Water Resources Control Board (SWRCB). This measure is derived from the California SWRCB Annual Compliance Reports (ACRs) from 2003-2014. The ACRs list public water systems** (PWSs) that have violated a Maximum Contaminant Level (MCL) for a SWRCB-regulated contaminant in the given year. Systems listed on the ACRs for monitoring and reporting violations were not considered in violation of a MCL in this analysis. In order to cover the most recent nine-year regulatory compliance cycle (which began in 2003) and analyze the most recent publicly available data (2014), our study analyzes data from 2003 to 2014.

Schools in California get their drinking water from either 1) their own source (usually a well), which is regulated by the SWRCB as an independent, non-transient non-community† (NTNC) public water system, or 2) a regulated community water system†† (CWS) that serves a larger population (for example, a water utility or municipality). We assess MCL violations for both types of school drinking water supplies.

In this study, we assumed a school was served by a CWS if the school was not a NTNC system and the school's geographic coordinates indicate that it is located within the geographic boundaries of an existing CWS (i.e., the school is "spatially correlated" with a CWS).

Our focus on schools "impacted by unsafe drinking water" is used to mean either: 1) a school directly regulated as a NTNC system that was cited for one or more MCL violations, of one or more contaminants, from 2003–2014; or 2) a school that is not itself a NTNC system and is spatially correlated with a CWS that was cited for one or more MCL violations from 2003–2014. We use this terminology because we can only conclude that a school is associated with a NTNC system or a CWS that reported a MCL violation. We do not know conclusively whether the schools delivered contaminated water or provided it to students; no state agency maintains a database with information about where each school gets its water, nor is there any statewide reporting or assessment of whether impacted schools took action to shut down contaminated water fountains and provide alternative water sources.

This study assumes that if no MCL violation was issued or reported for either of the two types of school water supplies, then no violation occurred for a given

*These school types have the following "School Ownership Codes" in California Department of Education spreadsheets: 08 – Preschool, 60 – Elementary School (Public), 61 – Elementary School in 1 School District (Public), 62 – Intermediate/Middle Schools (Public), 64 – Junior High Schools (Public), 65 – K-12 Schools (Public), 66 – High Schools (Public), 67 – High Schools In 1 School Dist. (Public), 68 – Continuation High Schools, 69 – District Community Day Schools. We included "active" schools, that is, all schools in these categories that opened before 2003 and remained open in 2015 (so that the number of schools in the study stayed constant over the study period).

**Throughout this study, we use "public water system" (PWS) to refer to the EPA's definition of Public Water Systems, i.e., a water supplier regulated by the Safe Drinking Water Act that serves piped water to at least 25 persons or at least 15 service connections for at least 60 days each year.

†A nontransient, noncommunity water system, or NTNC, is a public water system that serves at least 25 people who use the water for non-residential purposes for more than six months of the year (e.g., schools, office buildings, etc.).

††A community water system is a public water system (serving at least 25 people or 15 connections) that serves the same people year-round.

school for that contaminant. In actuality, anecdotal evidence suggests that MCL violations have been under-reported for PWSs.[1] Since we have no way to quantify this factor, we simply note the assumption.

Sources of Data

Our nine data sources are detailed in **Table 1**.

Annual Compliance Report (ACR) Data Cleaning

The ACR reports existed in PDF format, so we converted them to spreadsheets using CometDocs, a file conversion service. The original ACR data did not standardize the names of contaminants in each MCL violation category across the 2003-2014 time frame, so we standardized the names of the contaminants based on shared terminology using PostgreSQL code. The ACR included a public water system identification number for each NTNC system and CWS listed with an MCL violation.

School Grouping Based on Associated Water System Type

The study population is comprised of all public schools in the state that we could either associate with a NTNC system or a CWS and that were active from 2003–2014 **(see Figure 1)**. First, from the 7,709 schools that were active during the entire study period and met our definition of a school (see above), we removed 104 schools that did not have latitude and/or longitude information. We then removed schools that did not match to a public water system (details on these methods are below), and divided the remaining study population of 6,974 schools into two groups, based on the type of system providing the school's drinking water:

- **NTNC Group:** 320 schools with their own drinking water systems (i.e., directly regulated as a NTNC system).
- **CWS Group:** 6,654 schools served by a CWS (i.e., those spatially correlated within CWS boundaries).

In order to derive the two groups of schools, two sets of analyses were conducted. First, the list of NTNC schools ("NTNC Group") was derived from CDPH and SWRCB, Division of Drinking Water data, which together listed a total of 504 NTNC entities thought to be schools and their associated water system identification numbers. We matched NTNC entities from these two data sources to the CDE list of schools through several steps. First, we matched 46 schools from the SWRCB to the CDE list based on the provided County-District-School (CDS) Codes. Second, we matched 95 schools that had the exact same name and county on the SWRCB and CDE lists. Third, we matched 180 schools from the SWRCB list to the CDE list manually if the counties matched and the school names appeared to be the same (e.g., we matched Silver Fork Elementary in El Dorado County with SILVERFORK in El Dorado County). Fourth, we manually matched 8 schools from the CDPH list to the CDE list by county and apparent school name. Finally, we excluded duplicates and NTNC entities that did not form part of our target population definition (e.g., churches, community centers, rehabilitation centers, day cares, private schools, and schools not active from 2003–2014). From this process, we were able to match 320 of these NTNC entities to the list of 7,605 public schools used in the study.

Second, schools falling within CWS boundaries ("CWS Group") were identified using PostgreSQL and ArcGIS spatial analyses. Using the geographic coordinates included in the list of all public schools in California dataset, school locations were compiled into one point-layer map. This point layer was intersected with the California public water system boundary shapefiles. This analysis yielded a total of 6,654 schools spatially correlated with CWSs, i.e., schools which, based on their geographic location, likely received water from the CWS that serves that geographic area. Schools that were spatially correlated with exactly one CWS were assigned the associated PWS identification number.

However, 631 schools from the CDE list did not join to a public water system, meaning the school could not be spatially correlated with any public water system boundary included in the dataset. This may be due to inaccuracies in the California public water

Table 1. Data type, description, and source.

Data Type	Data Description	Data Source
State Water Resources Control Board (SWRCB) Annual Compliance Reports (ACRs) from 2003–2014	The ACRs provide information about water quality for all PWSs in California.	PDFs available online from the SWRCB website: www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Publications.shtml
List of all public schools in California	This dataset includes geographic coordinates for "active" (open for school), closed, and merged schools and districts.	Available on the California Department of Education (CDE) website: www.cde.ca.gov/ds/si/ds/pubschls.asp
List of NTNC water system schools from the SWRCB	This spreadsheet contains a list of NTNC entities thought to be schools and their associated public water system identification numbers.	SWRCB Division of Drinking Water contact Nick Chudeau. Data are accurate as of November 11, 2015.
List of NTNC water system schools from CDPH	This spreadsheet of list of NTNC water system schools (i.e., schools on their own well) was maintained by the California Department of Public Health (CDPH). It lists the system name and PWS identification number (PWSID).	"CDPH_Schools_081613": Excel spreadsheet obtained through a public information request to CDPH on August 20, 2013.
California public water system boundary shapefiles	This dataset contains ArcGIS shape files from the California Environmental Health Tracking Program (CEHTP). We used the "Most Current" shapefile dataset of water boundaries and selected only Active water systems (i.e., we did not include any water systems that are currently inactive).	Available on the CEHTP website: http://cehtp.org/page/water/download
Regional Water Quality Control Board boundaries	This dataset contains ArcGIS shape files of the nine Regional Water Quality Boards	Available on the SWRCB website: www.waterboards.ca.gov/waterboards_map.shtml
Department of Water Resources' hydrology region boundaries	This dataset contains ArcGIS shape files of hydrologic regions in California.	Available on the Department of Water Resources (DWR) website: www.waterplan.water.ca.gov/maps/
Free and Reduced Price Meals (FRPM) data	The 2013-2014 spreadsheet includes the number of students who are eligible for Free or Reduced Price Meals (FRPM) at each school in California in 2013-2014.	Available on the CDE website: www.cde.ca.gov/ds/sd/sd/filessp.asp
Ethnicity data	The 2013-2014 spreadsheet includes the enrollment data and number of students of each ethnicity at each school in California in 2013-2014.	Available on the CDE website: www.cde.ca.gov/ds/sd/sd/filesenr.asp

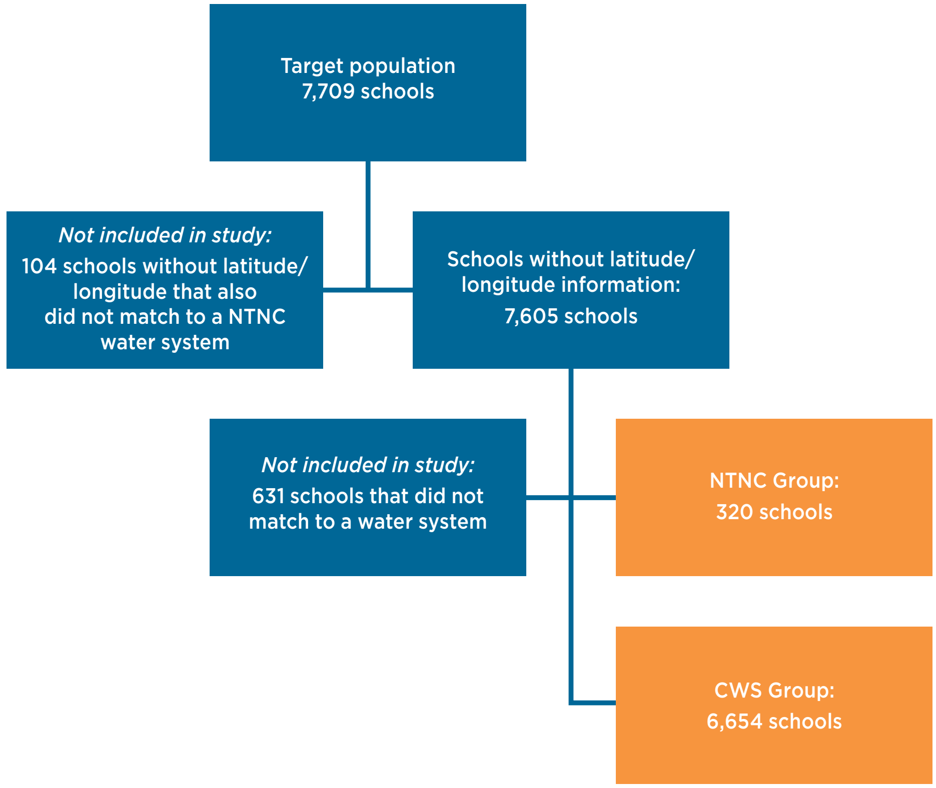


Figure 1. Study design. The study population (indicated in orange) comprised 6,974 schools, which were further separated into a NTNC Group and a CWS Group.

system boundary shapefiles provided by CEHTP.* Because these schools could not be associated with any public water system, we did not include them as part of the study population.

Further, of the 6,654 schools that did join to a CWS, 3,923 were spatially correlated with more than one system, meaning we were unable to determine which CWS serves water to the school. Therefore, we developed a set of assumptions to arrive at both a low and high estimate of the schools impacted. We note that even where a school joined only one CWS boundary, our spatial correlation methodology is not conclusive as to the system supplying a school's drinking water, and additional surveys of schools and subsequent analysis should be done to determine actual school water suppliers and to test the accuracy of this methodology, as discussed further in the Discussion.

Low and High Estimates for CWS Group

To deal with the 3,923 schools that joined to more than one CWS, we developed low and high estimates based on assumptions. For the low estimate, a school is assumed to be served by the water system that has the fewest distinct years with at least one MCL violation, and is thus joined to this water system. For the high estimate, a school is joined to the water system that has the most distinct years with at least one violation **(Figure 2)**. Schools were assigned a CWS PWS identification number in PostgreSQL for each of these two definitions, creating a "low-estimate scenario" and a "high-estimate scenario." As a result of those definitions, in some cases the low estimate may be a higher number than the high estimate. When this happened, we noted it with an "*" in the Results tables.

We use these two definitions to provide an estimated range of the number of schools impacted; however, the definitions are but one way of estimating

*During our analysis, we discovered some errors with the ArcGIS shape files of CWSs from the California Environmental Health Tracking Program. For instance, a few CWSs appeared to overlap with each other, and a few CWSs had shapes that suggested they were not mapped accurately. We assumed the ArcGIS shape files from CDPH were accurate, since we lacked the capacity to manually collect information about CWSs to correct the statewide ArcGIS dataset of CWSs in this working paper. To carry out more accurate studies of unsafe drinking water in schools and communities, we suggest it is important to have accurate, publicly accessible data on CWSs, as is mentioned in the Recommendations.

Water System	Associated ACR Data	Scenario
CWS1	Arsenic violation in 2013 Nitrate violation in 2013	Low estimate
CWS2	Arsenic violation in 2014 Arsenic violation in 2015	High estimate

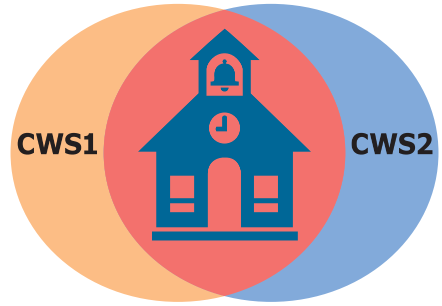


Figure 2. For schools that were spatially correlated with more than one CWS, we assigned two CWS PWS identification numbers to create low- and high-estimate scenarios. For the low estimate, a school is assumed to be served by the water system that has the fewest distinct years with at least one MCL violation, and is thus joined to this water system. For the high estimate, a school is joined to the water system that has the most distinct years with at least one violation.

the number of schools impacted and do not reflect absolute best- and worst-case scenarios. For instance, the low and high estimates could have been defined as the fewest and greatest number of violations associated with each school. Based on our method for associating MCL violations with schools, however, the definitions for these two estimates had to be based on MCL violations associated with the CWS rather than the school. As mentioned above, even our low estimate does not indicate that a school actually received unsafe water or served that water to its students, since we did not independently confirm which CWS actually served each school.

For these reasons and others, the total number of schools impacted by unsafe water over the course of the study period could be higher or lower than our estimates indicate. We discuss study limitations at further length in the Discussion.

Determination of Schools Impacted by Unsafe Drinking Water

The PWS identification number associated with each NTNC Group school was used to join the associated ACR primary MCL violation data to that school in PostgreSQL.

Similarly, once CWS Group schools had PWS identification numbers associated with them, we used PostgreSQL to join the CWS's associated ACR primary MCL violation to the school.

MCL Violation Types

The ACRs from 2003–2014 document many types of primary MCL violations impacting schools in California. These range from violations associated with disinfectant byproducts such as TTHMs and bacteriological contamination, to common groundwater contaminates such as arsenic and nitrate. Because the names of contaminants and violation categories were not standardized across ACRs from 2003–2014, we standardized the names of contaminants in our PostgreSQL database into 14 violation types, including dibromochloropropane (DBCP), arsenic, uranium, ethylene dibromide, disinfectant and disinfection byproduct, fluoride, gross alpha, haloacetic acids, nitrate, nitrite, TTHMs, total organic carbon, aluminum, and bacterial.

We defined bacterial violations as including "bacteriological," "total coliform rule," "surface water treatment rule," and "enhanced surface water treatment rule" MCL violations. While bacterial violations occurred frequently throughout the report, we often removed them from portions of the subsequent analysis to focus on other primary MCL violations that necessitate new drinking water sources, infrastructure, or more expensive treatment projects. We removed bacterial violations in part also because non-acute total coliform rule violations do not necessarily reflect the presence an unsafe contaminant in and of itself, but rather the non-acute total coliform rule violations are more of an indicator of a very high risk for unsafe water and of potential operation and maintenance challenges in the system.[2] Further, for large PWSs, bacterial contamination is more frequently a challenge in one part of a distribution system and thus would not impact every school in a very large city. Because we lack access to the level of detailed information about where within the CWS the bacterial MCL violation occurred, we would have had to consider every school in a large city potentially impacted.* Because of that, we generally focus on non-bacterial violations in this report. However, for some portions of the analyses, we included these bacterial violations because they are still primary MCL violations that indicate a problem at the system level.

It should be noted that the number of MCL violations depends on the monitoring schedule for each contaminant, which is based in part on the concentration level, and in part on monitoring requirements that differ for each type of contaminant (e.g., bacteriological violations are tested more frequently than arsenic). Standardizing the number of MCL violations based on differences in the monitoring schedule for each contaminant type was beyond the scope of this study, which is an important assumption to note.

Regional Impact Analyses

To assess the regional impact of unsafe drinking water in schools, we used the boundaries of the Regional Water Quality Control Boards, and split the large Central Valley region into three sub-regions based on hydrology. The nine Regional Water Quality Control Board regions are: Central Coast, Colorado River, Lahontan, Los Angeles, North Coast, San Diego, San Francisco Bay, Santa Ana, and Central Valley. The Central Valley region was then split into the Sacramento River, San Joaquin River, and Tulare Lake regions based on the California Department of Water Resources' hydrologic region boundaries.

Schools Impacted in Multiple Years

To understand which schools in California were impacted by unsafe drinking water in more than one year between 2003 and 2014, we looked at schools facing non-bacterial violations in multiple years. Schools impacted in multiple years refers to schools that either: 1) have a NTNC system that was cited for at least one non-bacterial MCL violation in multiple years, or 2) were spatially correlated with a CWS that was cited for at least one non-bacterial MCL violation in multiple years. The MCL violation was not necessarily for the same contaminant nor were the violations necessarily chronological, for example, a school impacted by nitrate in 2009 and arsenic in 2011 would be listed as being impacted in multiple years.

Recurring Violations

For many schools and communities throughout California, unsafe drinking water is a recurring issue that water systems and their customers have had to face for years and even decades. In this study, schools are considered to have been impacted by unsafe drinking water on a recurring basis if the school or the associated CWS was cited for the same contaminant for more than one year during the 2003–2014 study period (not necessarily consecutively). For this analysis we included bacterial violations since recurring bacterial violations over multiple years indicate a more serious problem and one that may not have been not eliminated immediately through corrective operations actions, such as disinfection.

School Enrollment and Socioeconomic Conditions

This report focuses primarily on the number of schools impacted by unsafe drinking water, but we also include a rough estimate of the number of students in impacted schools to provide another metric for assessing the scale of the problem of unsafe drinking water in schools. The CDE tracks enrollment and ethnicity data for each school, as well as data about the proportion of students that are eligible for Free or Reduced Price Meals (FRPM) through the National School Lunch Program. To analyze school enrollment and student poverty, we used the computer program Tableau to match the 2013–2014 CDE data (i.e., the last year of the study period) to schools. To do so, we used the County-District-School (CDS) codes to estimate the number of students impacted by unsafe water at schools across California, and to evaluate whether impacted schools have a disproportionate number of low-income students or students who self-identify as Hispanic or Latino.

*It should be noted that this problem affects other non-bacterial contaminants in large CWSs that serve many schools, as well. For instance, we know this was the case for at least one DBCP violation at a single well in the City of Fresno in 2009 that, due to our study methods, appeared to impact 113 schools but, even before the well was brought offline, most certainly did not impact all 113 schools. (See the footnote associated with Figure 4 for details.)

FRPM and ethnicity data was available for 6,963 of the 6,974 schools in the study. The 11 schools for which data was not available from these datasets were excluded from this section of the analysis, creating a small source of bias in the results for this section.

Using enrollment data from the 2013–2014 school year, and assuming that enrollment, relative income, and ethnic composition stayed relatively constant at schools between 2003 and 2014, we estimate the number of students attending schools that were impacted by unsafe water, and the percentages of students who are FRPM-eligible and who self-identify as Latino or Hispanic at those schools.

IV. Results

Schools Impacted by Unsafe Drinking Water in California

Our estimate for the range of schools impacted by unsafe drinking water between 2003–2014 is 979–1,688 schools, or 14-24% of all study population schools.* More specifically, 813–1,522 schools were associated with a CWS that had received at least one MCL violation, and 166 were schools with their own NTNC system that had received at least one MCL violation **(Table 2)**. As **Table 1** indicates, 52% of NTNC Group schools were impacted by unsafe drinking water, compared to 12–23% of CWS Group schools.

Notably, our analysis indicates that our low-estimate scenario was relatively conservative since it did not substantially add to the total number of impacted schools. In our low estimate of 813 violations associated with a CWS Group school, 805 were for schools matched to exactly one CWS, and only 8 were matched to two systems which both had MCL violations. This means that if we excluded the 3,923 schools associated with more than one CWS, our overall count of "schools with unsafe water" associated with a CWS would only decline by 8 schools.

In order to focus on primary MCL violations that require new drinking water sources, infrastructure, or expensive treatment projects, many of the results presented below exclude bacterial violations *(see Methods)*. When excluding bacterial violations, between 2003–2014, 398–645 schools were associated with a CWS that had received at least one non-bacterial MCL violation, and 49 NTNC Group schools received at least one non-bacterial MCL violation **(Table 1)**. NTNC Group schools had a higher percentage (15%) of schools impacted by non-bacterial MCL violations than did CWS Group schools (6–10%).

Figure 3 indicates the spatial distribution of California schools impacted by unsafe drinking water during the 2003–2014 time frame, both for all MCL violations and for non-bacterial MCL violations. Similar maps showing only the most recent violations for which data are available (i.e., 2014) are provided in **Appendix Figure A**.

MCL Violation Types

The ACRs from 2003–2014 document 14 types of primary MCL violations impacting schools in California. These range from violations associated with disinfectant

Table 2. Number of schools in study sample that were impacted by unsafe drinking water, by group type and overall (ranges based on low and high estimates).

School Group	Schools included in study	Schools impacted by unsafe drinking water	Schools impacted by unsafe drinking water (excluding bacterial violations)
CWS Group	6,654	813–1,522** (12%–23% of CWS schools in the study)	398–645 (6%–10% of CWS schools in the study)
NTNC Group	320	166 (52% of NTNC schools in the study)	49 (15% of NTNC schools in the study)
Total	**6,974**	**979–1,688 (14%–24% of study population schools)**	**447–694 (6%–10% of study population schools)**

*The range is due to our system of assessing low and high estimates for CWS Group schools that were spatially correlated with more than one CWS (see Methods).

** We depict ranges for CWS Group schools in this table and throughout the study based on our assumptions for low and high estimates.

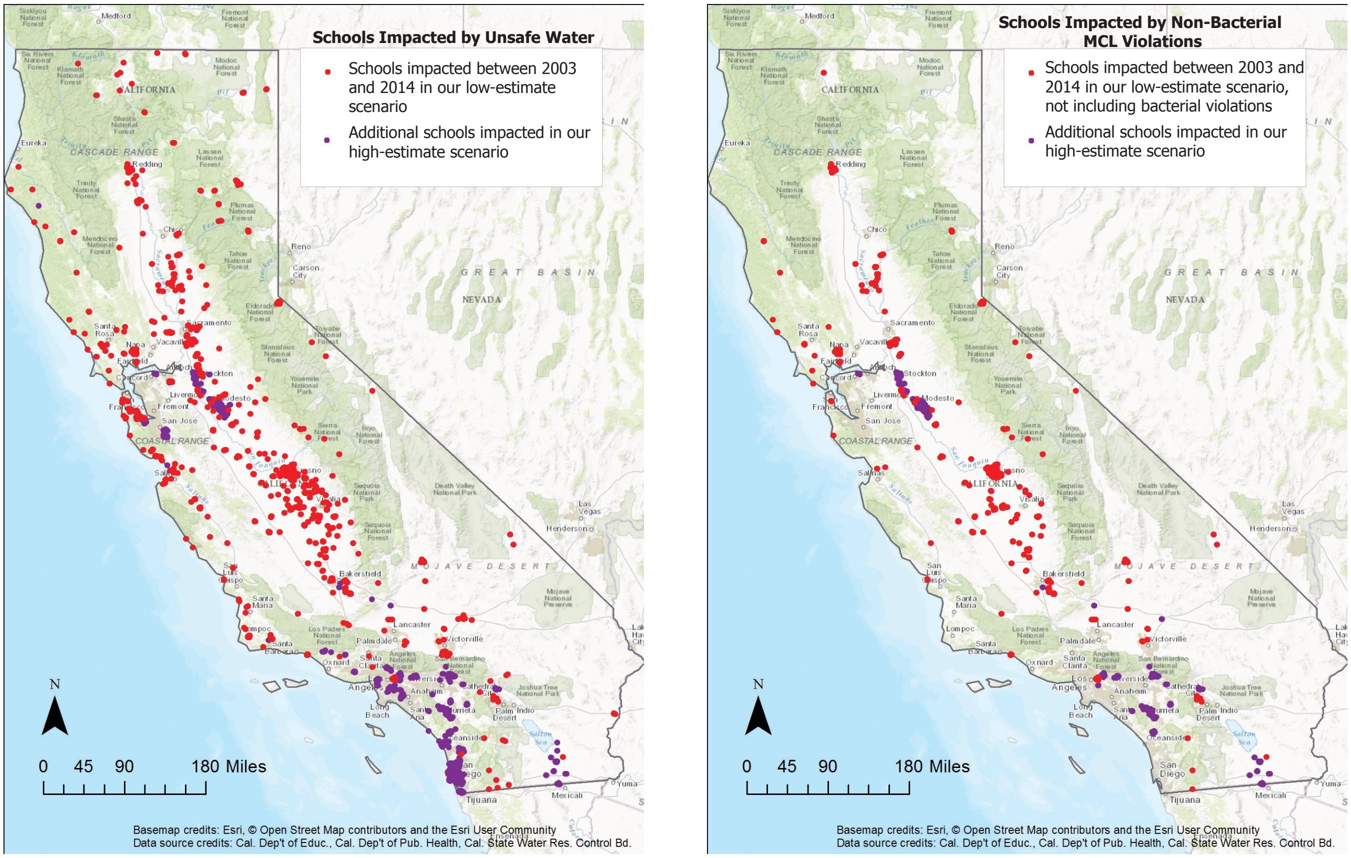


Figure 3. Schools impacted by unsafe drinking water at some point during the 2003–2014 study period *(left)*, and schools impacted by at least one non-bacterial MCL during that same time period *(right)*.

byproducts such as TTHMs and bacterial contamination, to common groundwater contaminants such as arsenic and nitrate. Bacterial violations occurred most frequently. Following bacterial violations, the five most common contaminants impacting schools in the study are arsenic, DBCP, TTHMs, haloacetic acids, and nitrates. Total MCL violations by type are indicated in **Figure 4** for all schools and by school water system type.

The spatial distribution of the top five non-bacterial violations across California is depicted in **Appendix Figure B**.

Regional Impact Analysis for Non-Bacterial Violations

Schools that are impacted by unsafe drinking water are located across the entire state. **Figure 5** illustrates impacted schools as points and uses shading to indicate differences by region in both the number and percentage of schools impacted by unsafe water. This section of the analysis does not include bacterial violations *(see Methods)*.

The Central Valley region is the most affected region by both number and percent of schools impacted by non-bacterial violations. This is true in both the high and low estimates. Of the three subregions within the Central Valley, the Tulare Lake hydrologic region was the most impacted in terms of both the number and percentage of schools in the region that were impacted.

Table 3 provides more details on the number and percentage of schools that were impacted by region. **Appendix Table A** also includes more details about the number and percentage of schools impacted by region in 2014 alone.

To understand regional variations in the type of contaminants impacting schools, we indicate contaminants by region in **Figure 6**.

Schools Impacted in Multiple Years

With bacterial violations included, 423–612 schools were impacted in multiple years, representing 6–9% of study schools. With bacterial violations excluded,

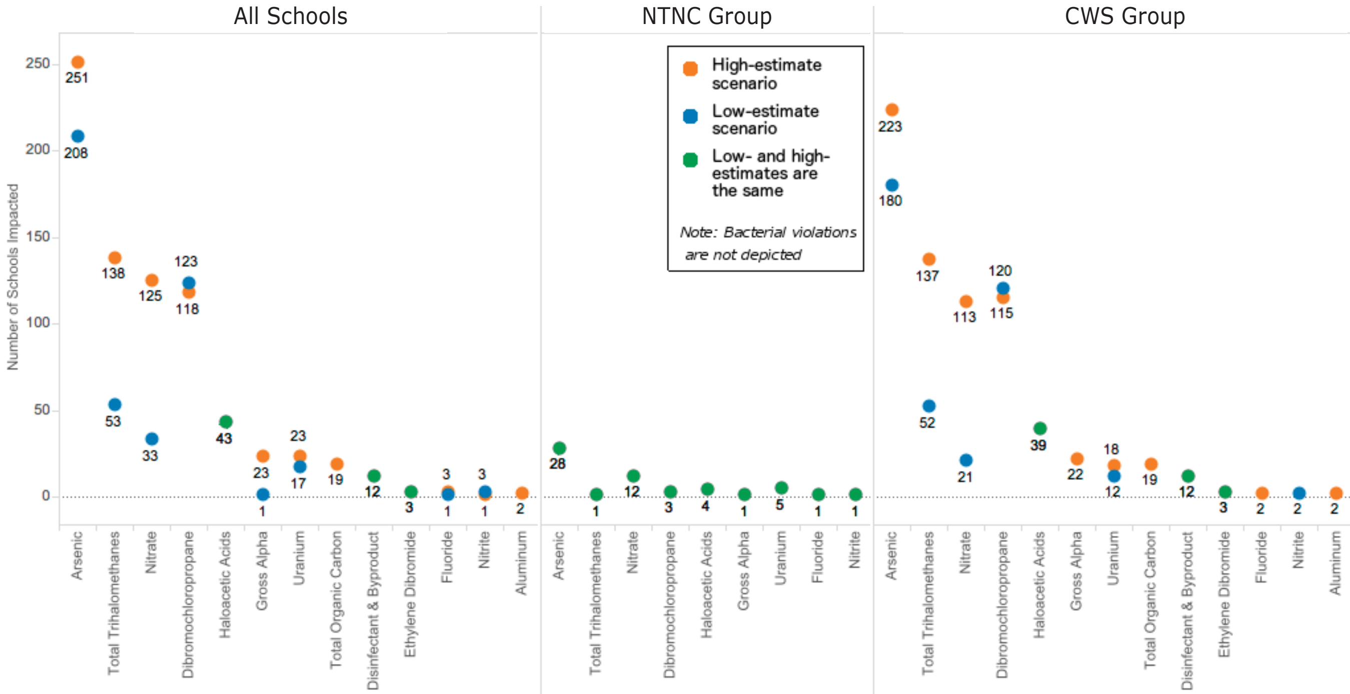


Figure 4. MCL violations by school water system type, excluding bacterial violations.* **

236–358 schools were impacted in multiple years, representing 3–5% of study schools.

The percentage of schools impacted in multiple years differed for each school group type. When bacterial violations are included, 27% of NTNC Group schools (n=85/320 schools) were impacted in multiple years, as compared to 5–8% of CWS Group schools (low estimate, n=338/6654, high estimate, n=527/6654). When bacterial violations are excluded, 11% of NTNC Group schools (n=34/320 schools) had multiple violations, as compared to 3–5% of CWS Group schools (low estimate, n=202/6,654, high estimate, n=324/6,654).

Table 4 depicts the number of schools impacted in multiple years by non-bacterial violations. 3–5% of study schools were impacted by non-bacterial contamination in multiple years, and 1–2% of schools were impacted in five or more years. Some schools were impacted in as many as 11 years of the 12-year study period.

Table 5 depicts regional variations in the number and percentage of schools impacted by at least one non-bacterial MCL violation in at least two years over the study period.

The Central Valley, and within it the Tulare Lake hydrologic region, had the greatest number of schools impacted in multiple years by at least one non-bacterial MCL violation.

Figure 7 illustrates the regional variation in the number of schools impacted in multiple years over the course of the study.

Recurring Violations

The most frequently recurring contaminant types were, in order: bacterial, arsenic, TTHMs, and nitrate. **Table 6** lists all of the contaminants that schools were impacted by on a recurring basis (i.e., for at least two years over the study period).

*The "low" estimate numbers can be higher than the "high" estimate numbers, because the scenarios for each school were determined based on which CWS had the most or least years with at least one MCL violation (i.e., regardless of the contaminant type). This highlights the limitations of our analysis for schools that matched to more than one CWS, which is described in more detail in the Discussion.

**The high number of schools impacted by Dibromochloropropane (DBCP) is largely due to an MCL violation at one well run by the City of Fresno in 2009 that, based on our spatial analysis, was associated with 113 schools. After receiving the MCL violation, the well was immediately brought offline, and even during the period when that single well was in violation of the MCL for DBCP, the violation most certainly did not impact all 113 schools since the City of Fresno has over 250 supply wells. This is one example of how our research methodology may overestimate the number of violations; however, other shortcomings of the available data may lead to underestimates. The Discussion section describes data shortcomings and sources of bias that may lead to under- and over-estimates.

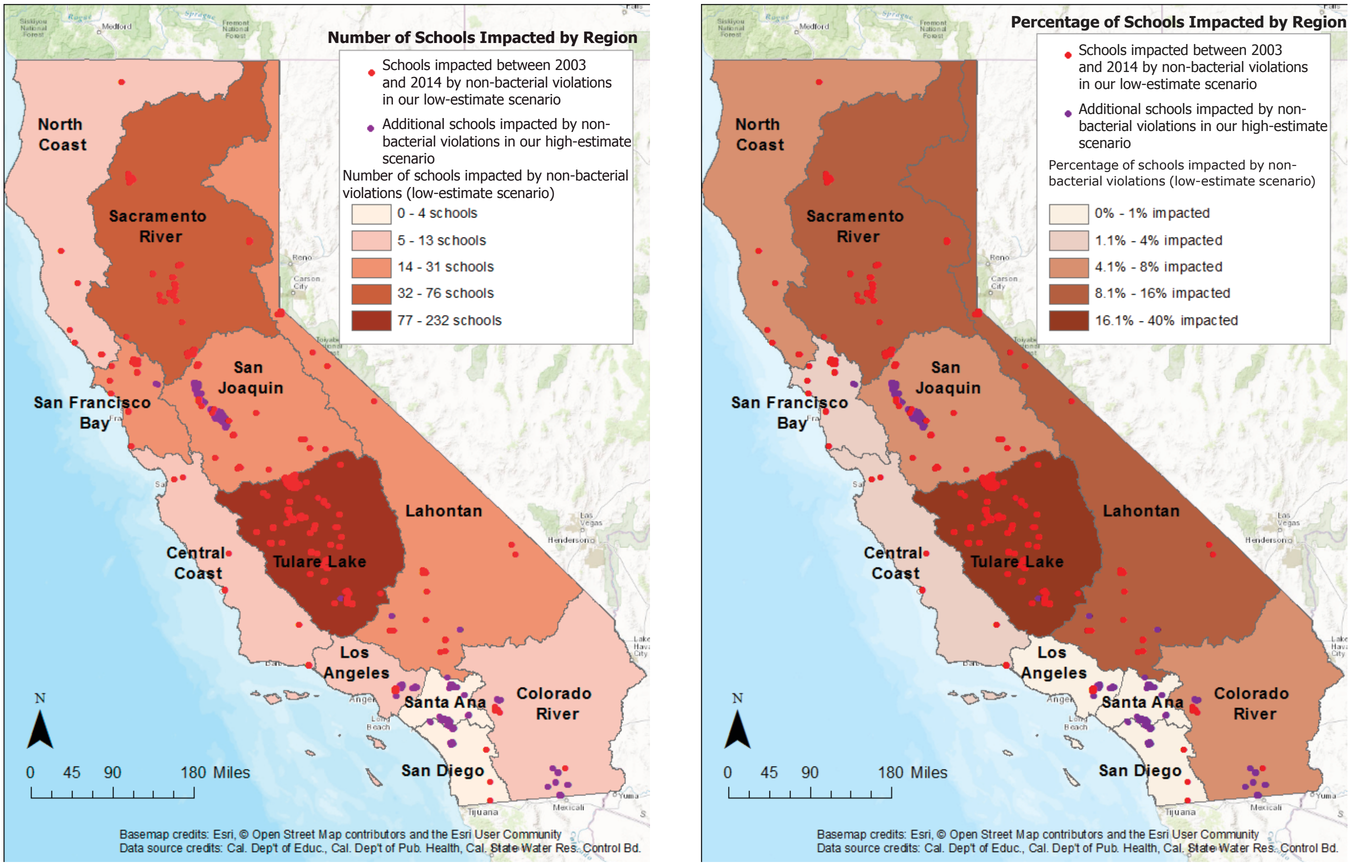
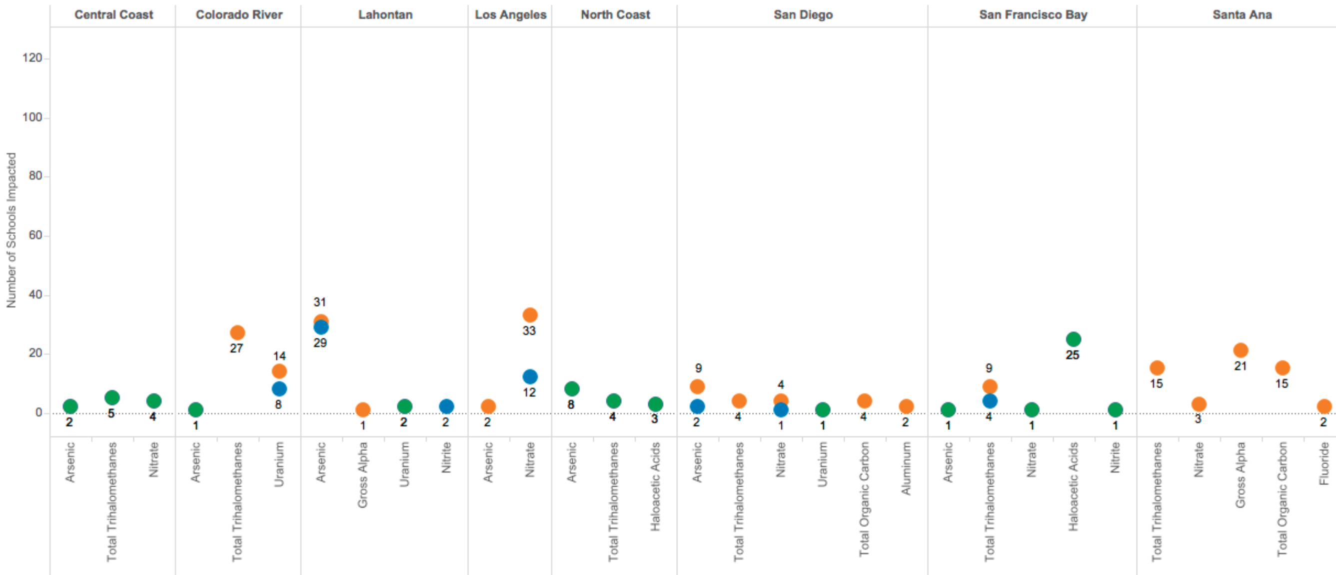


Figure 5. Regional impacts. Impacted schools are illustrated as points and shading indicates the number and percent of schools impacted by non-bacterial contaminants by region, with percent based on our low estimate of the number of impacted schools relative to the total number of study schools in each region.

Table 3. Number and percentage of schools impacted by unsafe drinking water during the 2003–2014 study period by region, not including bacterial violations (ranges based on low and high estimates).

Region	Total number of schools in study sample			Number of schools impacted			Percentage of schools impacted		
	NTNC Group	CWS Group	Total	NTNC Group	CWS Group	Total	NTNC Group	CWS Group	Total
Central Coast	30	243	273	2	9	11	7%	4%	4%
Central Valley	186	1,457	1,643	33	304–430	337–463	18%	21%–30%	21%–28%
Tulare Lake	*68*	*510*	*578*	*16*	*212–216**	*228–232**	*24%*	*42%*	*39%–40%**
Sacramento River	*61*	*556*	*617*	*9*	*67*	*76*	*15%*	*12%*	*12%*
San Joaquin River	*57*	*391*	*448*	*8*	*21–151*	*29–159*	*14%*	*5%–39%*	*7%–36%*
Colorado River	9	104	113	1	8–41	9–42	11%	8%–39%	8%–37%
Lahontan	16	176	192	5	26–29	31–34	31%	15%–17%	16%–18%
Los Angeles	10	1,722	1,732	0	12–35	12–35	0%	1%–2%	1%–2%
North Coast	49	179	228	2	11	13	4%	6%	6%
San Diego	8	643	651	3	1–17	4–20	38%	0%–3%	1%–3%
San Francisco Bay	11	1,147	1,158	3	27–32	30–35	27%	2%–3%	3%
Santa Ana	1	983	984	0	0–41	0–41	0%	0%–4%	0%–4%

*In this instance, the number of schools impacted in the "high" estimate was lower than the number of schools impacted in the "low" estimate due to the fact that the scenarios were defined based on the number of distinct years with violations that were associated with water systems (see Methods). The range depicted here lists the number from the high-estimate scenario first and the low-estimate scenario second.



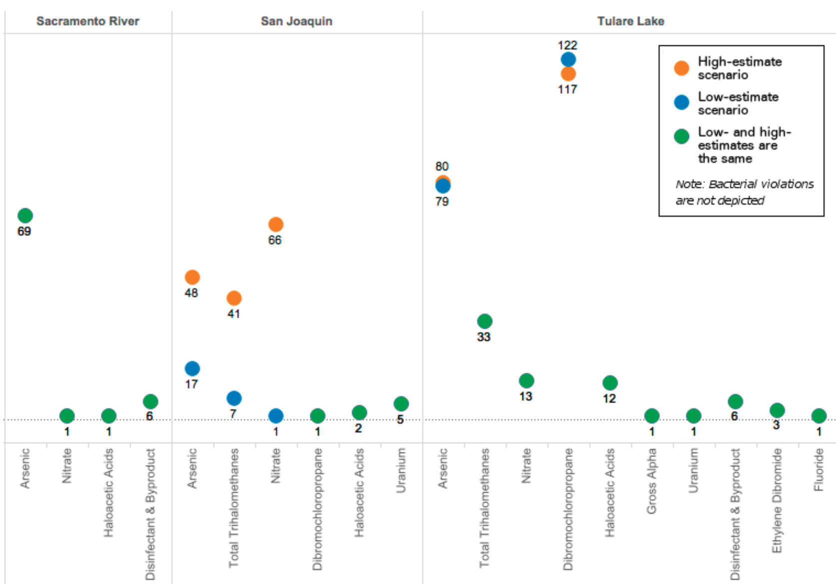


Figure 6. Non-bacterial contaminants occurring in each of the eleven study regions. Orange dots depict the high estimate for the number of schools impacted. Blue dots depict the low estimate for the number of schools impacted. Green dots indicate that the number of schools impacted was the same in both the high and low estimates.

School Enrollment and Socioeconomic Conditions

An estimated 514,269–1,048,222 students were enrolled at the schools in the study impacted by unsafe drinking water, representing 11–22% of students in the study schools **(Table 7)**. An estimated 254,511–438,178 students (5–9% of all students) were enrolled at schools impacted by non-bacterial MCL violations. Note that as mentioned in the Methods, because CED enrollment data from both the FRPM and ethnicity datasets was not available for 11 schools from the study population, the total number of schools impacted is also slightly smaller than the total listed in **Table 2**.

Schools impacted by unsafe drinking water had a higher percentage of students eligible for the FRPM program than the average percentage enrolled at the state level. 62–67% of students at schools impacted by unsafe drinking water were eligible for FRPM, compared to 59% for the matched schools from the study population. This trend held when looking at the portion of students impacted who identified as Hispanic or Latino, too, as 55–57% of students at impacted schools were Hispanic or Latino, compared to 53% for the matched schools from the study population.

These trends were even more pronounced when looking only at non-bacterial violations. The percentage

Table 4. Number of schools that were impacted in multiple years by non-bacterial violations (ranges based on low and high estimates).

Year	NTNC Group	CWS Group	Total
2+ years	34	202–324	236–358
3+ years	28	124–156	152–184
4+ years	25	91–123	116–148
5+ years	19	75–106	94–125
6+ years	14	56–89	70–103
7+ years	9	43–64	52–73
8+ years	6	19–25	25–31
9+ years	4	4	8
10+ years	3	0	3
11 years	2	0	2

Table 5. By region, the number and percentage of schools impacted in multiple years of the study (ranges based on low and high estimates).

Region	Number of schools impacted in more than one year			Percentage of schools in the region impacted in more than one year		
	NTNC Group	CWS Group	Total	NTNC Group	CWS Group	Total
Central Coast	1	6	7	3%	2%	3%
Central Valley	27	160–233	187–260	15%	11%	11%–16%
Tulare Lake	*15*	*100–101*	*115–116*	*22%*	*20%*	*20%*
Sacramento River	*8*	*40*	*48*	*13%*	*7%*	*8%*
San Joaquin River	*4*	*20–92*	*24–96*	*7%*	*5%–24%*	*5%–21%*
Colorado River	0	0–15	0–15	0%	0%–14%	0%–13%
Lahontan	2	22–25	24–27	13%	13%–14%	13%–14%
Los Angeles	0	0	0	0%	0%	0%
North Coast	1	11	12	2%	6%	5%
San Diego	2	0–11	2–13	25%	0%–2%	0%–2%
San Francisco Bay	2	4	6	18%	0%	1%
Santa Ana	0	0–39	0–39	0%	0%–4%	0%–4%

Table 6. Number of recurring violations by contaminant and school water system type (ranges based on low and high estimates).

Contaminant	NTNC Group	CWS Group	Total
Bacterial	56	198–276	254–332
Arsenic	22	155–185	177–207
Total Trihalomethanes (TTHMs)	1	44–59	45–60
Nitrate	7	4–59	11–65
Dibromochloropropane	1	6	7
Haloacetic acids	2	4	6
Uranium	2	2	4
Fluoride	1	0	1
Gross alpha	0	0–22	0–22

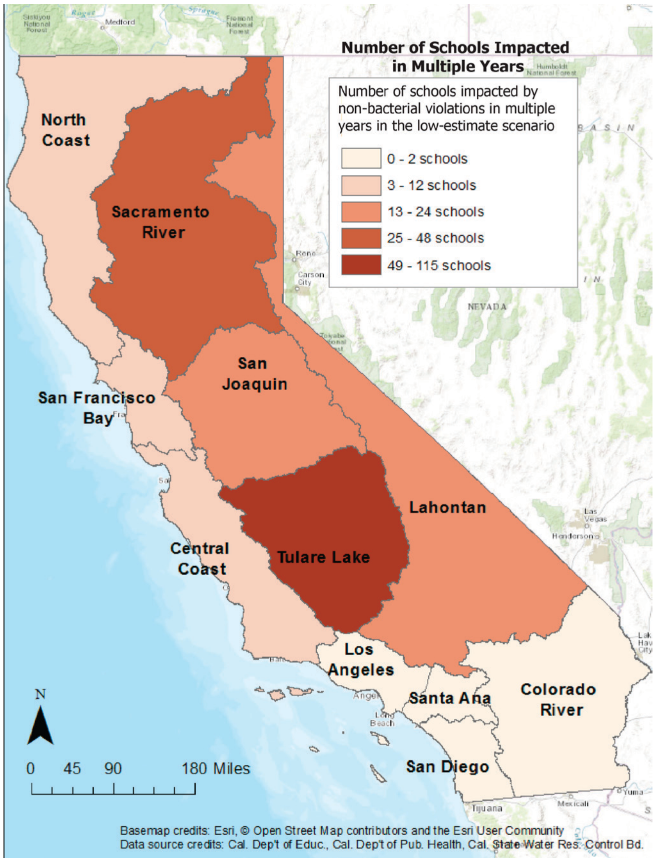


Figure 7. Regional differences in the number of schools impacted in multiple years in the low-estimate scenario, not including bacterial MCL violations.

of students eligible for FRPM was 11–12% higher at schools impacted by non-bacterial violations than at study population schools. Similarly, the percentage of students who identified as Hispanic or Latino was 6% higher at schools impacted by non-bacterial violations than at study population schools.

Many impacted schools were located in regions with high proportions of low-income students and Hispanic or Latino students; however, even in the most heavily impacted region (Tulare Lake), which also has some of the highest percentages of FRPM-eligible students and Hispanic or Latino students, impacted schools still had higher percentages of both FRPM-eligible and Hispanic or Latino students than the background percentages in the matched schools from the study population.

V. Discussion

Schools throughout California are impacted by unsafe drinking water at the tap, and many schools face recurring challenges to providing safe water. Of the 6,974 schools in the study, 14–24% were impacted by unsafe drinking water from 2003–2014, and 6–9% were impacted in multiple years. An estimated

Table 7. Descriptive statistics for school enrollment and socioeconomic conditions. Ranges based on the low and high estimates for the number of schools and students impacted at some point during the 2003–2014 study period.

		All Violations			Non-Bacterial Violations		
	Number of Schools (CDE dataset)	Number of Students (Average of FRPM and Ethnicity datasets)	Percentage of Students Eligible for FRPM	Percentage of Students Hispanic or Latino	Number of Students (Average of FRPM and Ethnicity datasets)	Percentage of Students Eligible for FRPM	Percentage of Students Hispanic or Latino
Total	6,963	4,846,227	59%	53%	4,846,227	59%	53%
Impacted	977-1,686†	514,269–1,048,222	62–67%*	55–57%*	254,511–438,178	70–71%*	59–60%*
Percentage Impacted	14–24%	11–22%	–	–	5–9%	–	–
Difference Between Percentages for the Impacted Population and the Total Population	–	–	3–8%*	2–4%*	–	11–12%*	6%

† CED enrollment data was not available for two impacted schools, as noted above and in the Methods.

*In this instance, the number of schools impacted in the "high" estimate was lower than the number of schools impacted in the "low" estimate due to the fact that the scenarios were defined based on the number of distinct years with violations that were associated with water systems (see Methods). The range depicted here lists the number from the high-estimate scenario first and the low-estimate scenario second.

514,269–1,048,222 students, representing 11–22% of the students in the study sample, attended impacted schools, and were themselves potentially affected. Bacterial MCL violations were the most common type of violation, followed by arsenic. Arsenic and bacterial contamination were the most prevalent types of recurring violations, as well. Excluding bacterial MCL violations to look more closely at other types of MCL violations, 6–10% of schools were impacted by non-bacterial MCL violations. The Central Valley region had both the greatest number and percentage of schools in the region impacted by unsafe drinking water in both the low and high estimates. In fact, the Tulare Lake hydrologic sub-region alone had a greater number and percentage of schools impacted than any other region in the study. One in four schools in the Central Valley and one in three schools in the Tulare Lake hydrologic region were impacted by unsafe drinking water. The Central Valley, and within it the Tulare Lake hydrologic region, also had the highest number of schools impacted in multiple years.

Our finding that schools on their own water systems (i.e., NTNC schools) were more impacted by unsafe water than schools served by CWSs is consistent with previous research suggesting that small systems have more difficulty reliably providing safe drinking water than larger CWSs. Small system size makes a water system physically vulnerable to contamination (e.g., by relying on only 1 or 2 wells), and a range of sociohistorical factors can determine contaminant exposure and coping capacity.[3] Small systems, especially those in low-income areas, often lack adequate technical, managerial, and financial capacity to reliably provide safe drinking water. These systems often lack the economies of scale to implement system-wide treatment, and they can suffer from inadequate regulatory protection and inconsistent monitoring and reporting.[4, 5] Regional solutions that consolidate smaller water systems into larger ones are effective because larger water systems often have more frequent water testing than smaller systems,[6] as well as faster interventions when contaminants are found.[7]

Our finding that bacterial and arsenic MCL violations were the most frequent types of violations found both overall and as recurring violations is consistent with other studies of unsafe water in California public water systems.[8] A bacterial problem generally indicates infrastructure and/or disinfection problems, some of which may be corrected quickly and relatively inexpensively, others of which may require significant work and investment to correct. Arsenic contamination indicates a problem with the source water, as arsenic occurs naturally in many aquifers. Arsenic contamination requires investment in expensive water treatment technologies or securing a new source of water to correct the problem and provide safe drinking water. All community and NTNC water systems were required to comply with a new federal arsenic MCL starting in January 2006, which reduced the MCL from 50 ppb to 10 ppb.[9] Many systems did not immediately return to compliance, so while arsenic remained a frequently occurring contaminant throughout the study, the number of systems out of compliance dropped from 155–179 in 2008 to 52–70 in 2014, reflecting a significant investment in bringing these systems into compliance. However, as the 2014 data indicate, 52–70 schools remained impacted by arsenic nine years after the MCL was lowered. Our data on the frequency of violations by contaminant varies in part based on how frequently schools or CWSs test for a given contaminant. Thus, bacterial violations may be the most common violation type in part because they are tested for most frequently.

The fact that the Central Valley region had both the greatest number and percentage of schools impacted by unsafe drinking water is likely associated with the overall poverty and greater number of NTNC systems in this agricultural region. Despite its booming agricultural economy, the Central Valley has some of the highest poverty rates in the country. Partly as a result of this agriculture, the region also has some of the worst water quality in the nation.[10, 11] Recurring violations could simply be a function of the contaminated water in these agricultural regions. But water quality at the tap and socioeconomics are inter-linked: treatment or alternative solutions for water systems that exceed drinking water standards require substantial economic and human resources. Thus, a related reason for this concentration of recurring violations is linked to the lack of capacity of the public water systems that supply water to the schools to address this contamination. This report illustrates where schools are struggling to provide unsafe drinking water, which is information that can be used to begin prioritizing funding and investment in the regions that need it most.

That the Central Valley has the greatest number and percentage of schools impacted by unsafe drinking water is relevant in the context of the overall public health of the region's residents, who suffer from higher asthma rates, lower life expectancy, higher overweight/obese rates, and worse health outcomes than residents in other parts of the state.[12] Children in the Central Valley are exposed to a variety of cumulative environmental contaminants.[13] This study adds to that list the fact that many schools are also a potential place for exposure to contaminants.

Since FRPM data are frequently used as an indicator of poverty, our finding that the sample of schools impacted by unsafe drinking water has a higher percentage of FRPM program eligibility than the matched schools in the study sample suggests that drinking water challenges disproportionately impact schools with high poverty rates. Disproportionate impacts of unsafe drinking water based on race and class have been found by previous studies. For example, community water systems serving larger percentages of Latinos and renters receive drinking water with higher nitrate levels.[14] Higher arsenic levels and higher odds of receiving an MCL violation for arsenic are also more frequently found in CWSs serving predominantly socio-economically disadvantaged communities, suggesting communities with greater proportions of low socioeconomic status residents face disproportionate arsenic exposures and unequal MCL compliance challenges.[15] Communities with a higher proportion of low socioeconomic status residents may face both a higher exposure burden to drinking water contaminants as well as a compliance burden, creating a composite burden that leads to the persistence of social disparities in exposure to drinking water contaminants.[16] A thorough statistical analysis of unsafe water in schools based on enrollment data by race/ethnicity and poverty was outside the scope of this study, but is needed to test for the likely

possibility of disproportionate impacts based on socioeconomic status.

This study provides a glimpse into the issue of unsafe drinking water in schools, but several study limitations must be taken into consideration. First, the most recent data needed to analyze school water contamination are often out-of-date or inaccessible to the public. For instance, this study only looked at Annual Compliance Report data through 2014 because more recent reports are not yet available. Second, the major obstacle this project faced was the lack of any publicly accessible data about which PWS is serving each public school site. While our spatial analysis attempted to determine which CWS most likely serves each pubic school based on geographic proximity, a survey of public schools would provide more accurate information. A survey of more than 7,000 schools was beyond our capacity with this working paper.

Further, the data we were able to access lacked accuracy: 104 schools were excluded from the study because their latitude and longitude were not included in the list of all public schools in California as of late 2015, when we began this portion of the analysis; 631 schools were not included because they could not be directly associated with any CWSs through our spatial analysis, which illustrates the limitations of the PWS shapefiles; 717 impacted schools could not conclusively be matched to a CWS because they matched to more than one CWS, necessitating low and high estimates of the number of impacted schools; and 11 schools from the main study sample were excluded for the FRPM and ethnicity analyses because their CDS codes were not listed in those datasets. Comprehensively analyzing the biases inherent in each of these excluded groups of schools was beyond the scope of the study. In particular, the way in which we assigned CWSs to the 717 schools which matched to more than one CWS with MCL violations is based on assumptions about the number of years those associated public water systems received MCL violations, rather than an estimate of the fewest and greatest number of violations associated with each school. Defining the low and high estimates based on the fewest and greatest number of violations associated with each school was beyond the scope of our methods in PostgreSQL, since the MCL violations were associated with CWSs, not schools.

The total number of schools impacted by unsafe water during the study period could thus be higher or lower than our estimates indicate. In some cases our analysis is an overestimate and in some places it is an underestimate, since some schools and CWSs may not adequately sample or report their water quality information and since some schools may not have been joined to the correct CWS. For example, as mentioned in the *Methods*, we know conclusively that at least one DBCP violation in Fresno in 2009 did not impact 113 schools.

As mentioned in the Methods section, above, we expect additional limitations exist in the PWS shapefile dataset as well, since we found incidences where CWS boundaries overlapped each other. “Ground truthing” the CWS data was outside the scope of this working paper, but would be a useful undertaking to ensure the accuracy of future reports.

Standardizing the number of MCL violations based on differences in the monitoring schedule for each contaminant type was not done for this study, but it is also an important factor in how many violations get issued. For example, total coliform (i.e., bacterial) samples are collected on a monthly or weekly basis, depending on the size of the water system. By contrast, most other contaminants are tested on either annual or three-year compliance schedules. Inorganic compounds like arsenic, for example, are monitored every year for surface water systems and every three years for groundwater systems. Violations, or long periods without a violation, can also alter monitoring schedules. When a violation is detected, system providers are often required to monitor on a quarterly schedule instead of an annual or three-year schedule. When a violation is not detected for an extended period of time, system providers can apply for a monitoring waiver. Some waivers enable providers to reduce monitoring to once every nine years, hence our decision to start the study in 2003 to include the most recent full nine-year compliance period.

The data presented here essentially does not consider contaminants that occur in the distribution system, like lead and copper, which are tested for differently from other primary MCLs, and for which the current testing rotations inadequately sample schools. Specifically, lead, copper, and total coliform samples are collected at taps to account for entrance through the water distribution system, but system providers are required to take only a certain number of samples throughout an entire water system (e.g. lead must be monitored every six months at 100 taps in a system serving 100,000 people or more[17]). This means that the taps at schools connected to a CWS are not monitored for these distribution contaminants unless the school happens to be included as one of the tap sampling sites. In addition, the standard methods to assess the concentration of lead in drinking water can underestimate the amount of lead that is present because standard sampling protocols fail to capture particulate lead, and because lead release varies with flow rate.[18]

ACR data also has inherent limitations. The accuracy of ACR data is reliant on: first, each PWS complying with monitoring and reporting requirements; second, state, regional, and/or county health regulators reviewing that information and taking regulatory action to issue a formal violation; and third, accurate violation reporting to the state by those health regulators. Previous analyses of water quality data and violation systems during this time period indicate significant underreporting of water quality data and under-enforcement of violations for PWSs, particularly for small systems under 200 connections and for schools, which are often regulated by Local Primacy Agencies (local county public health officers). In addition, the ACR only lists violations for contaminants with established Maximum Contaminant Levels (MCLs); it does not include any indicators for drinking water contaminants that are known to pose threats to human health but that lack an established MCL. For instance, the contaminants Hexavalent Chromium (chromium-6) and 1,2,3-Trichloropropane (1,2,3-TCP), which both have known impacts on human health, were not included in this study because they lacked established MCLs during the majority of the study period. (An MCL for Hexavalent Chromium became effective on July 1, 2014, but it was not included in the ACRs in time for this study.) Anecdotally, we expect many schools, especially in the Central Valley, are likely impacted by 1,2,3-TCP contamination, because groundwater contamination by 1,2,3-TCP is widespread in the Central Valley. Finally, ACRs assume a bright-line standard for contamination, and thus this study does not take into consideration PWSs with water contamination near the MCL.

Taking these limitations into consideration, the utility of this report lies primarily in its investigation of the geographic, socio-economic, and temporal elements of the problem of unsafe water in schools, which can be used to guide further research and, importantly, the development of a multi-scalar solution set, i.e., local, regional, and statewide.

This research echoes the stories we hear on the ground from school administrators and parents, whose school-aged children struggle to realize the human right to water at an early age and in their place of learning. Unsafe drinking water in schools is a statewide issue that reaches from Siskiyou to San Diego and everywhere in between; however, the weight of this issue is not balanced equally throughout California. The regions with the highest risk of unsafe water in schools are those where the magnitude of the issue is intensified by poverty, greater fragmentation and smaller scales of public water systems, and disproportionate and cumulative environmental hazard exposures. This is an issue of environmental justice.

VI. Recommendations

Address Immediate Needs

Our finding that schools were most frequently impacted by bacterial and arsenic contamination indicates the types of interim solutions that may be needed to provide students with safe water at school. For schools impacted by bacterial contamination, the interim solution would most likely be temporary hauled or bottled water, rather than installation of new filtration systems, since in some cases these challenges can be relatively quickly resolved through disinfection and changes in operation and maintenance. For arsenic, nitrates, and other types of source water contaminants, schools may want to install point-of-use (POU) or point-of-entry (POE) systems that are certified to adequately remove the particular contaminant or contaminants, since development of a community-wide solution (such as a new community-wide treatment plant) or new water sources can take many years to complete. The remediation of arsenic and nitrate require expensive treatment technology, especially on a large and centralized scale for the whole system.

A growing number of POU and POE technologies (e.g. reverse osmosis, media adsorption, ion exchange, etc.) are certified by NSF International and the SWRCB, and the SWRCB has had funding available for interim solutions in recent years. Schools in the Arvin Union School District have received POU treatment through this new funding at the SWRCB, in partnership with the Agua4All initiative with the Rural Community Assistance Corporation, Community Water Center, Pueblo Unido Community Development Corporation, local Building Healthy Communities South Kern partners, and The California Endowment. This may be a model for other schools to learn from.

If schools choose to pursue point-of-use treatment systems to address the need for an interim source of safe water, careful consideration is needed to ensure that: 1) any filtration system is certified and appropriately matched to the source water chemistry and contaminant levels, 2) filters are professionally installed and maintained, and 3) the school has a plan for regular monitoring to ensure filters are effectively removing contaminants. Depending on the specific contaminant and school context, hauled or bottled water may still be the cheapest and most effective interim solution for some schools, particularly if the school is expecting a CWS system-wide solution to be implemented relatively quickly (e.g., under two years).

This research suggests hotspot regions most in need of targeted intervention to improve drinking water quality. The state should provide funding for safe water access points at schools that lack access to safe drinking water, particularly those with recurring violations where the systems lack the capacity to reliably provide safe drinking water or resolve problems in a swift manner. Filtered water bottle filling stations cost approximately $10,000 per station, meaning a modest investment of $10 million could fund 1,000 stations. This would be enough to provide 7-9 safe water access points to each of the 103-144 schools impacted in 2014 **(see Appendix, Table A)**.

Based on the total number of schools impacted by unsafe drinking water in multiple years, solutions should be first directed to schools in the Central Valley, particularly the Tulare Lake hydrologic region. We suggest prioritizing funding for safe water access points at the schools within each region that were impacted by unsafe drinking water on a recurring basis, because these schools lack the capacity to reliably provide safe drinking water or resolve problems in a swift manner.

Monitor and Track the Problem

An improved statewide data collection system and a more comprehensive study of unsafe water in schools is needed in order to have a complete and accurate picture of the problem, and to ensure that solutions will come to the schools most in need of safe drinking water. Specifically, additional data collection and research is needed to address three main questions that this research was unable to definitively answer: 1) what public water systems provide water to each school; 2) what is the water quality at the tap in schools (e.g., did these water sources deliver unsafe water to schools, did additional contaminants like lead or copper enter the water through the distribution system); and 3) what were the impacts of having unsafe water for these schools (e.g., were schools able to provide alternative water sources, were schools able to effectively notify students, did the school make budget tradeoffs to buy alternative water sources)?

To address the lack of accurate data on which public water system provides water to each school, we recommend that the SWRCB and CDE work together to develop a regularly updated dataset linking schools to their water source. Until such a dataset is developed, future studies could survey every school that is not directly regulated as a NTNC system to find out where each school is sourcing its water. However it is developed, it is important to maintain a dataset of information linking schools to their associated water systems so that parents and the public can determine where a school gets its water. We recommend that the SWRCB develop and maintain a search capability for the public to search for any school in the CDE's school list and access the most recent Consumer Confidence Report (CCR), which would explain the water quality for the appropriate water system that supplies the water to the school. This would enable concerned parents, students, and school staff can access this information.

Further, the state should maintain a specific list of schools that are unable to provide safe drinking water from the tap. This list can be used to target funding and assistance to accelerate lasting solutions for these schools. Funding and assistance should be targeted to regions whose residents have the least capacity to finance sustainable solutions.

To determine risk and to prioritize schools and regions most in need of intervention, future research should include an analysis of the actual water quality data reported by the PWS serving the school (rather than just the violations listed on the ACRs), as well as testing at school sites where a school is served by a larger CWS with a water quality problem that may only affect part of its service area. We strongly recommend that the SWRCB develop a system to monitor distribution system contaminants, like lead and copper, at school taps, and to make the data from this monitoring system publicly available.

Currently, no dataset exists to track which schools have functioning safe water access points (water fountains or water bottle filling stations), much less whether those access points are appealing enough for students to drink from and use. Data on how schools are adapting when they are impacted by unsafe drinking water (e.g., continuing to serve contaminated water, shutting off drinking water fountains and providing bottled water, installing point-of use filtration, etc.) is also not tracked statewide. The lack of data on both water access and adaptation actions when unsafe water is present must be addressed. We recommend that schools be required to report whether they provide functioning and appealing water access points (fountains or filling stations) and whether they provide safe drinking water. The latter could be done either by submitting the appropriate CCR showing no MCL violations or, if there was a violation, by providing information on what adaptation actions were taken (e.g., filters, bottled water, etc.). We recommend this information be collected by CDE, perhaps as part of the Local Control Accountability Plans, and shared with the SWRCB, where it can be connected to a publicly searchable database (described above) linking the CCR and this additional water access information to each school.

Additional Research to Understand the Possibility of Disproportionate Impacts

Future studies should examine the relationship between drinking water contamination in schools and the racial/ethnic and socioeconomic characteristics of students. The possibility of disproportionate impacts based on poverty is indicated by our finding that schools impacted by unsafe drinking water had a higher percentage of students eligible for the Free and Reduced Price Meals program than the percentage of students eligible in matched schools from the study population. Further research is needed to assess the possibility of disproportionate impacts by race/ethnicity and/or poverty. This environmental justice lens is particularly important for future analyses of unsafe drinking water in schools, particularly because the study found that schools with recurring violations were concentrated in the Central Valley, which has large low-income and Latino populations that are already subject to multiple other environmental health hazards.

Priority Water Systems

We recommend that projects to address unsafe drinking water in schools focus on regional solutions that connect small water systems with both interim and long-term water solutions. Resources should be targeted to schools reliant on their own water systems (NTNC schools), which are more impacted by water contamination and by multiple years of contamination than CWS Group schools. When considering which schools require intervention to address drinking water challenges, decision makers should target resources to NTNC schools to help them connect to larger water systems, perhaps using consolidation incentive programs, and even the SWRCB's new consolidation powers where appropriate.

Promote Sustainable, Community-Wide Solutions

Safe drinking water is particularly important in our schools, but ultimately, all Californians should have safe drinking water from the tap. Sustainable, long-term solutions require targeted funding to impacted communities and schools. Solutions for schools with unsafe water are often tied directly to the water solutions being developed in communities. Ideally, when possible and appropriate, schools should be integrated into larger nearby public water systems, either physically or at least operationally. This integration will enable schools to focus their limited resources on providing education rather than safe water, since a larger entity with more technical, managerial, and financial capacity would then be responsible for maintaining the public water system. The problem of unsafe drinking water in schools should be addressed by promoting community-driven solutions that provide lasting, safe drinking water to entire regions, thus leaving schools, communities, and residents less vulnerable to drinking water challenges in the future.

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APPENDIX: Figure A, Table A

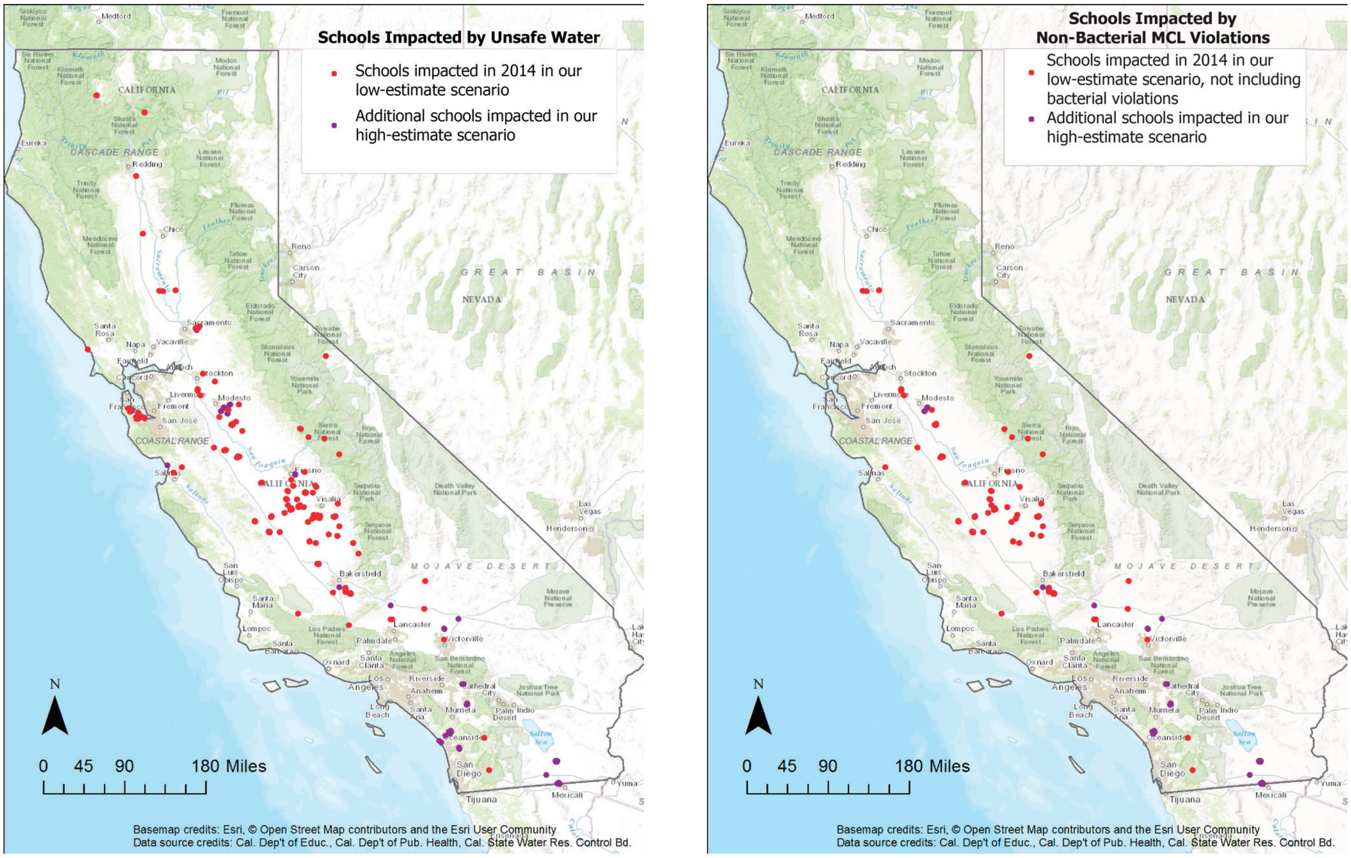

Figure A. Schools impacted by unsafe drinking water in 2014 *(left)*, and schools impacted by non-bacterial MCL violations in 2014 *(right)*.

Region	Total number of schools in study			Schools impacted in 2014	
	NTNC Group	CWS Group	Total	Total Number Impacted	Percentage of Schools Impacted
Central Coast	30	243	273	2	1%
Central Valley	186	1,457	1,643	92–99	56-60%
Tulare Lake	*61*	*556*	*617*	*3*	*0%*
Sacramento River	*57*	*391*	*448*	*18–24*	*4%–5%*
San Joaquin River	*68*	*510*	*578*	*71–72*	*12%*
Colorado River	9	104	113	0–18	0%–16%
Lahontan	16	176	192	6–10	3%–5%
Los Angeles	10	1,722	1,732	0	0%
North Coast	49	179	228	0	0%
San Diego	8	643	651	3–10	0%–2%
San Francisco Bay	11	1,147	1,158	0	0%
Santa Ana	1	983	984	0–5	0%–1%
Total	320	6,654	6,974	103–144	15–21%

Table A. Number and percentage of schools impacted by unsafe drinking water during 2014 by region, not including bacterial violations (ranges based on low and high estimates).

APPENDIX: Figure B

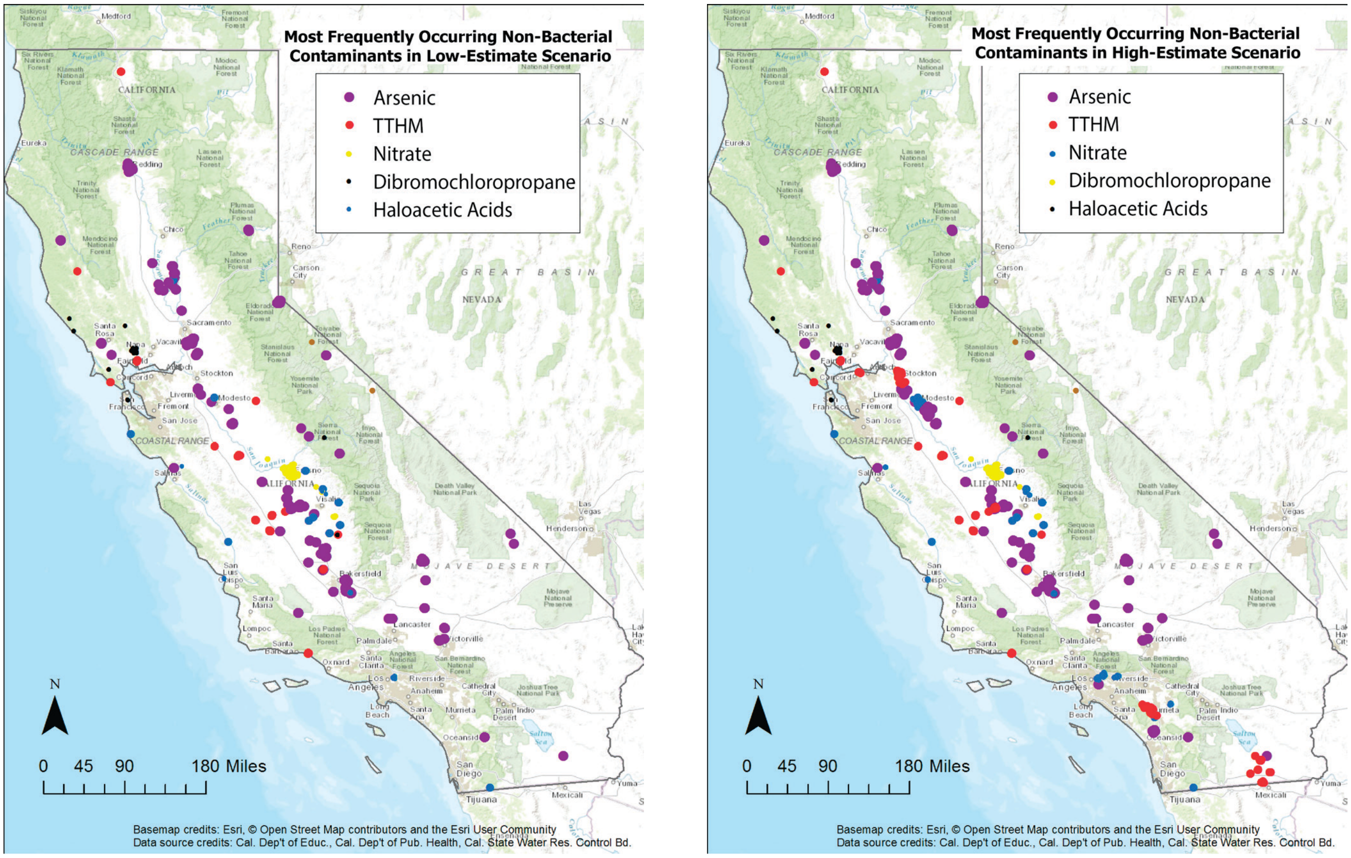

Figure B. The spatial distribution of the top five non-bacterial violations during our 2003–2014 study period across California in the low-estimate scenario *(left)* and high-estimate scenario *(right)*.