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A multi-methods assessment of water and sanitation challenges faced by residents of Imperial Valley, California

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This is A multi-methods assessment of water and sanitation
challenges faced by residents of Imperial Valley, California

A thesis submitted in partial satisfaction of the requirements for the Master's degree

in

Public Health

by

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The thesis of Audrey R. Yang is approved, and is acceptable in quality and form for publication microfilm and electronically.

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LIST OF ABBREVIATIONS

CDWNA – California Drinking Water Needs Assessment

CPWSS – California Public Water Supply Systems

EPA – Environmental Protection Agency

DBPs – Disinfectant Byproducts

DOCs – Dissolved Organic Carbons

IID – Imperial Irrigation District

MCLs – Maximum Contaminant Levels

POE – Point of Entry

RMM – Routine Major Monitoring

SAFER – Safe and Affordable Funding for Equity and Resilience

SDWIS – Safe Drinking Water Information Systems

THAAs – Total Haloacetic Acids

TTHMs – Total Trihalomethanes

UCSD – University of California, San Diego

WASH – Water Access, Sanitation, and Hygiene

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ABSTRACT OF THE THESIS

A multi-methods assessment of water and sanitation
challenges faced by residents of Imperial Valley, California

by

Audrey R. Yang

Master of Public Health

University of California San Diego, 2022

Professor Georgia Kayser, Chair

Contamination of drinking, domestic, and irrigation water poses serious health risks for residents and workers in the Imperial Valley, a region in which the majority of individuals identify as Hispanic or Latinx. While current literature on water source quality in the Imperial Valley exists, there is a lack of research on specific water access, sanitation, and hygiene (WASH) challenges faced by those living in this region. This multi-methods study aims to fill the literature gap through independent quantitative and qualitative analysis. Quantitative data was collected from three government databases and analyzed to assess the health risks and drinking water violations made by community water systems in the Imperial Valley and qualitative interviews with nine WASH key informants were conducted to inform future interventions. Interviews were transcribed and analyzed using the software programs Otter.ai and Delve.

Quantitative and qualitative results suggest that chemical and microbiological contamination is present in irrigation and potable water in the Imperial Valley. Multi-method analyses also showed that pollution by wastewater treatment systems and septic tanks could be possible causes of microbiological contamination. Quantitative data and key informant interviews reported that low-income and rural communities were at a greater risk of facing these water quality challenges. Knowledge by key informants on the specific WASH challenges faced by agricultural workers in the workplace was limited. Future research should therefore be dedicated towards understanding the inequities low-income, rural, and agricultural worker communities face so that solutions aimed at lessening these disparities can be developed.

CHAPTER 1: INTRODUCTION

In 2015, the member states of the United Nations established Sustainable Development Goal 6. This outlined the availability and management of clean water and sanitation for all by the year 2030 and recognized access to water and sanitation as a basic human right[1,2]. While worldwide progress has been made towards addressing this goal, there are major deficits that need to be addressed within this health sector.

Inaccessibility to clean drinking and domestic water and a lack of proper sanitation facilities are issues that affect populations in high- and low-income countries. In lower-income countries, water access, sanitation, and hygiene (WASH) challenges have led to increased rates of diarrheal diseases such as typhoid and cholera[3]. In higher-income countries, including the United States, WASH inequities include a lack of treated surface water and poorly constructed wastewater infrastructure[4]. More than two million Americans do not have access to safe drinking water or sanitation, and these challenges disproportionately affect rural and marginalized communities[5]. A 2019 poll found that 17% of individuals living in rural areas of the United States reported drinking water quality issues and 12% reported sewage issues[6]. According to a report published in 2019 by the nonprofit Dig Deep and the United States Water Alliance, Latinx and Black households are

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[1] "Goal 6 | Department of Economic and Social Affairs," accessed October 11, 2021, https://sdgs.un.org/goals/goal6.
[2] UN-Water, "Human Rights," *UN-Water* (blog), accessed May 5, 2022, https://www.unwater.org/water-facts/human-rights/.
[3] "Lower Income Countries | Hygiene | Healthy Water | CDC," December 22, 2018, https://www.cdc.gov/healthywater/hygiene/ldc/index.html.
[4] Kaitlin J. Mattos et al., "Reaching Those Left behind: Knowledge Gaps, Challenges, and Approaches to Achieving SDG 6 in High-Income Countries," *Journal of Water, Sanitation and Hygiene for Development* 11, no. 5 (July 28, 2021): 849–58, https://doi.org/10.2166/washdev.2021.057.
[5] "Closing the Water Access Gap in the United States_DIGITAL.Pdf," accessed October 11, 2021, http://uswateralliance.org/sites/uswateralliance.org/files/publications/Closing%20the%20Water%20Access%20Gap%20in%20the%20United%20States_DIGITAL.pdf.
[6] Life in Rural America: Part II" (National Public Radio, Robert Wood Johnson Foundation, and Harvard T.H. Chan School of Public Health, May 2019), 8, https://media.npr.org/documents/2019/may/ NPR-RWJF-HARVARD_Rural_Poll_Part_2.pdf.

two times more likely to lack proper plumbing as compared to White Americans. For Native American households, the risk is 19 times more likely than White Americans[7].

Legislation within the United States has attempted to establish better WASH practices throughout the country. The Clean Water Act, originally called the Federal Water Pollution Control Act, was enacted in 1948 and expanded upon in 1972. With this act, the United States Environmental Protection Agency (EPA) set industrial wastewater standards as well as water quality recommendations for surface water pollutants[8]. In 1974, Congress passed the Safe Drinking Water Act to regulate drinking water in the United States[9]. Since its initiation, the EPA has set maximum contaminant levels (MCLs) for various contaminants that must be followed by local and state authorities as well as water suppliers. The EPA also established the National Primary Drinking Water Regulations, which outlines standards and treatments public water systems must abide by[10].

The California State Water Resources Control Board estimates that about 718,000 individuals living in California have unsafe drinking water, with the most common contaminants being nitrate and arsenic[11]. In southern California, low-income residents and those living in rural communities face the potential risk of having environmental contaminants in their drinking water[12]. In response to this state-wide crisis, California Governor Edmund G. Brown signed

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[7] "Closing the Water Access Gap in the United States." United States Water Alliance, uswateralliance.org/sites/uswateralliance.org/files/publications/Closing%20the%20Water%20Access%20Gap%20in%20the%20United%20States_DIGITAL.pdf.
[8] OP US EPA, "Summary of the Clean Water Act," Overviews and Factsheets, February 22, 2013, https://www.epa.gov/laws-regulations/summary-clean-water-act.
[9] "Drinking Water Standards and Regulations | Public Water Systems | Drinking Water | Healthy Water | CDC," November 3, 2020, https://www.cdc.gov/healthywater/drinking/public/regulations.html.
[10] OW US EPA, "National Primary Drinking Water Regulations," Overviews and Factsheets, November 30, 2015, https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.
[11] "Drinking Water Programs | California State Water Resources Control Board," accessed October 11, 2021, https://www.waterboards.ca.gov/drinking_water/programs/.
[12] "Rural Water Issues: Progress and Challenges in Implementing California's Human Right to Water," n.d., 64.

Assembly Bill 685 in 2012, which legislatively acknowledges clean and affordable water as a human right[13]. It also led to the passing of Senate Bill 200 in 2019, which led to the creation of the Safe and Affordable Drinking Water Fund and the Safe and Affordable Funding for Equity and Resilience (SAFER) program in California. Unlike the Clean Water Act and the Safe Drinking Water Act, the SAFER program was specifically designed to achieve water equity[14,15]. Despite these policies, WASH conditions in southern California call for continuous improvements, especially in low-income regions.

1.1: The Imperial Valley

The Imperial Valley is located in the southern California border region and encapsulates all of Imperial County. It extends approximately 50 miles from the Salton Sea into Mexico, with its northern boundary lying near Riverside County and its southern boundary lying in Lower Baja California, Mexico (**Figure 1: A Map of the Imperial Valley**). Its western boundary is bordered by the Coast Range mountains and its eastern boundary is bordered by the Chocolate and Cargo Muchacho Mountains. The entire region is characterized by its desert climate, as it receives about three inches of rainfall a year[16,17].

According to the United States Census Bureau, Imperial County's current population is about 180,000 individuals. 85.0% of the population identify as Hispanic or Latinx, 10.0% identify

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[13] "Human Right to Water | California State Water Resources Control Board," accessed October 11, 2021, https://www.waterboards.ca.gov/water_issues/programs/hr2w/.
[14] "Bill Text - SB-200 Drinking Water.," accessed October 11, 2021, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB200.
[15] "About the SAFER Program | California State Water Resources Control Board," accessed October 11, 2021, https://www.waterboards.ca.gov/safer/background.html.
[16] "Imperial Valley | Valley, North America | Britannica," accessed March 24, 2022, https://www.britannica.com/place/Imperial-Valley.
[17] Dowd, M J. *IID: The First 40 Years*. Imperial Irrigation District, www.iid.com/home/showdocument?id=6000.

as White alone, and 3.3% identify as Black or African American alone. Of those under the age of 65 residing in Imperial County, 8.9% have a disability and 9.6% do not have health insurance. Almost one fifth (18.1%) of residents live in poverty[18]. Imperial County communities are among the top 15% of environmentally disadvantaged areas in California, with high rates of adverse health conditions such as asthma and cardiovascular disease[19].

1.1.2: The Imperial Valley Water Bodies

The importation of raw water from the Colorado River serves as the Imperial Valley's main source of surface water, which is mainly used for irrigation purposes. The introduction of the Colorado River into the Imperial Valley in 1905-1907 led to the creation of the Salton Sea and channels now known as the New River and the Alamo River[20]. These water sources run through the Imperial Valley.

The Salton Sea is not a water source for the Imperial Valley. It is approximately 35 by 15 miles and contains no water outflows. However, agricultural water from the Imperial, Coachella, and Mexicali valleys flow into this water body. Due to barriers on the southern end to prevent flooding, the sharp reduction in return flows, and high evaporation rates of the Salton Sea, lake levels have dropped since the early 2000s. The increased exposure of lake bed has led to increased salinity of the water source and resuspension of dust containing contaminants, which poses a serious environmental health threat[21].

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[18] "U.S. Census Bureau QuickFacts: Imperial County, California," accessed October 11, 2021, https://www.census.gov/quickfacts/imperialcountycalifornia.
[19] "Imperial County, CA | Data USA," accessed October 11, 2021, https://datausa.io/profile/geo/imperial-county-ca.
[20] "New River Introduction |Colorado River Regional Water Quality Control Board," accessed March 28, 2022, https://www.waterboards.ca.gov/rwqcb7/water_issues/programs/new_river/nr_intro.html.
[21] "Salton Sea | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/water/salton-sea.

The New River flows northward from Mexico, through the cities of Mexicali and Calexico, and into the Salton Sea. It carries urban and agricultural runoff as well as treated municipal and untreated industrial waste[22, 23]. Similarly, the Alamo River originates in Mexico and flows about 57 miles north before draining into the Salton Sea. This water source also carries agricultural runoff and is also polluted with agricultural contaminants including pesticides and sediments due to farming irrigation[24].

1.2: The Imperial Irrigation District

The largest irrigation district in the country, the Imperial Irrigation District (IID) was established as a public agency in 1911. While the IID provides treated irrigation water and electrical energy to municipal, industrial, and commercial customers, it is not a community water system. The IID has diverted water from the Colorado River via the All-American Canal since 1942 and transports about 98% of its treated water for irrigation purposes in the Imperial Valley. The All-American Canal Operation distributes water to the East Highline, Central Main, and Westside Main canals, which in turn distribute water to lateral canals located throughout the Imperial Valley. These lateral canals irrigate almost 500,000 acres of agricultural land[25].

The IID is also responsible for supplying non-agricultural water treated to potable standards to the areas of Brawley, Calexico, El Centro, the City of Imperial, Holtville, Westmorland, and Calipatria[26]. This includes seven municipalities, two special districts, one state,

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[22] "New River," Water Education Foundation, accessed March 28, 2022, https://www.watereducation.org/topic-new-river.
[23] "New River Introduction |Colorado River Regional Water Quality Control Board."
[24] "IID History | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/about-iid/mission-vision-statements/iid-history.
[25] "Irrigation | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/water/water-transportation-system/irrigation.
[26] "About IID Water | Imperial Irrigation District," accessed October 11, 2021, https://www.iid.com/water/about-iid-water.

and one federal institution[27]. Due to the Safe Drinking Water Acts, IID water users who have canal connections in their homes or businesses must also have an alternate source of drinking water approved by the State Water Resources Control Board – Division of Drinking Water that is delivered to their residencies. Approved providers include D&M Water Company, El Oasis Water Company, Roman's Water, and Sparkletts[28]. Delivery of this alternate source is paid for by the individual home and business owners, although financial assistance by the IID is available to certain customers based on their annual income. Currently, about 3,000 homes utilize this water delivery service, and the average cost of delivered drinking water is about 61 cents per gallon[29].

The IID's lateral drainage system contains about 1,450 miles of surface drains that collect excess surface water from farmlands, subsurface tile discharges from underground drainage pipes, and operational discharge from canals and connected laterals. These surface drains flow into the Salton Sea[30].

1.3: The California Water Boards

The California Water Boards are state government departments that were created in 1967. Comprised of the State Water Resources Control Board and the nine Regional Water Quality Control Boards of California, the Water Boards regulate surface water and groundwater discharge. This includes discharge from industrial and municipal activities[31]. These departments are

[28] "Imperial Valley," Water Education Foundation, accessed October 11, 2021, https://www.watereducation.org/aquapedia/imperial-valley.
[28] "Safe Drinking Water Act | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/water/service-pipe-customers/safe-drinking-water-act.
[29] "Water Delivery Assistance Program | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/water/service-pipe-customers/water-delivery-assistance.
[30] "Drainage | Imperial Irrigation District," accessed March 28, 2022, https://www.iid.com/water/water-transportation-system/drainage.
[31] "California Integrated Water Quality System Project (CIWQS) | California State Water Resources Control Board," accessed March 29, 2022, https://www.waterboards.ca.gov/water_issues/programs/ciwqs/who_is_regulated.html.

responsible for establishing surface water and groundwater quality standards, allocating water rights, and resolving water right conflicts of California public water systems[32].

The Imperial Valley lies in Regional Board 7 of the California Water Boards. Known as the "Colorado River Regional Water Quality Control Board," this region covers all of Imperial County and portions of San Bernardino, Riverside, and San Diego counties. Due to the water quality issues associated with the Salton Sea, the California Water Boards are focused on implementing programs that monitor total maximum daily loads of contaminants, ambient surface water quality, agricultural runoff, and water source pollution in the Imperial Valley[33].

1.4: Literature Review

Research on the specific WASH challenges faced by Imperial Valley residents is not readily available. However, some existing studies provide context to the water and sanitation challenges that may exist in this region.

Water Body Levels

As demand for water from the Colorado River increases, existing literature reports that this water source may not be able to satisfy water needs in the coming years. A 2012 study that utilized a hydrologic model to simulate streamflow reported that there would be a mean reduction of about 3% in streamflow magnitude in the Colorado River Basin by the year 2035[34]. These results are similar to those found by Castle et al. in a 2014 study, in which researchers analyzed Colorado

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[32] "History of the Water Boards | California State Water Resources Control Board," accessed March 28, 2022, https://www.waterboards.ca.gov/about_us/water_boards_structure/history.html.

[33] "Salton Sea | Colorado River Basin Regional Water Quality Control Board," accessed March 29, 2022, https://www.waterboards.ca.gov/coloradoriver/water_issues/programs/salton_sea/.

[34] Srijana Dawadi and Sajjad Ahmad, "Changing Climatic Conditions in the Colorado River Basin: Implications for Water Resources Management," *Journal of Hydrology* 430–431 (April 2, 2012): 127–41, https://doi.org/10.1016/j.jhydrol.2012.02.010.

River Basin groundwater storage and found that it is depleting at a rapid rate. This poses a serious threat to the states that depend on the Colorado River as a water source for agricultural, domestic, and industrial purposes, including California[35]. The reduction in stream flow and the depletion of Colorado River groundwater can be credited to climate change, as outlined by a 2013 and a 2018 study that each investigated how rising temperatures and decreasing precipitation affect the water levels of the Colorado River[36,37].

The Salton Sea is also depleting, according to current research. Although it does not supply water to the Imperial Valley, its decreasing water levels have strong environmental health implications. According to studies, the Salton Sea's water levels have been rapidly shrinking due to the diversion of water from the Salton Sea for urban use[38,39]. The consequential exposure of dry lakebed has greatly contributed to an increase in ambient particulate matter mass and composition, as outlined by Frie et al. in a 2017 study[40]. According to a study published in 2018, the changes in dust emissions due to the Salton Sea recession could lead to an 11% increase in PM10 (particulate matter with a diameter ≤ 10 micrometers) in the surrounding area by 2030[41]. According to a 2020 report, wind-blown dust exposures from the Salton Sea may also have serious consequences on

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[35] Stephanie L. Castle et al., "Groundwater Depletion during Drought Threatens Future Water Security of the Colorado River Basin," *Geophysical Research Letters* 41, no. 16 (2014): 5904–11, https://doi.org/10.1002/2014GL061055.

[36] Darren L. Ficklin, Iris T. Stewart, and Edwin P. Maurer, "Climate Change Impacts on Streamflow and Subbasin-Scale Hydrology in the Upper Colorado River Basin," *PLOS ONE* 8, no. 8 (August 19, 2013): e71297, https://doi.org/10.1371/journal.pone.0071297.

[37] Mu Xiao, Bradley Udall, and Dennis P. Lettenmaier, "On the Causes of Declining Colorado River Streamflows," *Water Resources Research* 54, no. 9 (2018): 6739–56, https://doi.org/10.1029/2018WR023153.

[38] Douglas A. Barnum et al., "State of the Salton Sea—A Science and Monitoring Meeting of Scientists for the Salton Sea," *Open-File Report* (U.S. Geological Survey, 2017), https://doi.org/10.3133/ofr20171005.

[39] Andrew F. B. Tompson, "Born from a Flood: The Salton Sea and Its Story of Survival," *Journal of Earth Science* 27, no. 1 (February 1, 2016): 89–97, https://doi.org/10.1007/s12583-016-0630-7.

[40] Alexander L. Frie et al., "The Effect of a Receding Saline Lake (The Salton Sea) on Airborne Particulate Matter Composition," *Environmental Science & Technology* 51, no. 15 (August 1, 2017): 8283–92, https://doi.org/10.1021/acs.est.7b01773.

[41] Sagar P. Parajuli and Charles S. Zender, "Projected Changes in Dust Emissions and Regional Air Quality Due to the Shrinking Salton Sea," *Aeolian Research* 33 (August 1, 2018): 82–92, https://doi.org/10.1016/j.aeolia.2018.05.004.

the health of children residing in close proximity to the water source[42]. Additionally, a 2018 analysis by Hinck et al. also concluded that reduction of this water body as well as an annual 1% increase in particulate matter concentration will drastically decrease the value of family residences in the surrounding area, with rural communities being the most vulnerable[43].

Water Contamination

Previous studies have been published in the past 20 years regarding contaminants detected in Colorado River water. A 2006 study by Tikkanen et al. reported that perchlorate was detected in levels as high as 9 micrograms per liter in this water source[44]. A study conducted in 2009 that utilized ion chromatography followed by conductivity of tandem mass spectrometry for perchlorate detection reported similar results, concluding that study participants may have been exposed to perchlorate through the consumption of crops irrigated with Colorado River water[45]. Similarly, a 2011 pilot study investigated perchlorate exposure among 31 individuals living in the Imperial County who consumed locally grown produce. Researchers reported that not only was perchlorate present in drinking water samples, but also that the study participants had increased dose levels of perchlorate compared to federal reference dose levels. Previous research suggests that exposure to high levels of perchlorate could lead to adverse health effects, such as impaired

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[42] Jill Johnston et al., "The Disappearing Salton Sea: A Critical Reflection on the Emerging Environmental Threat of Disappearing Saline Lakes and Potential Impacts on Children's Health," *The Science of the Total Environment* 663 (May 1, 2019): 804–17, https://doi.org/10.1016/j.scitotenv.2019.01.365.
[43] Amrita Singh, Jean-Daniel Saphores, and Tim Bruckner, "A Spatial Hedonic Analysis of the Housing Market around a Large, Failing Desert Lake: The Case of the Salton Sea in California," *Journal of Environmental Planning and Management* 61, no. 14 (December 6, 2018): 2549–69, https://doi.org/10.1080/09640568.2017.1405799.
[44] Maria W. Tikkanen, "Development of a Drinking Water Regulation for Perchlorate in California," *Analytica Chimica Acta* 567, no. 1 (May 10, 2006): 20–25, https://doi.org/10.1016/j.aca.2006.03.087.
[45] Charles A. Sanchez et al., "Perchlorate Exposure from Food Crops Produced in the Lower Colorado River Region," *Journal of Exposure Science & Environmental Epidemiology* 19, no. 4 (May 2009): 359–68, https://doi.org/10.1038/jes.2008.26.

thyroid function[46]. Along with perchlorate, a 2007 study on fish collected from the Colorado River Basin found elevated concentrations of selenium and mercury in the study samples[47].

While the Salton Sea is not utilized for drinking, domestic, or irrigation water in the Imperial Valley, contamination of this water body presents environmental health issues. Discharge into the Salton Sea could be leading to increased pollutant levels. In their 2016 study, Xu et al. assessed the environmental contaminants found in water, sediments, and fish of the Salton Sea by examining 229 semi volatile organic compounds and 12 trace metals. The study found that measured levels of selenium, dichloro-diphenyl-trichloroethanes, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, chlorpyrifos, and pyrethroids found in the Salton Sea surpassed risk thresholds and that levels of certain contaminants have been increasing in recent years[48]. The elevation in selenium could negatively affect reproductive and survival rates of aquatic species found in this water body[49].

A few studies on water contamination caused by agricultural practices in the Imperial Valley have been conducted. A 2012 study found the presence of the insecticide imidacloprid in Imperial Valley sample sites of agricultural drainage water[50]. A 2017 assessment by Anderson et al. of pesticide use in California agricultural regions reported that Imperial County had higher

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[46] Paul English et al., "Direct Measurement of Perchlorate Exposure Biomarkers in a Highly Exposed Population: A Pilot Study," *PloS One* 6, no. 3 (March 4, 2011): e17015, https://doi.org/10.1371/journal.pone.0017015.
[47] Jo Ellen Hinck et al., "Chemical Contaminants, Health Indicators, and Reproductive Biomarker Responses in Fish from the Colorado River and Its Tributaries," *Science of The Total Environment* 378, no. 3 (June 1, 2007): 376–402, https://doi.org/10.1016/j.scitotenv.2007.02.032.
[48] Elvis Genbo Xu et al., "Spatial and Temporal Assessment of Environmental Contaminants in Water, Sediments and Fish of the Salton Sea and Its Two Primary Tributaries, California, USA, from 2002 to 2012," *Science of The Total Environment* 559 (July 15, 2016): 130–40, https://doi.org/10.1016/j.scitotenv.2016.03.144.
[49] Michael K. Saiki, Barbara A. Martin, and Thomas W. May, "Selenium in Aquatic Biota Inhabiting Agricultural Drains in the Salton Sea Basin, California," *Environmental Monitoring and Assessment* 184, no. 9 (September 1, 2012): 5623–40, https://doi.org/10.1007/s10661-011-2367-1.
[50] Keith Starner and Kean S. Goh, "Detections of the Neonicotinoid Insecticide Imidacloprid in Surface Waters of Three Agricultural Regions of California, USA, 2010–2011," *Bulletin of Environmental Contamination and Toxicology* 88, no. 3 (March 1, 2012): 316–21, https://doi.org/10.1007/s00128-011-0515-5.

concentrations of the pesticide chlorpyrifos in comparison to Monterey County[51]. Exposure to this pesticide has been shown to cause cognitive and behavioral dysfunctions, which presents a serious health risk to surrounding residents[52].

Soil Contamination

While research on sanitation systems and wastewater found in the Imperial Valley is currently limited, there are a few existing studies that have investigated the presence of *Escherichia coli* (*E. coli*) in the region's soil. A 2014 study on different strains of bacteria concluded that a nonpathogenic strain of *E. coli* survived longer than a pathogenic strain in Imperial Valley soil, which provide implications on compromised soil quality found in this region[53]. Ma et al. also reported that in their 2016 study on microbial water and sediment quality of agricultural regions in the United States, sediment samples taken from the Imperial Valley had an average of 396.1 *E. coli* forming units per 100 mL. 55.6% of these samples also tested positive for *Salmonella*[54]. These studies suggest that microbiological contamination in Imperial Valley soil could be caused by human activity, such as untreated wastewater leakage. However, because microbiological contamination can be caused by both animals and humans, the results of these studies do not provide conclusive evidence for this contamination route[55].

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[51] Brian S. Anderson et al., "Changing Patterns in Water Toxicity Associated with Current Use Pesticides in Three California Agriculture Regions," *Integrated Environmental Assessment and Management* 14, no. 2 (March 2018): 270–81, https://doi.org/10.1002/ieam.2005.
[52] Leonardo Trasande, "When Enough Data Are Not Enough to Enact Policy: The Failure to Ban Chlorpyrifos," *PLOS Biology* 15, no. 12 (December 21, 2017): e2003671, https://doi.org/10.1371/journal.pbio.2003671.
[53] Jincai Ma et al., "Persistence of Escherichia Coli O157 and Non-O157 Strains in Agricultural Soils," *Science of The Total Environment* 490 (August 15, 2014): 822–29, https://doi.org/10.1016/j.scitotenv.2014.05.069.
[54] M. Partyka et al., "Multistate Evaluation of Microbial Water and Sediment Quality from Agricultural Recovery Basins.," *Journal of Environmental Quality*, 2016, https://doi.org/10.2134/jeq2015.06.0323.
[55] Louise Bélanger et al., "Escherichia Coli from Animal Reservoirs as a Potential Source of Human Extraintestinal Pathogenic E. Coli," *FEMS Immunology & Medical Microbiology* 62, no. 1 (June 1, 2011): 1–10, https://doi.org/10.1111/j.1574-695X.2011.00797.x.

1.5: Public Drinking Water Databases

There are a few publicly available government databases that outline the risk status and health-based violations of community water systems. The California Drinking Water Needs Assessment (CDWNA) was established by the State Water Resources Control Board through the SAFER Program. This assessment annually evaluates risk, cost, and affordability of community water systems, domestic wells, and small water systems. The purpose of this assessment is to identify community water systems that are at-risk of failing to provide safe drinking water. This information is used to guide the Fund Expenditure Plan for the Safe and Affordable Drinking Water Fund[56].

The Safe Drinking Water and Information System (SDWIS) was developed by the EPA and annually provides data on about 156,000 public water systems across the United States in accordance with the Safe Drinking Water Act and its succeeding amendments. This database evaluates treated drinking water and outlines any health-based violations made by community water systems in accordance with the EPA's drinking water standards.[57]

Because the IID is not a public water company and is a privately owned, information on the majority of IID-owned water systems is not published in the CDWNA and SDWIS databases. However, there are three community water systems owned by the IID, which are IID Village, IID Drop 4, and IID North End Consolidation. The California Public Water Supply Systems (CPWSS) database sources data from the SDWIS database and provides specific information on these systems that is not available in other databases.

[56] "Drinking Water Quality: Needs Assessment | California State Water Resources Control Board," accessed March 31, 2022, https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/needs.html.
[57] OMS US EPA, "SDWIS Overview," Data and Tools, August 28, 2015, https://www.epa.gov/enviro/sdwis-overview.

1.6: Study Aims

While literature on water quality and contamination in the Imperial Valley exists, there is a lack of research on the causes of chemical and microbiological pollution of drinking and irrigation water in this region. This multi-methods study aims to gather formative research that will:

1) Identify WASH challenges faced by Imperial Valley residents
2) Identify knowledge deficits on existing WASH challenges

We will fulfill these study aims by performing a quantitative analysis of data on community water systems published by public water system databases and through the conduction and analysis of qualitative interviews with key informants. These analyses will be conducted independently. In this formative research, we aim to gain an understanding of the WASH challenges in Imperial Valley to inform future interventions.

CHAPTER 2: METHODS AND PROCEDURES

2.1: Study Design

This thesis follows a multi-methods study design in which quantitative and qualitative methodology was utilized. Quantitative data collection and analysis occurred first, and qualitative interviews were then conducted and analyzed.

2.2: Quantitative Methods

This study collected quantitative data to understand the risk status and health-based violations of public water systems. All data utilized in this quantitative analysis were obtained from public databases using a search filter for Imperial County. This includes the 2021 California Drinking Water Needs Assessment (CDWNA), which was developed by the State Water Resources Control Board between September 2019 and March 2021. Data provided by the SDWIS database were collected by the EPA in 2021, and data from the CPWSS databases were sourced from the SDWIS archives in 2021 by the State Water Resources Control Board. This study extracted CPWSS data regarding the three community water systems owned by the IID, which are IID Village, IID Drop 4, and IID North End Consolidation. The correlating water system numbers are CA1300588 (IID Village), CA1300591 (IID Drop 4), and CA1300652 (IID North End Consolidation).

Specific data on community water systems in Imperial County were extracted from these three databases in the years 2021 to 2022. Data were then transferred to an excel sheet and organized accordingly. Proportions on characteristics such as service area type, primary water source type, health-based water violations, and risk status, were calculated to assess past and present drinking water challenges faced by Imperial Valley residents.

2.3: Qualitative Methods

In this formative research, we collected qualitative data to understand WASH challenges in the Imperial Valley to inform future interventions. This study utilized a purposive sampling strategy to identify and select key informant interviewees for qualitative data collection, which was most appropriate towards selecting individuals with the professional experience we aimed to interview. The justification behind interviewing only key informants, as opposed to also interviewing community members, was because we aimed to collect the perspectives held by environmental health professionals.

2.3.2: Ethics

IRB approval for this study was obtained on October 19, 2021 by the UCSD Human Research Protections Program (study #800840). Once participants agreed to participate in the study, a time and date for a zoom interview was decided upon. After participants agreed to participate, they were emailed a digital consent form that outlined the study procedures and confidentiality practices of the study. At the beginning of each zoom interview, they were again asked to consent to the study procedures and to provide verbal consent for their continued participation. Participants' anonymity and confidentiality were ensured at the start of the interview.

To assure privacy and confidentiality, interviewees were assigned a four-digit identification number that only researchers had access to. Interview recordings and transcripts were assigned the appropriate identification numbers and were kept on a secure device that was only accessible with a passcode. Participants were made aware that they would receive no direct benefits as a result of their participation.

2.3.3: Data Collection and Analysis

A list of WASH questions was created and revised by the thesis chair (**Table 1**). These questions were divided into water access, sanitation, and hygiene questions. A pilot interview using these interview questions was conducted on December 29, 2021.

Twenty-two key informants were contacted for interview, of which nine agreed to participate in the study. Those nine key informant interviews were conducted from January 2022 to February 2022. The key informants included in this study hold professional titles such as district engineer, environmental health compliance specialist, and senior programs manager and their work includes local, county, and state-level water and sanitation management. Because this study utilized a semi-structured interview format, additional follow-up questions were asked when the interviewee provided a response that required clarification or lacked specificity. For example, follow-up questions were utilized if an interviewee used a term or acronym that the interviewer was not familiar with or if the interviewee provided a general response that required greater detail to understand. All interviews were conducted by this study's primary author, who has previously studied qualitative methods at a graduate level.

Seven interviewees agreed to being recorded and two interviewees declined recording prior to their interviews. For the interviews that were recorded, transcription of those seven interviews was achieved using the software Otter.ai and stored securely on a private account. Each transcription was carefully looked over while simultaneously listening to the individual interview recording to ensure that the transcription accurately represented the conversation and revisions were made as necessary. For the two interviews in which participants declined recording, the study's primary author received permission to actively take notes on an electronic device during the interview.

The interview transcripts were viewed and analyzed by the primary author using Delve, a qualitative data analysis software package used to organize and make notations for analysis. Qualitative results were derived from a thematic analysis of the interview transcripts. The transcripts were read through multiple times to identify specific WASH challenges mentioned by each of the interviewees. The decision to code was based on if a response identified a specific WASH challenge or revealed a deficit of knowledge (for example, an answer that included "I'm not sure" or "I don't know"). A first round of coding produced 16 a priori codes, which were validated by a second round of coding. A final round was then performed to consolidate the original codes into nested categories, which yielded eight sub-codes. To ensure validity of the selected codes, a secondary discussion was then held with the thesis committee chair to discuss the excerpts that were extracted from the data. Discussion was held until a consensus on the coding analysis was reached.

CHAPTER 3: RESULTS

3.1: Quantitative Results

The following quantitative analysis was performed on community water systems found in Imperial County based on data provided by the state and federal government. It should be noted that because the IID is not a regulated public water system, violations made by the majority of IID water systems are not published by the following databases. However, the three community water systems owned by the IID, which are IID Village, IID Drop 4, and IID North End Consolidation, are included in this analysis. All three databases report on potable drinking water.

Table 2 displays data collected and published by the State Water Resources Control Board in their 2021 California Drinking Water Needs Assessment (CDWNA)[58]. Data from Imperial County was included in this analysis, which identified 34 community, non-transient water systems. The community water systems that served the largest populations were the City of Imperial (19,929 people), City of Brawley (27,337 people), and the City of Calexico (40,357 people). Two service areas were characterized as "institutions", five as schools, nine as residential areas, and ten as mobile home parks.

Weighted risk scores were calculated by the State Water Resources Control Board for each public water system by multiplying the risk indicators and categories by a predetermined value or weight. This was done to acknowledge that some risk indicators or categories are more critical than others. Therefore, a higher weighted score indicates that the system is more at-risk than a lower weighted score. The five water systems with the highest water quality category weighted score were a residential area called IID Village (score of 2.25), a mobile home park called Valley Mobile Home Park (2.40), a mobile home park called the Mitchell Camp Family Association

[58] *California Drinking Water Needs Assessment,* 2021. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/needs.html.

(3.00), and two residential areas: the Winterhaven County Water District (3.60), and the Palo Verde County Water District (4.20). Of the five community water systems with the highest total weighted risk scores, three are residential areas (IID Drop Four – 1.24, Winterhaven County Water District – 1.56, and Palo Verde County Water District – 1.99) and two are mobile home parks (Mitchell Camp Family Association – 1.72 and Valley Mobile Home Park – 1.80).

Of the 34 identified water systems in Imperial County, the CDWNA database classified 12 systems (35.3%) as "at-risk," 5 systems (14.7%) as "potentially at-risk," and 17 (50.0%) as "not at-risk." The final SAFER status reported that ten systems (29.4%) were "at-risk" and four systems (11.8%) were "HR2W (Human Right to Water)." The HR2W list refers to community water systems that are out of compliance with SAFER standards or constantly do not meet primary drinking water standards[59]. Final SAFER status also concluded that four community water systems (11.8%) were classified as "potentially at-risk" and that the remaining 16 community water systems (47.1%) were classified as "not at-risk." Of the ten water systems that serviced mobile home parks, three systems (33.3%) received a final SAFER status of "at-risk" and two systems (20.0%) received a status of "HR2W." Of the nine water systems that serviced residential areas, four systems (44.4%) received a final SAFER status of "at-risk" and two systems received a status of "HR2W" (22.2%).

Table 3 outlines data obtained from the Safe Drinking Water Information Systems (SDWIS) Federal Report published by the EPA in 2021 in accordance with the Safe Drinking Water Act[60]. While schools were not classified as community water systems, but as non-community non-transient water systems, the health-based violations made by schools have been

[59] "Hr2w_expanded_criteria.Pdf," accessed April 21, 2022, https://www.waterboards.ca.gov/water_issues/programs/hr2w/docs/hr2w_expanded_criteria.pdf.
[60] *SDWIS Federal Reports Search*, 2021. https://ordspub.epa.gov/ords/sfdw/sfdw/r/sdwis_fed_reports_public/200.

included due to the risks they pose for the health of children and students (**Table 4**). However, these data were not included in the following analysis.

Of the 31 identified community, non-transient water systems identified in Imperial County by the SDWIS database, 12 systems (38.7%) used ground water as their primary source of water, 18 systems (58.1%) used surface water, and 1 system's primary water source was unknown. Almost half (45.2%) of the community systems had ten or more drinking water violations and twenty-two systems (71.0%) had at least one health-based drinking water violation during the years 1993 to 2021. The community water system with the highest number of drinking water violations was Seeley County Water District, with 48 out of the 55 (87.3%) total violations classified as health-based. While the city of Holtville had considerably fewer violations (23), a similar percentage (87.0%) of reported violations were health-based.

The most common health-based violations were Maximum Contaminant Level (MCL) violations, in which the level of a contaminant in drinking water exceeds the highest allowable limit[61]. This violation was committed by 19 water systems. Four systems had MCL total haloacetic acids (THAAs) violations, nine systems had MCL coliform violations, and eleven systems had MCL total trihalomethanes (TTHMS) violations. Other violations found across all 31 public water systems were Treatment Technique and Monthly Turbidity Exceed violations. A Treatment Technique violation occurs when "a [community water system] does not complete their corrective action within the required timeframe after a Level 1 or Level 2 Assessment"[62]. Ten of the community water systems (32.3%) had reports of these violations. A Monthly Turbidity Exceed

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[61] OW US EPA, "National Primary Drinking Water Regulations," Overviews and Factsheets, November 30, 2015, https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.
[62] REG 08 US EPA, "Public Notification - RTCR Treatment Technique Violation Template," Reports and Assessments, March 16, 2017, https://www.epa.gov/region8-waterops/public-notification-rtcr-treatment-technique-violation-template.

violation for conventional and direct filtration systems occurs when "the turbidity standard of representative samples of a [community water system's] filtered water [is not] less than or equal to 0.3 Nephelometric Turbidity Units in at least 95 percent of the measurements taken each month"[63]. Two systems had reports of these violations in the last thirty years.

Table 5 outlines data obtained from the California Public Water Supply Systems. This public portal sources data from the SDWIS and Drinking Water Quality results of the Electronic Data Transfer library dataset published by the Division of Drinking Water[64]. This analysis includes more details on the most recent drinking water violations of the three community water systems owned by the IID.

While IID Village had MCL violations of arsenic in their drinking water system in 2020, IID Drop 4 and IID North End Consolidation have both received Routine Major Monitoring (RMM) violations in recent years for revised total coliform, stage 2 disinfection by-products (DBPs), and THAAs. IID Village has still not achieved compliance for its violation, while IID Drop 4 and IID North End Consolidation have. It is not known as to why IID Village has not yet achieved compliance.

3.2: Qualitative Results

Qualitative results were derived from a thematic analysis of the interview transcripts. The two themes were Water Challenges and Sanitation Challenges. The decision to code was based on if a response identified a specific water or wastewater treatment challenge or revealed a deficit of knowledge. A first round of coding produced 16 a priori codes, which were validated by a second

[63] OW US EPA, "Turbidity Provisions," Overviews and Factsheets, June 17, 2020, https://www.epa.gov/dwreginfo/turbidity-provisions.
[64] *California Public Water Supply Systems Search Parameters*, 2021. https://sdwis.waterboards.ca.gov/PDWW/.

round of coding. A final round of coding produced eight sub-codes. Discussion with the thesis committee chair strengthened the validity of the coding. **Table 6** provides a list of the final themes and sub-codes that were derived from the qualitative analysis.

3.2.2: Water Challenges

All nine key informants were asked a series of questions on some of the water challenges faced by Imperial Valley residents. This included questions on water access, continuity, quality, and quantity (Table 1).

Chemical Contamination of Surface Water Sources

Chemical contamination of surface water sources was discussed by key informants. Colorado River water is treated for irrigation purposes once it reaches the Imperial Valley; however, five key informants stated that there can be issues with water quality before it is treated. This included chemical contamination by substances such as selenium and perchlorate.

> … by the time it makes it down that far in the Colorado system, it's picked up quite a few contaminants… some of the things that are in [untreated Colorado River water] are selenium and perchlorate.
>
> *(Professional Civil Engineer)*

> "...[untreated] Colorado River water has quite high [concentrations of] selenium"
>
> *(Water Resource Control Engineer)*

Key informant responses were supported by our quantitative analysis. For example, two key informants stated that TTHMs were the most predominant contaminant in untreated Colorado River water. Our quantitative analysis of SDWIS data showed that TTHMs were also shown to be a frequent contaminant of potable water in community water systems in the Imperial Valley, which supply potable water to residents (Table 3).

Microbiological Contamination

Five key informants stated that microbiological contamination was a quality issue for drinking and irrigation water in the Imperial Valley, and three of those five key informants stated it was the primary issue of concern. When asked to specify what microbiological contaminants could be found in potable drinking or irrigation water, *E. coli* and total coliforms were mentioned as being specifically tested for. The presence of these microbiological contaminants was also found in some community water systems of Imperial County according to our quantitative analysis of SDWIS data (Table 3).

> … we're following more of kind of the protocol for, you know, the California Safe Drinking Water Act. A lot of times we're specifically testing just for those constituents, whether it's this case, it'd be more total [coliform] and E. coli.
>
> *(Environmental Health Specialist)*

> Yeah, we're looking for primarily what we're seeing is coliform, a total coliform. E. coli is one of the key things that we pick up and what we're looking for.
>
> *(Public Health Official)*

Two key informants commented on the fact that treated irrigation water supplied by the IID is expected to have microbiological contaminants since it is exposed to the atmosphere through open channel canals.

> … all the water that's being conveyed [from the IID] is through open channel canal systems…. So yeah, you're going to get, you know, bacteria in there, obviously.
> *(Environmental Health Specialist)*

Water Inequities

According to some key informants, inequitable access to potable drinking water by Imperial Valley residents is due to geographical location and a lack of affordability. These communities not only receive poor quality treated water, but residents might have to make the decision between paying for water or paying for other resources on a monthly basis.

> … some people have the choice of living out in the county and some people enjoy living out in the county that's what they choose. But… their water quality is so poor that they kind of are okay with it… Some people do choose to live out there for whatever reason, like if you know, rent’s cheaper out there, they'll live out there… I think it comes down to one of those things where it's like okay, well, I need to pay my light bill, but I also need to bathe so you know, I guess I'll deal with this water.
> *(Environmental Health Specialist)*

Two key informants stated that about 2,700 to 3,000 homes located in unincorporated areas of the Imperial Valley utilize agricultural and irrigation water from the Colorado River for domestic use. Due to the poor quality of this water, the Imperial County Public Health Department created the Point of Entry (POE) pilot project, which was mentioned by six key informants. The POE system consists of a bag or cartridge filter followed by UV. While the POE system provides filtered water to residencies for domestic use, free installation by the county is only available to residents of a certain annual income and is otherwise very costly.

> … not everyone can afford these expensive [POE] systems that are installed… They cost about anywhere from nine to $10,000. Of course, that's including our

> prevailing wages. So you're talking about maybe more like seven to $8,000 but the average person in our county can’t afford that.
>
> *(Environmental Health Specialist)*

Communities Experiencing Water Challenges

When key informants were asked about communities that may experience challenges with access to potable drinking water, all nine key informants mentioned rural communities. Rural communities included residences that lived in unincorporated areas of the Imperial Valley, in which the houses are spread apart and lay outside the boundary of public water supply.

> Access to clean [drinking and domestic] water is more difficult in rural settings because of decentralized systems and little investment for seasonal workers or low-income communities.
>
> *(Environmental Health Manager)*

> … there's a lot of rural homes and rural homes within the irrigated parts of the county are not connected to public water systems. So they pull directly from canals.
>
> *(Environmental Health Specialist)*

3.2.3: Sanitation Challenges

All interviewees were asked about the sanitation challenges faced by residents in the Imperial Valley. Qualitative questions on sanitation challenges included inquiries on cost, pollution, and safety and security (Table 1).

Pollution by Wastewater Treatment Systems

Five key informants mentioned that pollution caused by wastewater treatment systems was an issue in the Imperial Valley. These issues present a major threat to the health and safety of humans, animals, and plants in the Imperial Valley Region.

> Sewage is collected and sent to a treatment plant and the treatment plant treats it and you end up with an effluent and that water is returned to the water body… in the end, it just flows into the Salton Sea.
>
> *(Environmental Health Manager)*

One key informant cited instances of individuals in the Imperial Valley pouring untreated wastewater into the New River.

> There [have] been witnesses where people are dumping [untreated wastewater] into the New River. So we do have that super polluted waterway that goes through our community and ends up in the Salton Sea, which, as you know I'm sure, is a huge, huge problem.
>
> *(Environmental Health Specialist)*

Maintenance and Operation of Septic Tanks

Three interviewees reported maintenance and operation challenges regarding privately-owned septic tanks, specifically equipment malfunctions. Interviewees reported that the incorrect installation of parts and the failure to properly maintain septic tanks pose serious dangers to residents.

> … we've encountered where [residents] have tried to make repairs to [their septic tanks] and they've put the system in too shallow and you have the tank is failing or is caved in and therefore that is actually definitely a safety issue for the resident of the property."
>
> *(Public Health Official)*

> … the danger is that it backs up into your home… the system can no longer take, you know, can't discharge any more water. And… the septic tank itself just serves no purpose anymore and water just backs up and into people's houses.
>
> *(Professional Civil Engineer)*

Sanitation Inequities

Inequities regarding sanitation systems exist in lower-income communities. Two key informants mentioned the lack of affordability that comes with maintaining and repairing septic systems in rural communities.

> I know for people who do own properties out in the country or out in the rural areas, they have septic issues and they can't afford to fix them… you have people who just kind of tried to resolve the issue on their own without permits and you know, kind of live with it that way just because it is so costly. So definitely septic issues with as far as your septic systems when people can't afford to repair them or maintain them.
>
> *(Environmental Health Specialist)*

> ...any home that is in the rural area is going to have an issue with septic systems.
>
> *(Professional Civil Engineer)*

Additionally, it was mentioned by one key informant that housing near wastewater treatment plants is generally more affordable due to their proximity to the facility. However, residents of these communities face much higher health risks.

> … a community that builds towards a facility is usually building lower income housing closer to the wastewater treatment plant. People will come because they need a house but the tradeoff is they're closer to you know, their potential for a spill from the plant or a chemical release.
>
> *(Environmental Health Manager)*

Communities Experiencing Sanitation Challenges

Mobile home parks were also mentioned by three key informants as communities that face sanitation challenges. While many mobile home parks are connected to sewage and wastewater treatment plants, interviewees cited specific instances in which certain mobile home park communities did not possess the proper infrastructure for waste disposal or treatment.

> A seasonal [mobile home park] was having issues with their sewage and we found that they had a pipe that was discharged into the New River.
> *(Environmental Health Specialist)*

3.2.4: Unexpected Results

Water Quantity

Water availability and quantity was not seen as an issue in the Imperial Valley by key informants due to the region's claim to a number of sufficient sources. Given the geographical location of these communities at the bottom of the Colorado River watershed, persistent California drought, and the dwindling water supply in southern California, this was a surprising result. Key informants credited this to the Imperial Valley's position as a senior water right holder, granting them access to a large water supply. However, while this may be true for irrigation water supply, it does not imply that Imperial Valley residents have an unlimited supply of domestic and drinking water.

> They have, they have very old water rights down there. So that isn't a problem.
> *(Professional Civil Engineer)*

> We have very good supply of water that comes from the Colorado River. We have very senior water rights. So as far as the quantity of water… that really has never been a problem and I don't anticipate it being a problem.
> *(Professional Civil Engineer)*

> So here in the valley… we do have kind of the largest allotment along the Colorado River through IID's kind of historical allotment to, or claim, to the river basically.
>
> *(Environmental Health Specialist)*

Hygiene

When asked, key informant interviewees did not know of any particular hygiene challenges faced by Imperial Valley residents. This could be due to the selected sample of key informants who may not have experience in this field.

> I don't know. It's not something that I've experienced in my line of work. I think if you ask somebody that work with you know directly with people who are in poverty, like a lot closer you might have a better answer, but I don't know. I don't know of any.
>
> *(Environmental Health Specialist)*

Agricultural Workers

When asked about the availability of occupational WASH services for agricultural workers living in the Imperial Valley, the majority of key informants said they were unsure of their working conditions. A few key informants commented saying they "didn't know" about or "didn't pay attention" to this particular topic. However, some interviewees said they were aware that agricultural companies were required by law to provide clean drinking water and proper sanitation facilities to their workers.

> So that is something that is that is required for the agricultural industry, that they provide potable water for their, for the individuals that are working in the fields, or that are harvesting or as I guess they're employed to provide that service... They have to provide I mean, that's one of the requirements for having porta potties, if you will, or sanitary facilities for them. Not only for restrooms but having potable

water for washing hands, having potable water for drinking purposes available as well.

(Public Health Official)

… they do have kind of an accompanying hand washing station… if they provide access to soap and they always have water in them? I couldn't tell you.

(Environmental Health Specialist)

CHAPTER 4: DISCUSSION

4.1: Water Quality

Quantitative results from the SDWIS database and key informant interviews revealed that chemical contamination of surface water sources could be a possible water challenge for Imperial Valley residents. Quantitative analysis of SDWIS data revealed the prevalence of coliform, THAAs, and TTHMs in community water systems exceeded maximum contaminant levels. According to recent literature, the formation of DBPs, such as TTHMs and THAAs, is common in some community water systems[65]. This is likely attributed to chlorination of the filtered water, an effective method for disinfecting drinking water and maintaining residual treatment throughout the distribution system[66,67]. Many public water systems in the Imperial Valley, including the city of Imperial and the city of El Centro, utilize chlorination for drinking water. These systems may also lack the necessary resources to sufficiently filter water prior to disinfection with chlorination, which could explain the high rates of TTHMs in these community water systems (Table 3).

Key informant interviews also reported possible chemical contamination in untreated surface water from the Colorado River. Longitudinal reports have found that loads of dissolved organic carbons (DOCs) have been identified in water from the Colorado River[68]. Studies have shown that the presence of DOCs influence the formation of DBPs during water treatment with

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[65] Steve E. Hrudey et al., "Evaluating Evidence for Association of Human Bladder Cancer with Drinking-Water Chlorination Disinfection By-Products," *Journal of Toxicology and Environmental Health, Part B* 18, no. 5 (July 4, 2015): 213–41, https://doi.org/10.1080/10937404.2015.1067661.

[66] Cristina M. Villanueva et al., "Overview of Disinfection By-Products and Associated Health Effects," *Current Environmental Health Reports* 2, no. 1 (March 1, 2015): 107–15, https://doi.org/10.1007/s40572-014-0032-x.

[67] Md. Pauzi Abdullah et al., "The Study of Interrelationship between Raw Water Quality Parameters, Chlorine Demand and the Formation of Disinfection by-Products," *Physics and Chemistry of the Earth, Parts A/B/C*, 9th WaterNet/WARFSA/GWP-SA Symposium: Water and Sustainable Development for Improved Livelihoods, 34, no. 13 (January 1, 2009): 806–11, https://doi.org/10.1016/j.pce.2009.06.014.

[68] Matthew P. Miller, "The Influence of Reservoirs, Climate, Land Use and Hydrologic Conditions on Loads and Chemical Quality of Dissolved Organic Carbon in the Colorado River," *Water Resources Research* 48, no. 12 (2012), https://doi.org/10.1029/2012WR012312.

chlorination[69,70,71]. While literature on the health effects of DBP exposure remains limited, evidence has shown there is a possibility that exposure could be associated with an increased risk of various forms of cancer, adverse reproductive outcomes, and poor respiratory health[72,73,74].

SDWIS data and key informant interviews also reported that that microbiological contamination was an issue in some potable water sources of Imperial Valley. Coliform exceeded MCLs in nine of the thirty-one treated public water systems identified in SDWIS (Table 3). Some key informant responses said that contamination could be due to pollution by wastewater treatment systems. While the prevalence of coliform in Imperial Valley water sources has not been heavily researched, wastewater pollution is a possible method through which coliform could be found. For example, previous studies indicate that it could be due to shallow wells or springs as well as improperly designed sanitation facilities[75,76]. The presence of some decentralized wastewater treatment systems in the Imperial Valley could also be contributing to high rates of contamination. Additionally, 2010 study conducted at Florida Gulf coastal beaches found that there was a

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[69] J. A. Fleck, D. A. Bossio, and R. Fujii, "Dissolved Organic Carbon and Disinfection By-Product Precursor Release from Managed Peat Soils," *Journal of Environmental Quality* 33, no. 2 (2004): 465–75, https://doi.org/10.2134/jeq2004.4650.

[70] Katherine M. H. Beggs, R. Scott Summers, and Diane M. McKnight, "Characterizing Chlorine Oxidation of Dissolved Organic Matter and Disinfection By-Product Formation with Fluorescence Spectroscopy and Parallel Factor Analysis," *Journal of Geophysical Research: Biogeosciences* 114, no. G4 (2009), https://doi.org/10.1029/2009JG001009.

[71] T.E.C. Kraus et al., "How Reservoirs Alter Drinking Water Quality: Organic Matter Sources, Sinks, and Transformations," *Lake and Reservoir Management* 27, no. 3 (September 1, 2011): 205–19, https://doi.org/10.1080/07438141.2011.597283.

[72] C. M. Villanueva et al., "Meta-Analysis of Studies on Individual Consumption of Chlorinated Drinking Water and Bladder Cancer," *Journal of Epidemiology and Community Health* 57, no. 3 (March 2003): 166–73, https://doi.org/10.1136/jech.57.3.166.

[73] K. Waller et al., "Trihalomethanes in Drinking Water and Spontaneous Abortion," *Epidemiology (Cambridge, Mass.)* 9, no. 2 (March 1998): 134–40.

[74] K. M. Thickett et al., "Occupational Asthma Caused by Chloramines in Indoor Swimming-Pool Air," *The European Respiratory Journal* 19, no. 5 (May 2002): 827–32, https://doi.org/10.1183/09031936.02.00232802.

[75] Eliapenda Elisante and Alfred N. N. Muzuka, "Sources and Seasonal Variation of Coliform Bacteria Abundance in Groundwater around the Slopes of Mount Meru, Arusha, Tanzania," *Environmental Monitoring and Assessment* 188, no. 7 (June 7, 2016): 395, https://doi.org/10.1007/s10661-016-5384-2.

[76] Frederick Ato Armah, "Relationship Between Coliform Bacteria and Water Chemistry in Groundwater Within Gold Mining Environments in Ghana," *Water Quality, Exposure and Health* 5, no. 4 (March 1, 2014): 183–95, https://doi.org/10.1007/s12403-014-0110-1.

significant reduction in the presence of fecal coliforms after the installation of proper wastewater infrastructure[77]. However, the results of our study do not provide definitive evidence that the presence of microbial species in potable water are caused by wastewater pollution.

There are other pathways through which microbiological contamination in Imperial Valley water sources can occur, such as wastewater effluence from Mexico via the New River or the Alamo River. Some key informants also alluded to the New River as a possible source of microbiological contamination due in Imperial Valley water sources. Research on this topic is sparse; however, a 2021 study by Tanahara et al. reported that pollution levels, including maximum counts of total coliforms, have recently increased in an area of northwestern Baja California due to improper waste disposal and increased rates of human activities[78]. This provides a possible explanation as to why microbiological contamination exists in water sources that originate from Mexico. Additionally, the presence of microbiological contamination of surface and irrigation water in the Imperial Valley could be due to the introduction of such contaminants after the water is treated. A possible route of contamination could be due to the Imperial Valley's robust agricultural economy[79]. A 2005 and a 2015 study both reported high rates of total coliform (including *E. coli*) in the soil of agricultural regions of California due to animal fecal contamination[80,81].

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77 A. Korajkic, M.j. Brownell, and V.j. Harwood, "Investigation of Human Sewage Pollution and Pathogen Analysis at Florida Gulf Coast Beaches," *Journal of Applied Microbiology* 110, no. 1 (2011): 174–83, https://doi.org/10.1111/j.1365-2672.2010.04869.x.

78 Sorayda Tanahara et al., "Spatial and Temporal Variations in Water Quality of Todos Santos Bay, Northwestern Baja California, Mexico," *Marine Pollution Bulletin* 173 (December 1, 2021): 113148, https://doi.org/10.1016/j.marpolbul.2021.113148.

79 "2021-Economic-Contribution-of-Imperial-County-Ag.Pdf," accessed April 20, 2022, https://agcom.imperialcounty.org/wp-content/uploads/2021/08/2021-Economic-Contribution-of-Imperial-County-Ag.pdf.

80 D. J. Lewis et al., "Linking On-Farm Dairy Management Practices to Storm-Flow Fecal Coliform Loading for California Coastal Watersheds," *Environmental Monitoring and Assessment* 107, no. 1 (August 1, 2005): 407–25, https://doi.org/10.1007/s10661-005-3911-7.

81 Subbarao V. Ravva, Chester Z. Sarreal, and Michael B. Cooley, "Male-Specific Coliphages for Source Tracking Fecal Contamination in Surface Waters and Prevalence of Shiga-Toxigenic Escherichia Coli in a Major Produce

4.2: Communities Facing Water Challenges

According to the information provided by the CDWNA database, the residential areas with the highest water quality category weighted scores are Mitchell Camp Family Association, Winterhaven County Water District, and the Palo Verde County Water District. In 2019, the population of Winterhaven was 192 residents, with 64.6% of residents living in poverty and only 12 individuals employed[82]. 2019 census data also reveals that the population of Palo Verde community was 65 residents, with only 36 (55.4%) of individuals employed[83]. SDWIS data also reported that the community water systems with the highest number of drinking water health-based violations were the city of Westmorland, the city of Holtville, and the Seeley County Water District. In 2019, Seely had a 35% poverty rate, Holtville had a 25.1% poverty rate, and Westmorland had a 33.1% poverty rate[84,85,86]. These demographics suggest that the possible reasons behind the existence of these WASH inequities are population size and a lack of economic resources in comparison to other communities in the Imperial Valley. Small communities with small population size have few resources to pay for advanced treatment and maintenance and operation upgrades and might have the most difficulty meeting new water quality regulations[87].

Qualitative results supported these findings, as key informants also emphasized that many WASH challenges may exist for Imperial Valley residents in low-income and rural areas.

Production Region of the Central Coast of California," *Environmental Science: Processes & Impacts* 17, no. 7 (July 8, 2015): 1249–56, https://doi.org/10.1039/C4EM00537F.

82 "Winterhaven, CA | Data USA," accessed April 20, 2022, https://datausa.io/profile/geo/winterhaven-ca.

83 "Palo Verde, CA | Data USA," accessed April 20, 2022, https://datausa.io/profile/geo/palo-verde-ca.

84 "Seeley, CA | Data USA," accessed April 20, 2022, https://datausa.io/profile/geo/seeley-ca.

85 "Holtville, CA | Data USA," accessed April 20, 2022, https://datausa.io/profile/geo/holtville-ca.

86 "Westmorland, CA | Data USA," accessed April 20, 2022, https://datausa.io/profile/geo/westmorland-ca.

87 Maura Allaire, Haowei Wu, and Upmanu Lall, "National Trends in Drinking Water Quality Violations," *Proceedings of the National Academy of Sciences* 115, no. 9 (February 27, 2018): 2078–83, https://doi.org/10.1073/pnas.1719805115.

According to a profile published by the Southern California Association of Governments Regional Council, the number of individuals residing in unincorporated areas of the Imperial Valley was 40,007 people. This was 21.0% of the population of Imperial County at the time[88]. Previous studies have shown that rural communities in California are highly vulnerable to factors such as drought and climate change, putting them at a greater risk of financial insecurity[89,90].

4.3: Communities Facing Sanitation Challenges

Some key informants cited that mobile home parks face particular wastewater treatment challenges. Many farmworkers often form informal mobile home communities called "polancos" in rural areas of California under the Employee Housing Act[91]. A 2014 qualitative study found that many of these communities lacked proper water connections and contained poorly constructed wells and septic tanks that were prone to leaking and infecting the area surrounding their homes[92]. A greater number of studies should be dedicated to understanding the sanitation challenges faced mobile home park residents.

4.4: Lack of Knowledge

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[88] "Unincareaimperialcounty.Pdf," accessed April 20, 2022, https://scag.ca.gov/sites/main/files/file-attachments/unincareaimperialcounty.pdf?1604708139.
[89] Amber Kerr et al., "Vulnerability of California Specialty Crops to Projected Mid-Century Temperature Changes," *Climatic Change* 148, no. 3 (June 1, 2018): 419–36, https://doi.org/10.1007/s10584-017-2011-3.
[90] Christina Greene, "Broadening Understandings of Drought – The Climate Vulnerability of Farmworkers and Rural Communities in California (USA)," *Environmental Science & Policy* 89 (November 1, 2018): 283–91, https://doi.org/10.1016/j.envsci.2018.08.002.
[91] "Bill Text - AB-2778 Polanco Agrihousing.," accessed April 20, 2022, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB2778.
[92] Vinit Mukhija and David R. Mason, "Resident-Owned, Informal Mobile Home Communities in Rural California: The Case of Rancho Don Antonio, Coachella Valley," *Housing Policy Debate* 25, no. 1 (January 2, 2015): 179–94, https://doi.org/10.1080/10511482.2014.921220.

Information on the WASH challenges faced by agricultural workers was not extensively detailed in the key informant qualitative interviews. In 2019, roughly 8,000 individuals worked in agricultural production in Imperial County, but it is unknown how many individuals migrate from other countries, particularly Mexico, to perform agricultural work[93]. However, literature on the WASH conditions for agricultural workers at their workplace is also limited. A 2018 article by Pena and Teather-Posadas that investigated national and regional responses to the National Agricultural Workers Survey found that not only do some agricultural workers face field sanitation risks, but also data concerning their sanitation access are extremely limited[94]. As mentioned by some key informant interviewees, the United States Department of Labor Occupational Health and Safety Administration (OSHA) requires that agricultural employers provide potable water, toilet facilities, and handwashing facilities to their employees[95]. However, some key informants said they were not sure if agricultural industries within the Imperial Valley truly abided by these regulations.

4.5: Study Limitations

There are limitations to this multi-methods study. The quantitative data provided by the CDWNA, SDWIS, and CPWSS databases only provide limited information on drinking water violations made by community water systems in the Imperial Valley. Therefore, our study does not include the health risks and health-based violations of water systems outside of that

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[93] "2021-Economic-Contribution-of-Imperial-County-Ag.Pdf," accessed April 20, 2022, https://agcom.imperialcounty.org/wp-content/uploads/2021/08/2021-Economic-Contribution-of-Imperial-County-Ag.pdf.

[94] Anita Alves Pena and Edward R. Teather-Posadas, "Field Sanitation in U.S. Agriculture: Evidence from NAWS and Future Data Needs," *Journal of Agromedicine* 23, no. 2 (2018): 123–33, https://doi.org/10.1080/1059924X.2018.1427642.

[95] "1928.110 - Field Sanitation. | Occupational Safety and Health Administration," accessed April 20, 2022, https://www.osha.gov/laws-regs/regulations/standardnumber/1928/1928.110.

jurisdiction. For example, this study did not include violations made by IID private water systems, since that data are not publicly available. This leaves out an estimated 2,700-3,000 households (5.6-6.2%) of the Imperial Valley from our quantitative analysis and limits the external validity of the quantitative results.

Additional qualitative interviews could have strengthened this study. While only key informants were interviewed in this study, valuable data could have also come from interviewing Imperial Valley residents in communities with several health-based drinking water violations. Some key informants mentioned that they had never lived in the Imperial Valley, and a lack of lived experience could have biased their responses. Additionally, qualitative data was initially coded by a single researcher, and while the final themes were cross-checked with another researcher, this could have produced bias and limits the validity of the qualitative results. The sample size of this qualitative study was also not large enough to provide saturation of interview responses.

4.6: Future Research

Existing research on the WASH challenges faced by residents living in the Imperial Valley is limited, and the results of this study reveal where future research should be dedicated. Studies should be dedicated towards understanding the primary cause of contamination of water sources in the Imperial Valley, especially chemical and microbiological contamination. While existing solutions, such as the Point of Entry pilot project, have been created to provide household water treatment to certain residences, data on the project's efficacy and sustainability should be collected so that the project can be expanded. Future studies should also focus on the collection and analysis of drinking water violations made by private water systems, such as those owned by the IID.

Additionally, researchers should create a database that gathers health-based violations on community wastewater treatment and privately-owned septic tank systems for better regulation.

Qualitative interviews with community members, as opposed to just WASH key informants, of the Imperial Valley could reveal valuable data on the WASH challenges faced by residents of this region. Additionally, both existing literature and key informant responses on the WASH challenges faced by agricultural workers in the Imperial Valley was limited. Future research should therefore investigate these challenges in order to characterize the WASH disparities this population may suffer from, so that proper solutions may be put into place. Along with research on the inequities faced by agricultural workers, research should also be dedicated towards the WASH challenges faced by rural communities and low-income homes in unincorporated regions of the Imperial Valley. This could be achieved by interviewing community members in which specific drinking water violations occur.

4.7: Conclusion

This multi-methods study is the first study to investigate the overall WASH challenges faced by residents of the Imperial Valley by utilizing quantitative data from government databases and qualitative data from key informant interviews. Our quantitative results and qualitative results showed that chemical and microbiological contamination cause serious issues for the region's drinking, domestic, and irrigation water sources, and that a possible route of such contamination could be caused by improper wastewater treatment. Additionally, both data sources support the conclusion that rural, low-income, and mobile home park communities face unique WASH disparities as compared to other communities in the Imperial Valley.

The results of this multi-methods thesis show that this is an important area for future study. It suggests there are many knowledge gaps regarding the WASH challenges faced by residents of the Imperial Valley, such as information on the WASH challenges faced by agricultural workers. Additionally, these results reveal the sanitation challenges that come from a lack of oversight of wastewater treatment systems and septic tanks. The results of this study will help a greater number of Imperial Valley residents access safe drinking water and proper wastewater treatment, define areas for future research, and identify interventions to improve public health.

APPENDIX

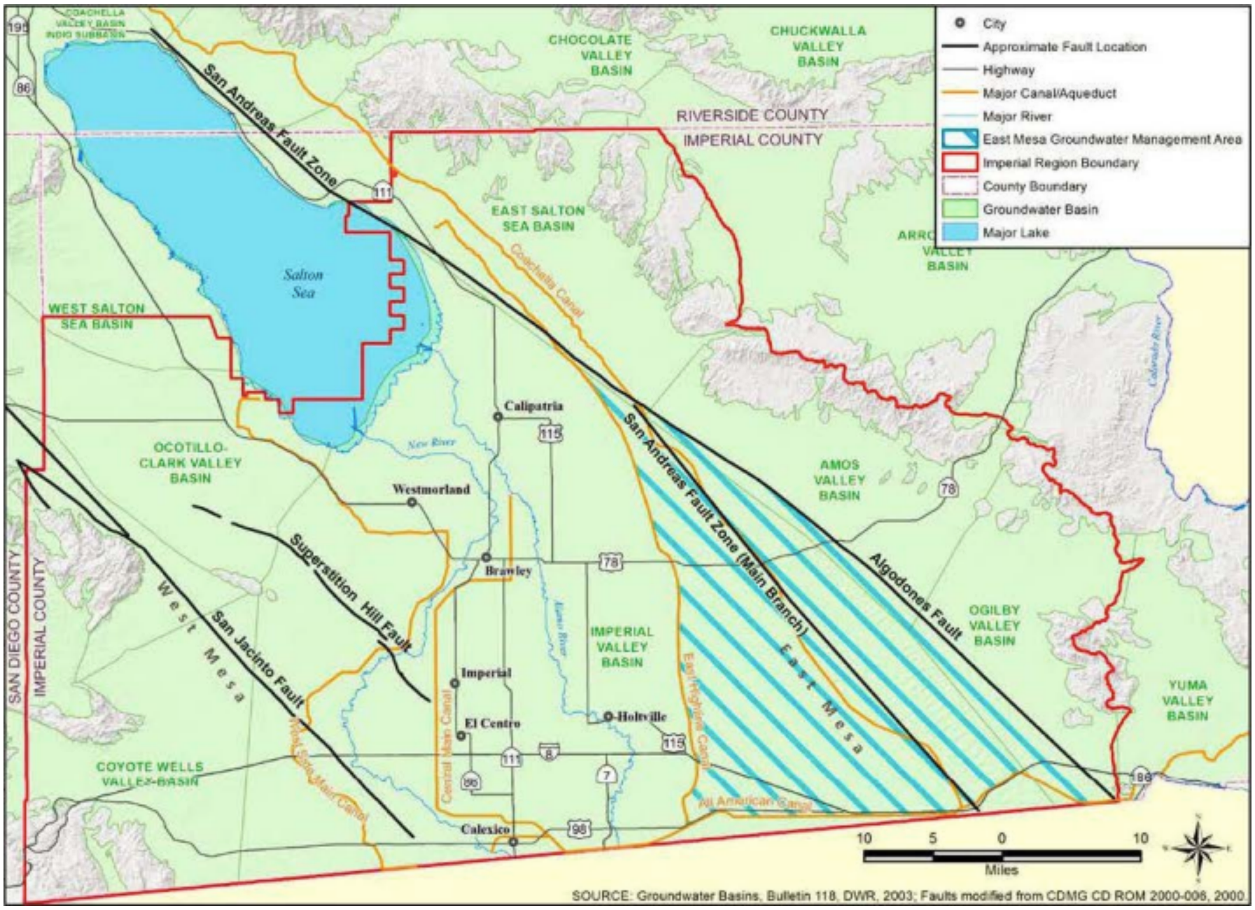

Figure 1: A Map of the Imperial Valley[96]

[96] "Figure P-3. East Mesa Groundwater Management Planning Area." *Appendix P Groundwater Management Planning Elements Guidance Document*, 2012, www.iid.com/home/showpublisheddocument/9546/635648001335730000.

Table 1: Qualitative Interview Questions

Water	o What communities do not have piped water or access to safe water? o What are some major challenges with drinking water quality contamination? o What are the specific water contaminants of concern? o What are some major challenges with intermittent or insufficient water supply? o What are some major challenges with water costs? o What are the water-related inequities that exist in the Imperial Valley? o What are the water challenges faced by agricultural workers in the Imperial Valley? o What are the solutions that have been put into place to address some of these water access challenges?
Sanitation	o What communities do not have access to proper sanitation, such as a lack of toilets or sewage systems? o What are some major challenges with pollution caused by sanitation systems? o What are some major challenges with the cost of sanitation systems? o What are some major challenges with the safety and security of sanitation systems? o What are the sanitation challenges faced by agricultural workers in Imperial Valley? o What are the solutions that have been put into place to address some of these sanitation challenges?
Hygiene	o What communities face hygiene challenges? o What are some major challenges with handwashing (for example, the availability of soap or water)? o What are the solutions that have been put into place to address some of these hygiene challenges?
Other	o Do you think these WASH challenges are more prominent in rural or urban areas in Imperial Valley? o Do any of these WASH challenges affect you personally? If so, how?

Table 2: Imperial County Preliminary Risk Assessment Results for Community Water Systems

Public Water System Name	Population	Service Area	Water Quality Category Weighted Score	Total Weighted Risk Score	Risk Assessment Result	Final SAFER Status
Palo Verde County Water District	410	Residential Area	4.20	1.99	At-Risk	At-Risk
Valley Mobile Home Park	70	Mobile Home Park	2.40	1.80	At-Risk	At-Risk
Mitchells Camp Family Association	175	Mobile Home Park	3.00	1.72	At-Risk	HR2W
Winterhaven County Water District	660	Residential Area	3.60	1.56	At-Risk	At-Risk
IID Drop Four	28	Residential Area	2.00	1.24	At-Risk	At-Risk
Sportsmans Paradise	60	Mobile Home Park	1.80	1.16	At-Risk	At-Risk
River Front Mutual Water Company	15	Other Area	1.80	1.10	At-Risk	At-Risk
IID Village	30	Residential Area	2.25	1.06	At-Risk	HR2W
Meadows Union Elementary School	550	School	0.25	1.06	At-Risk	At-Risk
City of Westmorland	2,444	Other Residential Area	1.75	1.02	At-Risk	At-Risk
Gold State Water Company – Calipatria	4,335	Residential Area	1.75	1.02	At-Risk	At-Risk
Imperial Lakes Inc.	40	Mobile Home Park	0.00	1.00	At-Risk	At-Risk

Table 2: continued

Public Water System Name	Population	Service Area	Water Quality Category Weighted Score	Total Weighted Risk Score	Risk Assessment Result	Final SAFER Status
Mulberry Union School	85	School	1.75	0.98	Potentially At-Risk	Potential At-Risk
City of Brawley	27,337	Other Residential Area	1.75	0.94	Potentially At-Risk	Potential At-Risk
Gold Rock Ranch	50	Mobile Home Park	0.60	0.87	Potentially At-Risk	HR2W
City of Imperial	19,929	Other Residential Area	1.75	0.81	Potentially At-Risk	Potential At-Risk
Date Gardens Mobile Home Park	101	Mobile Home Park	0.00	0.76	Potentially At-Risk	Potential At-Risk
Calipatria State Prison	4,800	Institution	0.00	0.73	Not At-Risk	Not At-Risk
City of Calexico	40,357	Other Residential Area	0.75	0.73	Not At-Risk	Not At-Risk
Gateway	1,800	Secondary Residences	1.25	0.71	Not At-Risk	Not At-Risk
Sunbeam Lake RV Resort	650	Mobile Home Park	0.00	0.70	Not At-Risk	Not At-Risk
McCabe Union School	1,350	School	0.25	0.66	Not At-Risk	Not At-Risk
Pine Union School	217	School	0.25	0.62	Not At-Risk	Not At-Risk
Magnolia Union School	142	School	0.25	0.62	Not At-Risk	Not At-Risk
Centinela State Prison	4,600	Institution	0.00	0.60	Not At-Risk	Not At-Risk
City of Holtville	6,355	Residential Area	0.75	0.57	Not At-Risk	HR2W
Jackson Hide-A-Way	29	Mobile Home Park	0.00	0.56	Not At-Risk	Not At-Risk

Table 2: continued

Public Water System Name	Population	Service Area	Water Quality Category Weighted Score	Total Weighted Risk Score	Risk Assessment Result	Final SAFER Status
Rio Bend RV Golf Resort & Storm Crossing	500	Mobile Home Park	0.00	0.55	Not At-Risk	Not At-Risk
Country MH & RV Park	600	Mobile Home Park	0.00	0.53	Not At-Risk	Not At-Risk
Seeley County Water District	2,010	Residential Area	0.25	0.53	Not At-Risk	Not At-Risk
Naval Air Facility El Centro	972	Secondary Residences	0.00	0.40	Not At-Risk	Not At-Risk
Ocotillo Mutual Water Co	150	Residential Area	0.00	0.33	Not At-Risk	Not At-Risk
Heber Public Utility District	6,979	Other Residential Area	0.25	0.27	Not At-Risk	Not At-Risk
Coyote Valley Mutual Water Co	125	Residential Area	0.00	0.11	Not At-Risk	Not At-Risk

Table 3: Imperial County Health-Based Violations of Community Water Systems

Public Water System Name	Primary Source of Water	Pop. Served	# of Violations	# of Health-Based Violations	Dates of Violations	Health-Based Violation Descriptions
Seeley County Water District	Surface water	2,010	55	48	July 2005 – Oct 2017	MCL (coliform, THAAs, TTHMs), Treatment Technique
City of Holtville	Surface water	6,355	23	20	Sept 2010 – Sept 2016	MCL (TTHMs, THAAs)
City of Westmorland	Surface water	2,444	20	18	July 1993 –July 2017	MCL (TTHMs), Monthly Turbidity, Treatment Technique
Heber Public Utility District	Surface water	6,979	19	14	Mar 1995 – April 2017	MCL (THAAs, TTHMs), Treatment Technique
Centinela State Prison	Surface water	4,600	14	12	Jan 2004 – April 2015	MCL (TTHMs), Treatment Technique
City of Imperial	Surface water	19,929	16	10	Jan 2009 – May 2018	MCL (TTHMs), Treatment Technique
City of Brawley	Surface water	27,337	7	5	Dec 1993 – Jan 2015	MCL (TTHMs), Treatment Technique
Naval Air Facility El Centro	Surface water	972	6	4	Jan 1996 – July 2009	MCL (coliform, TTHMs), Treatment Technique
Calipatria State Prison	Surface water	4,800	5	4	Feb 1998 – Feb 2012	MCL (coliform), Treatment Technique
Sportsmans Paradise	Ground water	60	9	3	Sept 1999 – Oct 2014	MCL (coliform)
City of Calexico	Surface water	40,357	3	3	Jan 2003 – July 2019	MCL (TTHMs)

Table 3: continued

Public Water System Name	Primary Source of Water	Pop. Served	# of Violations	# of Health-Based Violations	Dates of Violations	Health-Based Violation Descriptions
Valley Mobile Home Park	Surface water	70	44	2	Dec-16	Failure to Filter
Palo Verde County Water District	Ground water	410	10	2	Aug 2000 – Jan 2014	MCL (coliform, TTHMs)
IID Village	Ground water	30	6	2	Sept 1999 – Oct 1999	MCL (coliform)
Gold State Water Company – Calipatria	Surface water	4,335	2	2	Dec 2004 – Mar 2006	Monthly Turbidity Exceed, Treatment Technique
Jackson Hide-A-Way	Ground water	29	33	1	Aug-99	MCL (coliform)
Coyote Valley Mutual Water Co	Ground water	125	12	1	May-99	MCL (coliform)
Ocotillo Mutual Water Co	Ground water	150	8	1	Apr-99	MCL (coliform)
City of El Centro	Surface water	44,079	6	1	Oct-02	MCL (TTHMs)
Mitchells Camp Family Association	Ground water	175	4	1	Jul-12	MCL (combined uranium)
Rio Bend RV Golf Resort	Surface water	500	4	1	Jan-93	Treatment Technique
Gateway	Surface water	1,800	2	1	Jan-21	MCL (THAAs)
Date Gardens Mobile Home Park	Surface water	101	32	0	---	---

Table 3: continued

Public Water System Name	Primary Source of Water	Pop. Served	# of Violations	# of Health-Based Violations	Dates of Violations	Health-Based Violation Descriptions
County Life MH and RV Park	Surface water	600	28	0	---	---
Gold Rock Ranch	Ground water	50	10	0	---	---
Winterhaven County Water District	Ground water	660	10	0	---	---
IID Drop 4	Ground water	28	9	0	---	---
Imperial Manor Mobile Home Community	Ground water	200	6	0	---	---
Imperial Lakes Inc	Surface water	40	3	0	---	---
Riverfront Mutual Water Company	Ground water	15	2	0	---	---
Sunbeam Lake RV Resort	Unknown	650	1	0	---	---

Table 4: Imperial County Health-Based Violations of School Water Systems

Public Water System Name	Primary Source of Water	Pop. Served	# of Violations	# of Health-Based Violations	Dates of Violations	Health-Based Violation Descriptions
McCabe Union School	Surface water	1,350	32	0	---	---
Magnolia Union High School	Surface water	142	28	0	---	---
Meadows Union Elementary School	Surface water	550	27	0	---	---
Pine Union School	Surface water	217	24	0	---	---
Mulberry Union School	Ground water	85	2	1	Jul-12	MCL (arsenic)

Table 5: Violations of Public Water Systems Owned by the IID

Water System	Violation Category	Analyte	Result	Year	Compliance Achieved
IID Village	MCL	Arsenic	12.2 ug/L	2020	N
IID Drop 4	RMM	Revised total coliform	--	2021	Y
	RMM	Stage 2 DBPs	--	2020	Y
IID North End	RMM	THAAs	--	2016	Y
	RMM	Stage 2 DBPs	--	2018	Y

Table 6: Qualitative Codes

Themes	Sub-codes
Water Challenges	Chemical Contamination of Surface Water Sources
	Microbiological Contamination
	Water Inequities
	Communities Experiencing Water Challenges
Sanitation Challenges	Pollution by Wastewater Treatment Systems
	Maintenance and Operation of Septic Tanks
	Sanitation Inequities
	Communities Experiencing Sanitation Challenges

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