



APPENDIX:
MEDIAN HOUSEHOLD INCOME (MHI)
AND ECONOMIC STATUS
DETERMINATION METHODOLOGY

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Summary:

Median Household Income (MHI) is a measurement of the annual income level earned by the median household in a specified geographic area. The median household income represents the threshold that divides the income distribution into two equal parts, with half of the households in the specified area earning less than the MHI and half earning more.¹ Unlike the average (or mean), which can be skewed by a small number of very high-income households, the median gives a better sense of what a "typical" household earns. Since it focuses on the middle point of the income range, the median is often considered a more reliable way to understand income in a community than the average (or mean) – especially when some incomes are much higher than most. This may be particularly common in rural areas, where the income of second homes or vacation homes may be very different than the typical income earned by full-time residents. For this reason, MHI is commonly used in socioeconomic analyses and policy assessments to approximate the typical economic situation of households in a particular geographic area.

The American Community Survey (ACS) conducted by the U.S. Census Bureau is the most comprehensive and consistently available data source for estimating income at small geographic scales. The ACS provides 5-Year Estimates for block groups, census tracts, places, and Zip Code Tabulation Areas (ZCTAs) (in addition to other geographic levels, such as counties and metropolitan statistical areas), which collectively cover the entire state of California and allow for localized analysis.²

However, there are important limitations to consider. The ACS relies on a rolling sample survey methodology, meaning data are collected continuously over five years and reflect estimates based on randomly selected households during that period. The most recently published estimates are the 2024 5-Year Estimates, meaning they are based on data collected between January 1, 2020 and December 31, 2024. Monetary values reported in the ACS, including MHI, are inflation-adjusted to the final year of the period (2024 dollars for the 2024 5-Year Estimates). These estimates describe the average characteristics of the population and households over the full period. As a result, year-to-year comparisons can be imprecise, since different households are sampled in each cycle, and short-term economic shifts or demographic changes may not be fully captured. Additionally, even the smallest available geographic unit – the block group – may still encompass diverse economic conditions within its boundaries, especially in sparsely populated areas where block groups tend to be geographically large. Data coverage can be inconsistent. Densely populated areas tend to have more precise estimates and better data availability than sparsely populated areas.

Despite these challenges, MHI derived from ACS data is still one of the most widely accepted metrics for estimating income in policy settings. The data are publicly available, updated regularly, and provide full coverage for the State of California.

¹ [Median Household Income](https://www.census.gov/quickfacts/fact/note/US/INC110221), <https://www.census.gov/quickfacts/fact/note/US/INC110221>

² [U.S. Census Bureau Geography Program Glossary](https://www.census.gov/programs-surveys/geography/about/glossary.html), <https://www.census.gov/programs-surveys/geography/about/glossary.html>

MHI is used to assess the economic status of the community served by water systems and general economic trends over time. In the context of the Needs Assessment, MHI is critical for assessing the affordability of water service provided to a system's customer base, captured by the Percentage of Median Household Income indicator (% MHI).³ The % MHI indicator is used to measure affordability for both the Risk and Affordability Assessment components of the Needs Assessment. The State Water Resources Control Board also relies on MHI to determine Disadvantaged Community (DAC) and Severely Disadvantaged Community (SDAC) status, where DACs are defined as communities with an MHI less than 80% of the statewide MHI⁴, and SDACs as less than 60% of the statewide MHI.⁵

Water system-level median household income (MHI) is calculated using data from the 5-Year ACS Estimates, spatial data on water system service area boundaries, and residential tax parcels from Lightbox. If an income survey accepted by the State Water Board has been conducted in the last five years, the reported MHI from the survey is used, regardless of the methodology version. Twenty-seven (27) valid income surveys have been conducted in the last five years and are used for MHI determination. Spatial analysis is performed in ArcGIS and R using the sf (Simple Features) package by intersecting the water system service area boundary layer with census geographies and residential parcels. For each water system, a weighted average MHI is calculated based on the overlap between the system's service area boundary, census boundaries, and residential parcels.

Required Data Points & Sources:

- California Drinking Water System Area Boundary Layer: SABL⁶
- Median Household Income in the Past 12 Months (data table B19103): most recently available 5-Year Estimates from U.S. Census Bureau's American Community Survey for block groups, census tracts, places, and Zip Code Tabulation Areas (ZCTAs). Earlier ACS 5-Year Estimates (going back to 2016–2020 5-Year Estimates) were used selectively to address missing or suppressed data⁷
- Total Population (data table B01003): most recently available 5-Year Estimates from the U.S. Census Bureau's American Community Survey for block groups, census tracts, places, and Zip Code Tabulation Areas (ZCTAs)
- Census Geography Boundaries for block groups, census tracts, places and Zip Code Tabulation Areas (ZCTAs): most recently available TIGER/Line Shapefiles⁸

³ Percentage of Median Household Income (% MHI) is an indicator utilized by both the Risk and Affordability Assessments that measures the annual system-wide average residential customer charges for 6 hundred cubic feet (HCF) of drinking water usage per month relative to the annual median household income within a water system's service area. 6 HCF (4,488 gallons) of indoor water usage per month is roughly equivalent to 50 gallons per person per day for a three-person household for 30 days.

⁴ Health & Saf. Code, § 116275, subd. (aa)

⁵ Water Code § 13476, subd. (j)

⁶ [California Drinking Water System Boundaries \(SABL\)](https://gispublic.waterboards.ca.gov/portal/home/item.html?id=fbba842bf134497c9d611ad506ec48cc) (internally accessed from the water49 database), <https://gispublic.waterboards.ca.gov/portal/home/item.html?id=fbba842bf134497c9d611ad506ec48cc>

⁷ [American Community Survey Data Tables](https://data.census.gov/table), <https://data.census.gov/table>

⁸ [TIGER/Line shapefiles \(U.S. Census Bureau\)](https://www.census.gov/cgi-bin/geo/shapefiles/), <https://www.census.gov/cgi-bin/geo/shapefiles/>

- Assessor parcels data from Lightbox (internally accessed through the water49 database)⁹
- Income surveys accepted by the State Water Board¹⁰

Over the past several years, the methodology used to calculate water system-level MHI has been progressively refined to improve accuracy, geographic representation, and applicability across different types and sizes of water systems. Three primary methodological approaches have been used since the initial implementation of the Needs Assessment. A summary of all three versions is provided below, with detailed methodologies described thereafter.

Version 1 (2021–2024 Needs Assessment) uses an area-weighted approach based solely on block group-level MHI data from the most recently available ACS 5-Year Estimates.

Version 2 (2025–2026 Needs Assessment) expands the Version 1 methodology to incorporate multiple census geography types, including block groups, census tracts, and places, and by using ACS data dating back to the 2016–2020 5-Year Estimates to address gaps in data availability. Area-weighted MHI estimates are calculated independently for each of the three geography types, and the methodology selects the best-fitting census geography type with the highest percentage of area overlapping with water system service area boundaries. Once the best fit census geography is determined, the area-weighted MHI for that census geography is compared to the MHI threshold that defines disadvantaged communities (DAC). If the area of best fit MHI is lower than the DAC threshold, this MHI value is used as the final MHI for the water system. If the area of best fit MHI is not below the DAC threshold, the lowest MHI is chosen from the available estimates from the three geography types. This conservative approach errs on the side of capturing more potentially disadvantaged communities.

Version 3 (June 2026 and onward) further refines the methodology by incorporating additional census geographies, including ZIP Code Tabulation Areas (ZCTAs), and integrating residential tax parcel data to better identify the best-fitting census geography boundaries. This version transitions from an area-weighted to a population-weighted framework and introduces multiple estimation strategies depending on water system size, geographic overlap, and parcel distribution. For systems with larger service areas, weighted sums from multiple census geographies are combined. Small systems with limited overlap even with the smallest census geography area require additional adjustment or are ultimately classified as having indeterminate MHI.

In all versions of the methodology, ACS-provided Margins of Error (MOE) are incorporated into MHI calculations. Beginning in Version 3, when MHI estimates necessitate scaling or combining across multiple census geographies, the associated MOEs are proportionally

⁹ [LightBox Parcel Data | Comprehensive Nationwide Property Data](https://www.lightboxre.com/data/lightbox-parcel-data/), <https://www.lightboxre.com/data/lightbox-parcel-data/>

¹⁰ The income surveys used by the State Water Board are not publicly available and must be requested. Only valid surveys conducted in the last five years and accepted by the State Water Board are used as a water system's MHI estimate (27 total valid income surveys as of June 2026).

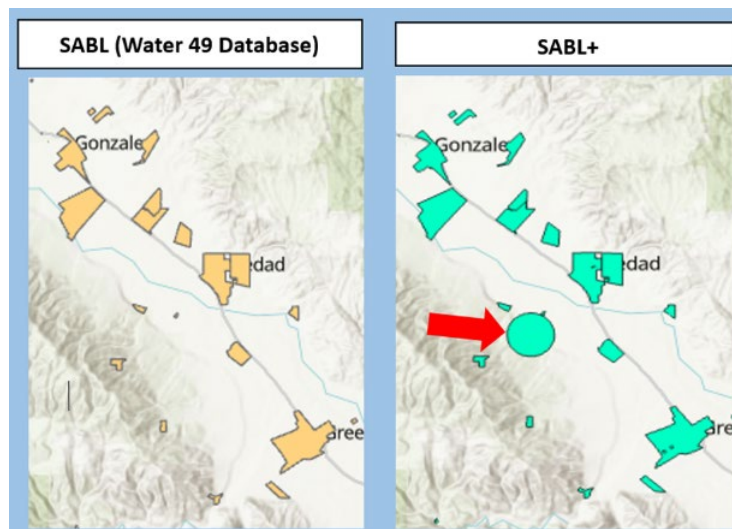
adjusted and propagated through the calculation process.¹¹ For all three versions, MOE estimates are capped using the “maximum usable MOE” approach described in Division of Financial Assistance guidance to avoid unrealistically low lower-bound estimates. Under this approach, MOE values are capped at \$15,000 for systems serving populations of 500 or fewer and \$7,500 for systems serving populations greater than 500. In Version 3, MOE estimates are capped and subtracted only after proportional adjustment and propagation. In Versions 1 and 2, MOE estimates are restricted to the maximum usable MOE *before* combining.

The calculation steps for each version of the MHI methodology are described in detail below.

Methodology Version 1 Calculation Steps (2021–2024 Needs Assessment):

Create System Area Boundary Layer+ (SABL+): First, existing water system boundaries from SABL are combined with artificial boundaries for water systems that do not have a known boundary in SABL. Artificial boundaries are generated for the purposes of the Needs Assessment by creating a 0.5-mile buffer around the location of the water system’s distribution system facility. The boundaries from SABL joined with the artificial boundaries are referred to as SABL+. Figure 1 shows a visualization of the creation of estimated water system boundaries for SABL+. The red arrow indicates the addition of the estimated water system boundary for a missing system.

Figure 1: Visual comparison of the Standard SABL layer to the SABL+ layer



¹¹ [ACS General Handbook Ch. 8. Calculating Measures of Error for Derived Estimates](https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018_ch08.pdf), https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018_ch08.pdf. See also [Documentation for the 2017–2021 Variance Replicate Estimates Tables](https://www2.census.gov/programs-surveys/acs/replicate_estimates/2021/documentation/5-year/2017-2021_Variance_Replicate_Table_Documentation.pdf), https://www2.census.gov/programs-surveys/acs/replicate_estimates/2021/documentation/5-year/2017-2021_Variance_Replicate_Table_Documentation.pdf

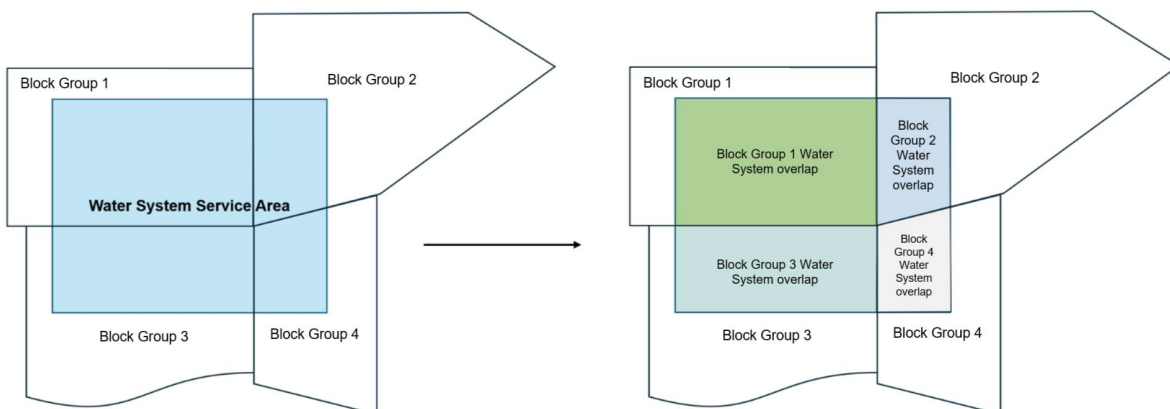
Join ACS data with Block Group Shapefile: To prepare spatial data for analysis, supplemented MHI data from ACS is joined to the corresponding TIGER/Line shapefiles for block groups using geographic identifier fields (GEOID).

MHI Margin of Error Adjustment: The ACS MHI data includes a margin of error (MOE) for each estimate, which is used to adjust MHI estimates for uncertainty. Following the procedure established by State Water Board’s Division of Financial Assistance (DFA), the MOE is used to calculate a “lower bound MHI” for each census area, meaning that the MOE is applied *only downward* by subtracting the MOE from the MHI. This approach ensures that potential error (reflected by the MOE) does not lead to an overestimation of household income and instead errs on the side of capturing more potentially disadvantaged communities.

Because some of the MOE estimations are quite large and would result in unrealistic lower bound MHI, the Version 1 methodology also follows DFA’s guidance on “maximum usable MOE”.¹² The block group MOE provided by ACS is adjusted to the maximum usable MOE based on the population of the water system intersecting with the census area. The maximum usable MOE for each census area is capped at \$15,000 for systems with a population of 500 or less, and \$7,500 for systems with a population greater than 500.

Intersect Water System and Block Group Boundaries: Service area boundaries from SABL+ are intersected with block group-level boundaries containing MHI data using the sf (Simple Features) package in R. This analysis produces a new shapefile, containing the geographic overlap between service areas and block groups.

Figure 2: Illustration of Block Group Area-Weighting Method



Determine Intersection “Weight”: For each water system, intersection weights are calculated based on the portion of the service area overlapping block groups containing non-missing MHI data. When a system intersects multiple block groups, and one or more of those block groups

¹² [DFA Policy for Developing the Fund Expenditure Plan](https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf), https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf

has missing MHI values, only the intersecting areas with non-missing values are included in the weighting. The total portion of intersecting area with valid (non-missing) MHI data is used as the denominator to calculate each area's share of the system-level weight. This ensures that missing data does not distort the final area-weighted MHI calculation.

Block Group Area-Weighted MHI Calculation: After determining the lower bound MHI for each area of intersection by applying the applicable maximum usable MOE, the system's overall MHI is calculated by weighting each intersecting lower bound MHI by the percentage of the block group area overlapping with the water system. The formula for this weighting is found in Equation 1.

If an income survey accepted by the State Water Board has been conducted in the last five years, the reported MHI from the survey is used.

Equation 1: Water System Block Group Area-Weighted MHI Calculation

$$\text{Median Household Income (Block Group Area-Weighted)} = \sum \left(\left(\frac{\text{Intersection Area}}{\text{Total Non-Missing Area}} \right) \times \text{Block Group Median Household Income} \right)$$

Methodology Version 2 Calculation Steps (2025–2026 Needs Assessment):

Create System Area Boundary Layer+ (SABL+): This step follows the same calculation procedure used in Version 1 Methodology. First, existing water system boundaries from SABL are combined with artificial boundaries for water systems that do not have a known boundary in SABL. Artificial boundaries are generated for the purposes of the Needs Assessment by creating a 0.5-mile buffer around the location of the water system's distribution system facility. The boundaries from SABL joined with the artificial boundaries are referred to as SABL+.

Supplement Missing ACS Data: Version 2 expands the MHI methodology to incorporate multiple census geography types, including block groups, census tracts, and places, to improve data coverage. Where a census geography lacks a current MHI estimate, missing values are supplemented with the most recently available MHI estimate from prior ACS survey years (2020 to present). This approach prioritizes more recent data, substituting a 2023 estimate before a 2022 estimate when multiple years are available. For a small number of areas where MHI falls at the lower or upper extremes of the income distribution (below \$2,500 or above \$250,000), estimates are reported as open-ended ranges and a margin of error (MOE) is not provided by the ACS. Where available, prior ACS estimates are incorporated to improve precision for these areas in the most recent data release. The incorporation of previous years of ACS data significantly reduces the number of census areas with missing MHI data, resulting in more precise water system-level income approximations.

Join ACS data with Census Geographies: This step follows the same calculation procedure used in Version 1 Methodology for each geography type. To prepare spatial data for analysis,

supplemented MHI data from ACS is joined to the corresponding TIGER/Line shapefiles for block groups, census tracts, and places using geographic identifier fields (GEOID).

Margin of Error Adjustment: This step follows the same calculation procedure used in Version 1 Methodology. The ACS MHI data includes a margin of error (MOE) for each estimate, which is used to adjust MHI estimates for uncertainty. Following the procedure established by State Water Board’s Division of Financial Assistance (DFA), the MOE is used to calculate a “lower bound MHI” for each census area, meaning that the MOE is applied *only downward* by subtracting the MOE from the MHI. This approach ensures that potential error (reflected by the MOE) does not lead to an overestimation of household income and instead errs on the side of capturing more potentially disadvantaged communities.

Because some of the MOE estimations are quite large and would result in unrealistic lower bound MHI, the Version 2 methodology also follows DFA’s guidance on “maximum usable MOE”.¹³ The census area MOE provided by ACS is adjusted to the maximum usable MOE based on the population of the water system intersecting with the census area. The maximum usable MOE for each census area is capped at \$15,000 for systems with a population of 500 or less, and \$7,500 for systems with a population greater than 500.

Intersect Water System Boundaries and Census Geographies: This step follows the same calculation procedure used in Version 1 Methodology for each of the three census geographies (block group, census tract, and place). Service area boundaries from SABL+ are intersected with each of the three census geographies boundaries containing MHI data using the sf (Simple Features) package in R. This analysis produces three new shapefiles, containing the geographic overlap between the service areas and each of the three spatial levels (block group, tract, place).

Determine Intersection “Weight”: This step follows the same calculation procedure used in Version 1 Methodology for each geography type. For each water system, intersection weights are calculated based on the portion of the system overlapping census areas containing valid MHI data within a given geography type. When a system intersects multiple census areas of a geography type (e.g., block groups), and one or more of those areas has missing MHI values, only the intersecting areas with non-missing values are included in the weighting. The total intersecting area with non-missing MHI data is used as the denominator to calculate each area’s share of the system-level weight. This ensures that missing data does not distort the final area-weighted MHI calculation.

Area-Weighted MHI Calculation: This step follows the same calculation procedure used in Version 1 Methodology for each geography type. After determining the lower bound MHI for each area of intersection by applying the applicable maximum usable MOE, the system’s

¹³ [DFA Policy for Developing the Fund Expenditure Plan](https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf),

https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf

overall MHI is calculated by weighting each intersecting lower bound MHI by the percentage of each census area that intersects with the water system.¹⁴

Select MHI for Water System: The area-weighting described above results in three sets of water system-level MHI estimations, one for each of the census geography types (block group, census tract, and place).¹⁵ The procedure for selecting the final MHI for each water system depends on the availability of additional income data and the census area that best corresponds with the system's service area boundaries.

If an income survey accepted by the State Water Board has been conducted in the last five years, the reported MHI from the survey is used. If no income survey data was available, the most appropriate census geography (block group, census tract, or place) is identified for each water system using two criteria. For water systems that fall predominantly within a single census geography, the geography with the greatest area overlap is selected. For water systems spanning multiple census geographies, the approach minimizes the number of intersecting geographies needed to calculate an estimate, favoring simpler aggregations over more complex ones.

Once the area of best fit is determined, the area-weighted MHI for that census geography is compared to the MHI threshold that defines disadvantaged communities (DAC), i.e., 80% of the statewide MHI. Because identifying DACs is critical for targeting resources and support to communities in need, the Version 2 MHI methodology is intentionally designed to make conservative determinations – meaning it errs on the side of identifying a water system as disadvantaged when there is reasonable evidence to support that classification. If the area of best fit MHI is lower than the DAC threshold, the best fit MHI value is used as the final MHI for the water system. If the area of best fit MHI is not below the DAC threshold, the lowest available MHI is chosen from the available block group, census tract, and place area-weighted estimates.

¹⁴ This method implicitly assumes that the population of each water system is evenly distributed across its service area. In other words, if 50% of a system's area overlaps with a given census area, it is assumed that 50% of the system's population resides within that census area. While this area-weighting approach is commonly used due to data availability and straightforward calculation, it does not account for the actual distribution of people within the service area. This assumption may be particularly problematic in rural areas, where census geographies tend to cover large expanses with sparse or uneven population densities. The State Water Board is actively working to develop alternative MHI estimation methods that incorporate population distribution to better reflect these realities. For example, Version 3 MHI methodology uses residential tax parcels to better estimate population distribution within water system service areas and reduce reliance on the assumption of evenly distributed population.

¹⁵ Because census places are not spatially continuous, not every water system analyzed in the Needs Assessment corresponds with a place. Therefore, there are significantly fewer systems that have a place area-weighted MHI.

Methodology Version 3 Calculation Steps (June 2026 and onward):

Load California Drinking Water System Area Boundary Layer (SABL): Version 3 uses the State Water Board's System Area Boundary Layer (SABL) to define public water system service area boundaries for spatial analyses. Following a comprehensive effort to add and verify community water system boundaries, all community water systems are now represented in SABL, eliminating the need for the supplemental SABL+ layer used in prior versions and removing the need to create artificial boundaries for systems previously absent from SABL. Efforts to verify and refine system boundaries remain ongoing.

Supplement Missing ACS Data: For census geographies (block group, census tract, place, or ZCTA) missing MHI estimates in the most recent data release, prior ACS survey years are used to improve data coverage. This approach prioritizes more recent data (e.g., a 2023 estimate would be used before a 2022 estimate when both are available). Incorporating prior ACS data substantially reduces the number of census geographies with missing MHI values, resulting in more precise water system-level income estimates.

Join ACS data with Census Geographies: To prepare spatial data for analysis, supplemented MHI data from ACS is then joined to the corresponding TIGER/Line shapefiles for block groups, census tracts, places, and ZCTAs using geographic identifier fields (GEOID).

Intersect Water System Boundaries and Census Geographies: Service area boundaries from SABL are then intersected with block group, census tract, place, and ZCTA-level boundaries containing MHI data using the sf (Simple Features) package in R. This analysis produces four new shapefiles containing the geographic overlap between the service areas and each of the four spatial levels (block group, tract, place, ZCTA).

Calculate Number of Residential Parcels Per Area: County assessor parcel datasets are obtained from Lightbox (internally accessible through the water49 database) for all California counties and processed in ArcGIS to identify residential parcels using county assessor land use codes. Residential parcels are identified using county assessor land use codes and classified using a methodology consistent with other studies and analytical efforts that use tax parcel data to estimate residential populations and characteristics.¹⁶ Residential parcel records are exported and combined in R to create a statewide residential parcel dataset. Residential parcel counts are then calculated for each water system service area boundary, each census geography (block group, census tract, place, and ZCTA), and each resulting intersecting area. These parcel counts are used to estimate the distribution of residences across intersect areas, identify the census geography that best represents where residents are located in each water system service area, and identify the best-fit census boundaries with which the highest percentage of residential parcels overlap.

¹⁶ One example is: Nicholas J. Depsky, Lara Cushing, and Rachel Morello-Frosch (2022): [High-resolution Gridded Estimates of Population Sociodemographics from the 2020 Census in California](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0270746), <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0270746>

Calculate Proportion of Residential Parcels Per Area: For each intersected water system service area and census geography, the proportion of residential parcels located within the service area boundary is calculated. These proportions are used to evaluate how well each census geography represented the population served by the water system.

Determine Appropriate Calculation Method: After identifying valid census geographies, each water system is classified according to how closely its service area aligns with available census geographies. The classification considers:

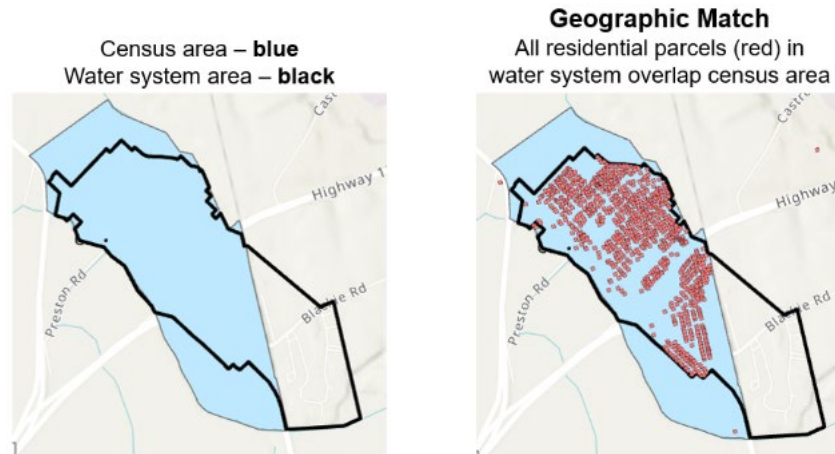
- The proportion of a water system's residential parcels contained within valid census geographies;
- Whether residential parcels are concentrated within a single census geography or distributed across multiple geographies; and
- Whether valid census geographies represent a single census geography type (e.g., place, block group) or multiple geography types. If multiple census geography types are determined to be valid, a hierarchical selection process based on relative size is used to combine estimates.

This classification is used to determine the most appropriate MHI estimation approach for each water system.

Calculate Service Area Median Household Income (MHI): Service area MHI estimates are calculated using one of several approaches depending on the degree of alignment between the water system service area and available census geographies. The methodology is designed to identify census geographies that collectively represent at least 95 percent of the residential parcels within each water system service area whenever sufficient data are available.

- Approach 1, Direct Assignment: A census geography's MHI is directly assigned to a water system when both of the following conditions were met: (1) at least 95% of the water system's residential parcels are contained within a single valid census geography, and (2) at least 70% of that census geography's residential parcels are contained within the water system boundary. These dual criteria ensure a strong spatial alignment between the water system and the census geography before a direct assignment is made. An example of a census area where the MHI would be directly assigned to the water system is shown in Figure 3.

Figure 3: Direct Assignment of Census Area MHI to Water System

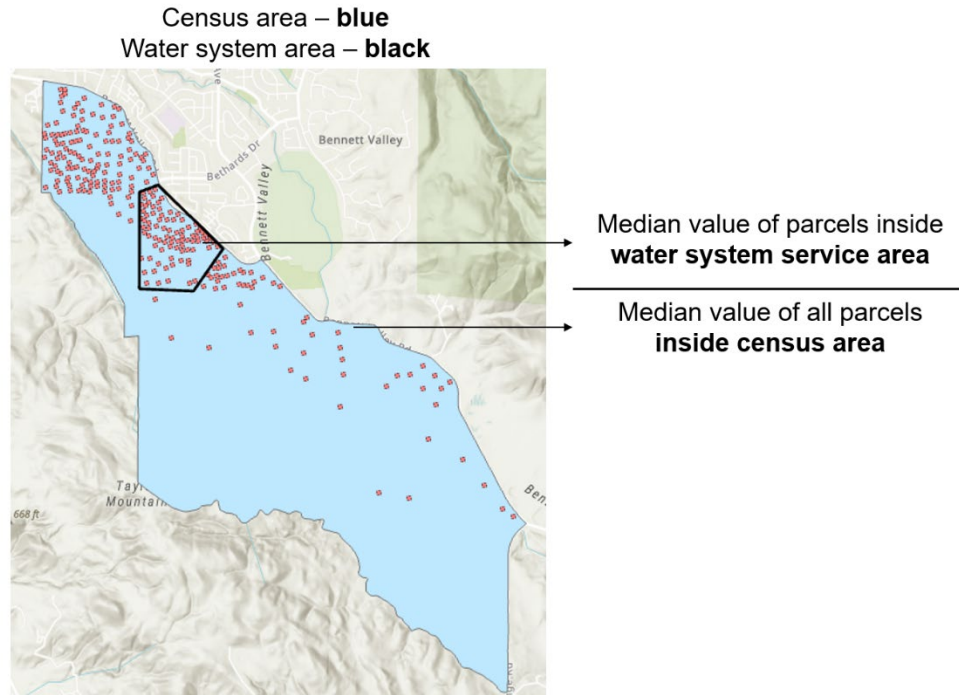


- Approach 2, Parcel-Based Scaling: For some small water systems, a single census geography contains at least 95 percent of the water system's residential parcels (Condition 1 is satisfied), but fewer than 70 percent of the census geography's residential parcels are located within the water system service area (Condition 2 is not satisfied). In these cases, the census area MHI may not accurately reflect local socioeconomic conditions because the census geography extends well beyond the area served by the water system. For example, there are cases where a lower-income water system community is located within a higher-income census area, or where a higher-income community is located within a lower-income census area. To address this limitation, MHI estimates are adjusted using parcel-based scaling techniques. Scaling factors are derived from the median of the assessed value of residential tax parcels inside the water system relative to the median of the assessed value of all residential tax parcels in the overlapping census area to better reflect the characteristics of the water system service area. The equation for the parcel-based scaling factor is found in Equation 2. An example of a water system where the census area MHI would require scaling is shown in Figure 4.

Equation 2: Residential Parcel Value Scaling Factor

$$\text{Water System MHI} = \text{Census Area MHI} \times \frac{\text{Median Home Value in Water System Boundary}}{\text{Median Home Value in Census Area}}$$

Figure 4: Water System Requiring Parcel-Based Scaling of Census Area MHI



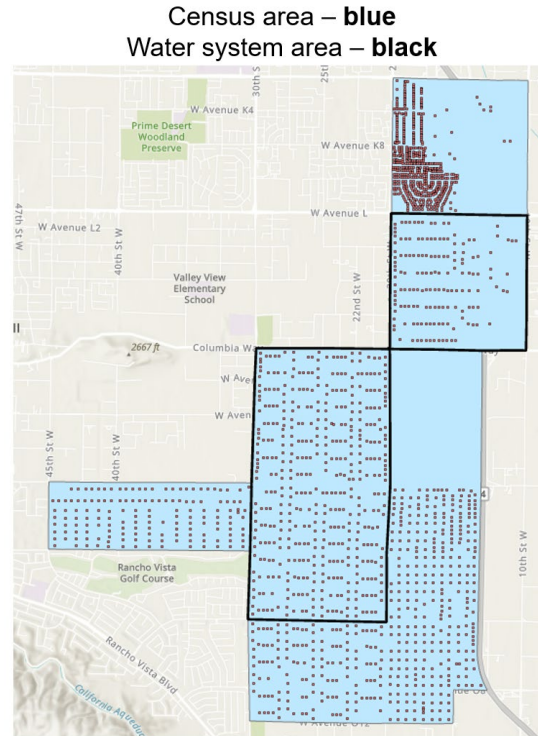
- Approach 3, Parcel-Based Scaling and Combination: For some small water systems, multiple census geographies contain at least 95 percent of the water system's residential parcels (Condition 1 is satisfied), but fewer than 70 percent of the residential parcels in each overlapping census geography are located within the water system service area (Condition 2 is not satisfied). In these cases, the census area MHI may not accurately reflect local socioeconomic conditions because the census geography extends well beyond the area served by the water system. To address this limitation, MHI estimates are adjusted using parcel-based scaling techniques. Scaling factors are derived from the median of the assessed value of residential tax parcels inside the water system relative to the median of the assessed value of all residential tax parcels in the overlapping census area to better reflect the characteristics of the water system service area. After scaling individual census area MHI estimates, the scaled estimates are then combined using weights based on the proportion of residential parcels represented by each census area. The equation for the parcel-based scaling and combination MHI calculation can be found in Equation 3. An example of a water system where the census area MHI would require both scaling and combining is shown in Figure 5.

Equation 3: Water System Parcel-Based Scaling and Combination MHI Calculation

$$\text{Parcel-Based Scaling Factor} = \frac{\text{Median Home Value in Water System Boundary}}{\text{Median Home Value in Census Area}}$$

$$\text{Water System MHI (Scaled and Combined)} = \sum \left(\text{\% of Water System Parcels per Individual Census Area} \times \text{Parcel-Based Scaling Factor} \times \text{Individual Census MHI} \right)$$

Figure 5: Water System Requiring Parcel-Based Scaling and Combination MHI Calculation



- Approach 4, Population-Weighted Combination: For water systems overlapped by multiple valid census geographies and geography types (with at least 70% of each of the census area’s residential parcels inside of the water system service area), MHI estimates are combined using population-weighted averages based on the most recently available ACS 5-Year population estimates. This approach is used when multiple valid census geographies collectively represent at least 95 percent of the water system’s residential parcels. The formula for this weighting is found in Equation 4 and an example population-weighted calculation is shown in Equation 5. An example of a water system where the calculation of MHI requires the population-weighted combination of multiple census areas is shown in Figure 6.

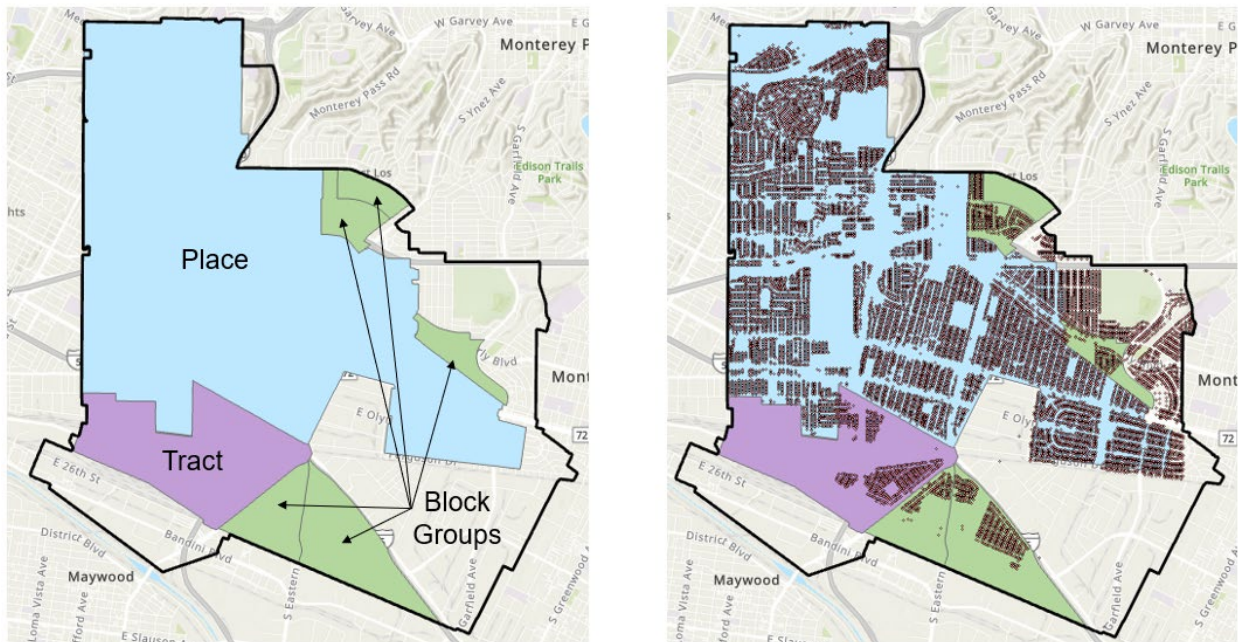
Equation 4: Water System Census Population-Weighted MHI Calculation

$$\text{Water System MHI (Population-Weighted)} = \sum \left(\left(\frac{\text{Individual Census Area Population}}{\text{Total Census Area Population}} \right) \times \text{Individual Census Area MHI} \right)$$

Equation 5: Example Population-Weighted Calculation

$$\text{Water System MHI (Population-Weighted)} = \left(\frac{\% \text{ of Total Census Area Population in Census Area A}}{\text{Population in Census Area A}} \times \text{MHI of Census Area A} \right) + \left(\frac{\% \text{ of Total Census Area Population in Census Area B}}{\text{Population in Census Area B}} \times \text{MHI of Census Area B} \right)$$

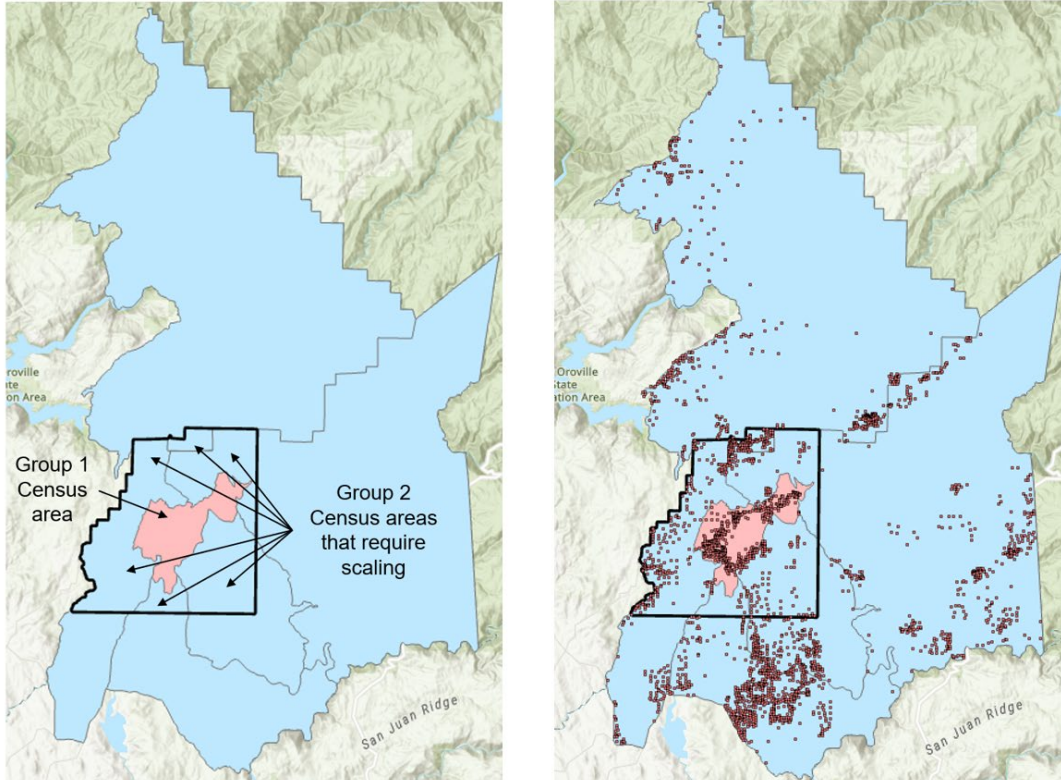
Figure 6: Water System Requiring Population-Weighted Combination of Census Area MHI



- Approach 5, Parcel-Weighted Combination with Parcel-Based Scaling (combination of Approach 3 and 4): For some water systems, one or more valid census geographies are identified to have at least 70% of each of the census area's residential parcels inside of the water system service area (Group 1 census area, as shown in Figure 7), but they collectively represent less than 95 percent of the water system's total residential parcels. In these cases, parcel-based scaling techniques (Approach 3) are used to estimate MHI for census geographies overlapping with the remaining portion of the service area but with less than 70% of their parcels inside the water system service area (Group 2 census areas, as shown in Figure 7). Direct MHI estimates from Group 1 census geographies (Approach 4) and scaled MHI estimates for Group 2 census geographies (Approach 3) are then combined using weights based on the proportion of residential parcels represented by each area. An example of a water system where the calculation of MHI requires both population-weighted combination and parcel-based scaling of multiple census areas is shown in Figure 7.

Figure 7: Water System Requiring Population-Weighted Combination and Parcel-Based Scaling

Census area – **blue & pink**
Water system area – **black**



- **Indeterminate MHI:** Water systems are classified as having an indeterminate MHI when insufficient data are available to produce a reliable estimate. This occurs when fewer than 15 residential tax parcels are present within the overlap between the water system service area and the selected census geography, or when MHI data are unavailable for the relevant census geography. Estimates based on fewer than 15 parcels are considered insufficiently reliable because the median assessed value of residential tax parcels used for the scaling factor becomes overly sensitive to individual parcel characteristics.

Margin of Error Adjustment: The ACS MHI data includes a margin of error (MOE) for each estimate, which is used to adjust MHI estimates for uncertainty. Following the procedure established by the State Water Board’s Division of Financial Assistance (DFA), the MOE is used to calculate a “lower bound MHI” for each census area, meaning that the MOE is applied *only downward* by subtracting the MOE from the MHI. This approach ensures that potential error (reflected by the MOE) does not lead to an overestimation of household income and instead errs on the side of capturing more potentially low-income communities.

Because some of the MOE estimations are quite large and would result in unrealistic lower bound MHI, the Version 3 Methodology also follows DFA’s guidance on “maximum usable MOE”.¹⁷ The census area MOE provided by ACS is adjusted to the maximum usable MOE based on the population of the water system intersecting with that census area. The maximum usable MOE is capped at \$15,000 for systems with a population of 500 or less, and \$7,500 for systems with a population greater than 500.

The MOE adjustment procedures described above apply directly to MHI estimates assigned from a single census geography (i.e., water systems with MHI calculated through Approach 1, direct assignment). However, additional adjustments are necessary when MHI estimates are modified through parcel-based scaling or when multiple census geographies are combined to produce a single water system-level estimate.

- **Parcel-Based Scaling:** for census areas where a parcel-based factor is used to scale the MHI estimate, the associated MOE is multiplied by the same scaling factor. The maximum usable MOE adjustment is applied to the parcel-scaled MOE and subtracted from the MHI estimate
- **Population-Weighted Combination:** for water systems represented by multiple census geographies, water system-level MOEs are calculated by combining the uncertainty associated with each contributing census area estimate. Because uncertainty from independent estimates does not accumulate linearly, MOEs are combined using a root-sum-of-squares (RSS) variance propagation approach.¹⁸ This method accounts for the contribution of uncertainty from each census area estimate while avoiding overstatement of the overall uncertainty associated with the combined water system MHI estimate. The calculation used to combine MOEs from multiple census geographies is shown in Equation 6.

Equation 6: Margin of Error Calculation for Population-Weighted MHI

$$\frac{\text{Individual Census Area}}{\text{Population Weight}} = \frac{\text{Individual Census Area Population}}{\text{Total Census Area Population}}$$

$$\text{Water System Margin of Error} = 1.645 \times \sqrt{\sum \left(\left(\frac{\text{Individual Census Area}}{\text{Population Weight}} \right)^2 \times \left(\frac{\text{Individual Census Area MOE}}{1.645} \right)^2 \right)}$$

¹⁷ [DFA Policy for Developing the Fund Expenditure Plan, https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf](https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/docs/2024/final-policy-for-dev-fep-sadwf.pdf)

¹⁸ [ACS General Handbook Ch. 8. Calculating Measures of Error for Derived Estimates, https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018_ch08.pdf](https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018_ch08.pdf). See also [Documentation for the 2017-2021 Variance Replicate Estimates Tables, https://www2.census.gov/programs-surveys/acs/replicate_estimates/2021/documentation/5-year/2017-2021_Variance_Replicate_Table_Documentation.pdf](https://www2.census.gov/programs-surveys/acs/replicate_estimates/2021/documentation/5-year/2017-2021_Variance_Replicate_Table_Documentation.pdf)

- Parcel-Weighted Combination with Parcel-Based Scaling: For water systems represented by multiple census geographies, including cases where parcel-based scaling is applied to portions of the service area, water system-level MOEs are calculated by combining the uncertainty associated with each contributing census area estimate. For census areas requiring parcel-based scaling, the associated MOE is multiplied by the same scaling factor used to adjust the MHI estimate. MOEs are then combined using a root-sum-of-squares (RSS) variance propagation approach shown by Equation 6 by replacing the population weight with the scaling factor for each individual census area. The resulting water system-level MOE is then subject to the maximum usable MOE adjustment before being subtracted from the final MHI estimate.
- Indeterminate MHI: no MOE is calculated