Community Water System (CWS) Boundaries

Created by the Water Equity Science Shop (WESS)

Shared with CWC on February 3, 2020

Metadata: Interactive_CWS_geography.shp

Data Type:	Shapefile Feature Class
Shapefile:	Interactive_CWS_geography.shp
Geometry Type:	Polygon
Coordinates have Z values:	No
Coordinates have measures:	No
Projected Coordinate System:	NAD_1983_California_Teale_Albers
Projection:	Albers
False_Easting:	0.00000000
False_Northing:	-4000000.00000000
Central_Meridian:	-120.00000000
Standard_Parallel_1:	34.00000000
Standard_Parallel_2:	40.50000000
Latitude_Of_Origin:	0.00000000
Linear Unit:	Meter
Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Summary

The Water Equity Science Shop (WESS) created a shapefile containing selected boundaries from the Tracking California Water System Service Areas tool (formerly known as the Water Boundary Tool) representing active, community water systems to be used in the Drinking Water Tool. WESS estimated the number of housing units served by CWS using data from the 2010 US Census and estimated the systems' water quality using data from CalEnviroscreen (CES) 3.0. This document details the methods and data sources used to create and clean CWS boundaries, estimate housing units, and estimate water quality for the 2,851 CWS included in the Interactive_CWS_geography.shp file.

In addition to the analysis undertaken by WESS, summarized in steps A through C below, additional water system characteristics were developed and joined to the WESS-created boundary file, based on each water system's Public Water System ID (PWSID) number and additional spatial analysis as described in steps D through G. An attribute table follows these brief methodological descriptions.

The Water Equity Science Shop (WESS) Methodology:

A. Creating CWS Boundaries:

Water system boundaries were accessed from the Water Boundary Tool in January 2019, now known as the Tracking California Water System Service Areas tool (https://trackingcalifornia.org/water-systems/water-systems-landing). A list of water systems from the State Drinking Water Information System (SDWIS) Public Drinking Water Watch dataset (https://data.ca.gov/dataset/drinking-water-public-water-system-information) was downloaded and joined to water system boundaries available in the Tracking California Water System Service Areas tool. This step was taken to select water systems that met the following inclusion criteria according to SDWIS 1) system was a "community" water system (defined as a public water system serving at least 15 connections (ie: households) and 25 year round residents), and 2) system was classified as "active." The boundaries of included water systems were cleaned by removing duplicate systems and resolving overlaps, and wholesale systems were identified and excluded using methods described in CalEnviroscreen 3.0 (https://oehha.ca.gov/media/downloads/calenviroscreen/report/ces3dwmethodology.pdf).

B. Assigning housing units to CWS:

Housing unit data from the 2010 Census were used to estimate the number of housing units served by Community Water Systems (CWS). Housing unit values were generated by intersecting Census Block 2010 geography (https://www.census.gov/geo/maps-data/data/tiger-data.html Accessed June 12, 2018) with cleaned CWS service area boundaries and then distributing the housing units from census blocks to each CWS by aerial apportionment.

C. Assigning Water Quality Values to CWS:

Water quality values for selected contaminants were assigned from the CES 3.0 dataset to the 2,851 CWS. The CES 3.0 dataset used monitoring data from the State Water Resources Control Board (SWRCB) Water Quality Monitoring (WQM) database. http://www.cdph.ca.gov/certlic/drinkingwater/pages/EDTlibrary.aspx. In brief, CES 3.0 downloaded reported water quality results from 2005-2013 from the SWRCB WQM database for all active drinking water systems. "Active treated" samples were primarily evaluated, as these represent water delivered to the consumer. Delivered water could include sources sampled post treatment or sampled from "untreated" sources, which is delivered without undergoing treatment. Approximately 3% of the data came from "raw" samples because the systems had no treated or untreated source classifications. Complete methods used in CES 3.0 are published elsewhere (https://oehha.ca.gov/media/downloads/calenviroscreen/report/ces3dwmethodology.pdf). Each contaminant has both an attribute for the concentration value and an attribute describing its data source. Version 1.0 of the Drinking water tool contains water quality data for Arsenic (As), Nitrate as N (N), 1,2,3-Trichloropropane (1,2,3-TCP) and Hexavalent Chromium (Cr6). These four contaminants were selected because of their acute or carcinogenic health effects. Updated versions of the Drinking Water Tool will incorporate data for additional high priority contaminants.

If downloading or using for analysis or reporting, please attribute and cite WESS generated fields as:
UC Berkeley Water Equity Science Shop Community Water System boundaries version 1.0, 2019.
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Methodology for Additional CWS characteristics

D. Joining characteristics from publicly available CWS datasets (CWC 2020)

Several water system characteristics were joined to the shapefile using the Community Water System's PWSID code. These fields were either joined directly from existing public data or compiled from public data.

Existing dataset fields include the water system ownership (**OWNERSHIP1**); total population served (**Total_Popu**); the total number of service connections (**Total_SCV_**) which are all from the same 2018 SWRCB/SDWIS file WESS used, referenced again (https://data.ca.gov/dataset/drinking-water-public-water-system-information, accessed 12/10/2018).

Two fields were joined from data available from the SWRCB's Human Right to Water Portal (HR2W) (2019): the water quality regulating agency and count of MCL violations for each water system.

- **Water Quality Regulating Agency (WQ_REG)**: The regulating entity named in this data layer is based on the "REGULATING" field from the SWRCB's HR2W EC Summary (Summary GIS shapefile, June 2019).
- **Count of MCL violations** (**MCLV_HRTW1**): The HR2W Portal tracks public water systems with current exceedance or compliance issues and those who have returned to compliance for the period 1/1/2012 through 8/30/2019. This field is a sum of the total count of unique MCL Violations from the period available. Note: any CWS that wasn't listed in either of the available spreadsheets from the state was assigned a "0" value. A data disclosure about dataset limitations is available online from the state (HR2W Data Disclosure).

Revised Water Source Type (Source_new): This revised source type field accounts for any systems that are able to produce water from both GW and SW, instead of limiting to Primary Water Source (Primary_Wa) from the SDWIS system which is a designation related to water treatment requirements. This field was based on data submitted by water systems in their electronic annual report (EAR) inventory information using the data available in the "produced-water-public-water-system-reported-in-the-electronic-annual-report-ear-2013-2016" file (SWRCB 2019) combined with data available from SWRCB/SDWIS 2018. Possible source water types are: BOTH (groundwater and surface water); GW (Groundwater); GWP (purchased groundwater); SW (surface water); SWP (purchased surface water).

Systems were assigned a value based on creating binary indicators for when a water system produced any volume of water greater than 0 (1) or zero volume (0) from groundwater, surface water, or purchased water. When groundwater and surface water were both > 0, the system was assigned, "Both". For systems with only Purchased Water (PW), their final source type was set equal to the SWRCB/SDWIS (2018) Primary Water Source. Any water system with missing data in the SWRCB (2019) EAR file was assigned their Primary Water Source from SWRCB/SDWIS (2018). In general, the benefit of using the SWRCB (2019) data was to better capture systems that have the ability to produce water from both surface and groundwater resources at least during the 2013-2016 time period.

E. Assigning Groundwater and Sustainable Groundwater Management Act attributes (CWC 2020)

Count of Private Domestic Wells within a CWS service area (Join_Count): this field was created using the Spatial Join tool with the match option or join rule of "Contains", so a count of private domestic wells were joined to the CWS if wells were located within the boundary of the CWS. This analysis relies on the Pace et al. (2019) Private Domestic Well location layer, which includes domestic wells from the OSCWR data.

Potential GSA Membership (GSA_Names, GSA_Name1:6, Basin1:6): These fields list the exclusive Groundwater Sustainability Agencies (GSAs) that may be developing a groundwater sustainability plan (GSP) that could impact a water system. The list of potential GSAs was generated using an aerial intersection approach: for each GSA and CWS, the area was calculated as meters squared, then intersected (Area_Int). To calculate the percentage of a water system's service area that was intersected by a GSA: divide [Area_Int] / [CWS Area_sqm] * 100). Any GSA with > 5% areal overlap was listed. The maximum number of GSAs for a water system was 6 while some water systems have no service areas that overlap with a GSA. The accuracy of this water system characteristic is contingent on the accuracy of both the water system boundaries (service areas) and GSA boundaries. The **GSA_Names** field includes a combined list of All GSAs that intersected with a water system boundary and thus should equal the set of GSAs in **GSA_Name1:GSA_Name6**. The sub-basin names associated with each GSA are also included in fields: Basin1 through Basin6.

<u>F. Determining Drought Scenario Results for Small Community Water Systems in the Central Valley (Gailey 2020)</u>

As described in the accompanying project report (Gailey 2020), R. M. Gailey, a Consulting Hydrogeologist PC generated a drought scenario analysis to evaluate public supply well impacts for small community water systems (populations less than 10,000 people) located in the Central Valley, as defined by the alluvial groundwater basin boundary. The analysis compares public supply well construction information to estimated decreases in groundwater levels, identifies potential impacts to well production regarding quantity, and estimates mitigation costs. Calculations are performed for each PLSS section in the Central Valley where information is available for both well construction and groundwater level during the 2012 to 2016 drought. For the CWS analysis, the PLSS results are then aggregated to CWS footprints with 1-mile buffers.

For a given drought scenario being considered, a single selected value for the drought factor (0.0, 0.50, 0.75, 1.0) is applied to all locations in the area of interest. The factor scales the maximum groundwater level change estimated to have occurred in each PLSS section during the 2012 to 2016 drought and adds this calculated level decrease to the estimated depth to groundwater at the beginning of the SGMA compliance period (Fall 2014). The result is an estimated groundwater level within the PLSS section for the drought scenario under consideration: *S1: Scenario 1 or reference case (0% of 2012-2016 groundwater level change); S2: Scenario 2, (50% of 2012-2016 groundwater level change); S3: Scenario 3 (75% of 2012-2016 groundwater level change); S4: Scenario 4 (100% of 2012-2016 groundwater level change).* For each drought scenario, mitigation measures considered include lowering pumps in existing wells, cleaning well screens and replacing wells with deeper wells. Only scenarios 2 (50%) through 4 (100%) are available in the interactive webmap.

For each scenario (S1 through S4), mitigation measures are identified separately:

- S1_PL_coun = Count of Wells with Pump Lowering (PL)
- S1_PL_cost = Pump Lowering Cost
- S1_SR_coun = Count of Wells with Screen Rehabilitation (SR)
- S1_SR_cost = Screen Rehabilitation Cost
- S1_WR = Count of Wells with Well Replacements (WR)
- S1_WR_cost = Well Replacement Cost

For each scenario (S1 through S4), summary figures of total wells impacted and costs are calculated:

- S1_CostXLi = Extra Lift Cost, which is the cost for extra pumping lift. If the water level decreases, all wells will experience extra lift cost but only some wells may experience other impacts that result in mitigation costs.

- S1_SumImpa = Count of all Drought Impacted Wells where the sum is a tally of all wells with at least one impact (pump lowering, well screen cleaning or well replacement).
- S1_TotalCo = Total Cost which is the sum of the CostImpact (total of all mitigation costs) + CostXLift

Additional details, including assumptions and parameters used in the calculations, are presented in the project report (Gailey 2020).

G. Assigning US 2016 American Community Survey Census Demographics for CWS (Goddard 2019)

These characteristics start with the column (pwsid_1) and were developed by J. Goddard for OEHHA and the WESS domestic wells project. Visit OEHHA's website to learn more about their Human Right to Water Project (https://oehha.ca.gov/water/report/human-right-water-california). These characteristics are available in the interactive tool, but not available for download.

Census estimates were downloaded from the Census Factfinder website (https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml) between 4/15/19 and 4/18/19. To estimate social and demographic characteristics within water systems, some adjustments to census data are necessary. The social and demographic data represented were created in two steps. First, estimates of households and populations served by each water systems were determined by aerially assigning household and population counts based on 2010 census blocks that intersect with water system. The population and household counts from blocks overlapping the water system were then summed to the block group. Second, household or population-weighted averages of various census estimates from the 2012-2016 American Community Survey were calculated based on all block groups intersecting a given water system.

It is important to note several areas of uncertainty. First, this approach assumes that the information at the block group scale is homogeneously distributed across the block group. Second, small water systems that fall within one block group are assigned 100% of the social or demographic data of that block group, even though they may only represent a portion of people living in a census area. Third, census data has varying reliability because of the underlying sample size. Estimates should be used with caution, especially in areas that are less populated or for smaller water system estimates.

The Census provides quantitative information on sample error–the margin of error at 90% confidence levels–for each estimate. This information was used to quantify coefficients of variation (COV) to determine the 'reliability' of demographic estimates. COV measures the ratio between an estimate's standard error, which can be calculated from the margin of error provided by the Census for each estimate–and the estimate itself. There is no hard-rule about what constitutes a reliable COV. ESRI uses COV thresholds of less than 12%, between 12% and 40%, and greater than 40% to denote high, medium, and low estimate reliability, respectively (ESRI 2014). OEHHA has used combined rules to determine an estimate is not reliable when COV is less than 50% and the standard error is greater than the mean standard error of all census block groups estimates for the data of interest (OEHHA 2019).

COVs were estimated for small systems within one Census block group. COVs for water systems with more than one block group were not calculated and are labeled "Not Calculated", because current methods for re-estimating margins of error at new geographies do not account for geographies with different boundaries from census units.

WESS Created CWS Characteristics (Pace et al. 2019):			
Column heading	**Type**	**Description**	**Original Source**

FID	Long Integer/Precision 10	GIS system generated field	NA
Shape	Geometry type	Stored geometry type: Polygon	NA
pwsid	String/Length 254	Drinking water system code	Tracking California / SDWIS 2018
System_Nam	String/Length 254	Water system name	WBT
County	String/ Length 254	County primarily served	SWRCB 2018
Primary_Wa	String/ Length 254	Primary water source: GU - Groundwater Under the Direct Influence (UDI) of Surface Water; GUP - Purchased Groundwater UDI of Surface Water; GW - Groundwater; GWP - Purchased Groundwater; SW - Surface Water; SWP - Purchased Surface Water	SWRCB 2018
As_ugL(*)	String/ Length 254	Arsenic concentration in ug/L	CES 3.0
As_Source(*)	Short Integer	Source of water quality data for arsenic 1=CES 3.0 3=no water quality value available	WESS generated
N_mgL(*)	String/ Length 254	Nitrate as Nitrogen (N) concentration in mg/L	CES 3.0
N_Source(*)	Short Integer	Source of water quality data for nitrate 1=CES 3.0 3=no water quality value available	WESS generated
TCP_ugL(*)	String/ Length 254	1,2,3-Trichloropropane (TCP) concentration in ug/L	CES 3.0
TCP_Source(*)	Short Integer	Source of water quality data for 123-TCP 1=CES 3.0 3=no water quality value available	WESS generated
Cr6_ugL(*)	String/ Length 254	Hexavalent chromium (Cr(6)) concentration in ug/L	CES 3.0
Cr6_Source(*)	Short Integer	Source of water quality data for Cr(6) 1=CES 3.0 3=no water quality value available	WESS generated
HOUSE_WESS	Double/ Precision 0/ Scale 0	Housing units served according to WESS aerial apportionment method	US Census 2010
Additional Water System Characteristics (generated by CWC, Gailey 2020)			
Heading	**Type**	**Description**	**Original Source**
Join_Count	Long Integer	Count of Private Domestic Wells located inside of a CWS service area, based on the Private Domestic Well Location layer available in this tool.	CWC generated from Pace et al. (2019)
OWNERSHIP1	String/ Length 254	CWS Ownership Types include: Federal Government; Local; Mixed (Public/Private); Private; State Government; Tribal	SWRCB 2018

SOURCE_new	String/ Length 254	Revised Water Source Type: BOTH: surface water and groundwater GW: groundwater (only) GWP: purchased groundwater (only) SW: surface water (only) SWP: purchased surface water (only)	SWRCB 2019: EAR 2013-2016; SWRCB 2018
Total_Popu	Long integer/ Precision 10	Total population served according to SWRCB dataset	SWRCB 2018
Total_SCV_	Long integer/ Precision 10	Total service connections according to SWRCB dataset	SWRCB 2018
WQ_REG	String/ Length 254	This attribute names either the SWRCB-District or LPA (county) responsible for enforcing Safe Drinking Water Act requirements for this CWS.	HR2W Portal 2019
MCLV_HRTW1	Long integer/ Precision 10	Count of Unique MCL Violations according to the HR2W Portal	HR2W Portal 2019
GSA_Names	String/ Length 254	This field includes a combined list of All GSAs that intersected with CWS boundary (should equal set of GSAs in GSA_Name1:GSA_Name6)	CWC generated from the DWR 2019- SGMA Dataviewer Exclusive GSA Master shapefile
GSA_Name1	String	Exclusive GSA Name	
Basin1	String	Sub-Basin Number	
GSA_Name2	String	Exclusive GSA Name	
Basin2	String	Sub-Basin Number	
GSA_Name3	String	Exclusive GSA Name	
Basin3	String	Sub-Basin Number	
GSA_Name4	String	Exclusive GSA Name	
Basin4	String	Sub-Basin Number	
GSA_Name5	String	Exclusive GSA Name	
Basin5	String	Sub-Basin Number	
GSA_Name6	String	Exclusive GSA Name	
Basin6	String	Sub-Basin Number	

Reminder: for the following Drought Scenario results, the column headings can be interpreted as follows: *S1: Scenario 1, or reference case (0% of 2012-2016 groundwater level change)* *S2: Scenario 2, (50% of 2012-2016 groundwater level change)* *S3: Scenario 3, (75% of 2012-2016 groundwater level change)* *S4: Scenario 4, (100% of 2012-2016 groundwater level change)* **For each attribute: -100 means no Data but in the analysis, -99 means not included in the analysis** **See Gailey (2020) for a complete methodology.**			
S1_PL_coun	Double	Count of Wells with Pump Lowering (PL)	Gailey 2020
S1_PL_cost	Double	Pump Lowering Cost	Gailey 2020
S1_SR_coun	Double	Count of Wells with Screen Rehabilitation (SR)	Gailey 2020
S1_SR_cost	Double	Screen Rehabilitation Cost	Gailey 2020
S1_WR	Double	Count of Wells with Well Replacements (WR)	Gailey 2020
S1_WR_cost	Double	Well Replacement Cost	Gailey 2020
S1_CostXLi	Double	Extra Lift Cost	Gailey 2020
S1_SumImpa	Double	Count of all Drought Impacted Wells *(sum is a tally of all wells with at least one impact - pump lowering, well screen cleaning or well replacement).*	Gailey 2020
S1_TotalCo	Double	Total Cost (S1_PL_cost + S1_SR_cost + S1_WR_cost + CostXLi)	Gailey 2020
S2_PL_coun	Double	Count of Wells with Pump Lowering	Gailey 2020
S2_PL_cost	Double	Pump Lowering Cost	Gailey 2020
S2_SR_coun	Double	Count of Wells with Screen Rehabilitation	Gailey 2020
S2_SR_cost	Double	Screen Rehabilitation Cost	Gailey 2020
S2_WR	Double	Count of Wells with Well Replacements	Gailey 2020
S2_WR_cost	Double	Well Replacement Cost	Gailey 2020
S2_CostXLi	Double	Extra Lift Cost	Gailey 2020
S2_SumImpa	Double	Count of all Drought Impacted Wells	Gailey 2020
S2_TotalCo	Double	Total Cost (S2_PL_cost + S2_SR_cost + S2_WR_cost + S2_CostXLi)	Gailey 2020
S3_PL_coun	Double	Count of Wells with Pump Lowering	Gailey 2020
S3_PL_cost	Double	Pump Lowering Cost	Gailey 2020
S3_SR_coun	Double	Count of Wells with Screen Rehabilitation	Gailey 2020

S3_SR_cost	Double	Screen Rehabilitation Cost	Gailey 2020
S3_WR	Double	Count of Wells with Well Replacements	Gailey 2020
S3_WR_cost	Double	Well Replacement Cost	Gailey 2020
S3_CostXLi	Double	Extra Lift Cost	Gailey 2020
S3_SumImpa	Double	Count of all Drought Impacted Wells	Gailey 2020
S3_TotalCo	Double	Total Cost (S3_PL_cost + S3_SR_cost + S3_WR_cost + S3_CostXLi)	Gailey 2020
S4_PL_coun	Double	Count of Wells with Pump Lowering	Gailey 2020
S4_PL_cost	Double	Pump Lowering Cost	Gailey 2020
S4_SR_coun	Double	Count of Wells with Screen Rehabilitation	Gailey 2020
S4_SR_cost	Double	Screen Rehabilitation Cost	Gailey 2020
S4_WR	Double	Count of Wells with Well Replacements	Gailey 2020
S4_WR_cost	Double	Well Replacement Cost	Gailey 2020
S4_CostXLi	Double	Extra Lift Cost	Gailey 2020
S4_SumImpa	Double	Count of all Drought Impacted Wells	Gailey 2020
S4_TotalCo	Double	Total Cost (S4_PL_cost + S4_SR_cost + S4_WR_cost + S4_CostXLi)	Gailey 2020
CWS 2016 Demographic Characteristics (Goddard 2019)			
pwsid_1	String	Public Water System ID code	Goddard 2019 (SDWIS)
MHI(*)	Double	Median Household Income, based on 2016 ACS 5-yr estimates	Goddard 2019
DAC(*)	Double	Status: DAC, SDAC, NA based on MHI from the 2016 ACS in the previous column. The statewide MHI for this dataset is $63,783; therefore, the calculated DAC and SDAC thresholds are $51,026 and $38,270, respectively. For CWS with $0 MHI, they are assigned NA. For systems above either MHI threshold, they're also assigned NA. CWS without any ACS2016 data have a 'null' value.	Goddard 2019
Perc_Rent(*)	Double	Percent of renters (2016), based on 2016 ACS 5-yr estimates	Goddard 2019
PerNHWhit(*)	Double	Percent of population that self identifies as non-Hispanic (NH) White (2016)	Goddard 2019

PerNHBlac(*)	Double	Percent of population that self identifies as non-Hispanic Black (2016)	Goddard 2019
PerNHAs_c(*)	Double	Percent of population that self identifies as non-Hispanic Asian (combines Asian and Pacific Islander) (2016)	Goddard 2019
PerNHNatA(*)	Double	Percent of population that self identifies as Native American or Alaska Native (2016)	Goddard 2019
PerNHot2o(*)	Double	Percent of population that self identifies as non-Hispanic other, or 2 or more races (2016)	Goddard 2019
PerHisp_L(*)	Double	Percent of population that self identifies as Hispanic/Latino (2016)	Goddard 2019
POCperc_c(*)	Double	Percent people of color: combines non-Hispanic (NH) Black, nh Native-American/Alaska native, NH Asian, Hispanic/Latino, and other/2 or more (2016)	Goddard 2019
COV_Rent(*)	Double	Coefficient of variation (Percentage) for percent renters, based on margin of error from based on 2016 ACS 5-yr estimates	Goddard 2019
COVNHWhit(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as non-Hispanic (NH) white (2016)	Goddard 2019
COVNHBlac(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as non-Hispanic black (2016)	Goddard 2019
COVNHAs_c(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as non-Hispanic Asian (combines Asian and Pacific Islander) (2016)	Goddard 2019
COVNHNatA(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as Native American or Alaska Native (2016)	Goddard 2019
COVNHot2o(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as non-Hispanic other, or 2 or more races (2016)	Goddard 2019
COVHisp_L(*)	Double	Coefficient of variation (Percentage) for percent of population that self identifies as Hispanic/Latino (2016)	Goddard 2019
COVperc_c(*)	Double	Coefficient of variation (Percentage) for percent people of color: combines non-Hispanic (NH) black, NH Native-American/Alaska native, NH Asian, Hispanic/Latino, and other/2 or more (2016)	Goddard 2019

(*)Not currently available for download, but can be visualized on the interactive web viewer.

Questions about the Community Water System (CWS) 2016 Demographic Characteristics available in the tool and provided by Goddard (2019) can be directed to jessjoangoddard@berkeley.edu.

Data Sources

1. CalEnviroscreen 3.0 report (https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30)
2. CalEnviroscreen 3.0 technical documentation (https://oehha.ca.gov/media/downloads/calenviroscreen/report/ces3dwmethodology.pdf),
3. California State Waterboards. Interconverting Nitrate-N and Nitrate-NO3 (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/drinkingwaterlabs/InterconvertingNitrate-NandNitrate-NO3.pdf
4. SWRCB/SDWIS (2018). SDWIS Public Drinking Water Watch Dataset: https://data.ca.gov/dataset/drinking-water-public-water-system-information. Accessed June 22, 2018.
5. Tracking California / Water Boundary Tool (http://www.cehtp.org/water/.) Accessed January 8, 2019. The current URL for this resource is https://trackingcalifornia.org/water-systems/water-systems-landing
6. US Census Bureau (https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml.
7. US Census Bureau (https://www.census.gov/geo/maps-data/data/tiger-data.html)
8. SWRCB Water Quality Monitoring (http://www.cdph.ca.gov/certlic/drinkingwater/pages/EDTlibrary.aspx)
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10. SWRCB (2019). Electronic Annual Reports (EAR) 2013-2016. Accessed October 15, 2019 https://data.ca.gov/dataset/drinking-water-public-water-system-annually-reported-water-production-and-delivery-information
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15. ESRI (2014). The American Community Survey, an Esri white paper. https://www.esri.com/library/whitepapers/pdfs/the-american-community-survey.pdf
16. Balazs C, Faust J B, Goddard J J, Bangia K, Fons E and Starke M (2019). *A Framework and Tool for Evaluating California's Progress in Achieving the Human Right to Water [Draft]* Online: https://oehha.ca.gov/media/downloads/water/report/hr2wframeworkpublicreviewdraft010319.pdf