

Drought and Water Shortage Risk Scoring:
California’s Small Water Supplier and Self-Supplied Communities

bathtub type assignment of sea level, though also uses the LMSL tidal datum from NOAA’s vdatum that is variable along the CA coast). This calculation is based on a steady-state (or equilibrium) groundwater model.

Metric generated: Spatial join of Block groups intersect with the spatial extent of projected salt water intrusion

Associate analysis units to hazard index: Generated presence/absence data per Block group polygon.

5.1.2 Exposure to Current Environmental Conditions and Events

Current hazard is composed of three groups of risk factors: episodic stressors, source vulnerabilities, and source quality risks. Each group is composed of several indicators, and the two latter groups measured using data related to groundwater basins. These data are available for Bulletin 118 Basins (DWR 2019), which do not cover the entire state.

Table 7 Indicators of current or recent hazardous conditions and events (Community – Component 2, SC2)

Group	Risk Factor	Indicator	Metric (measure)	Dataset	Data Source
Episodic	RC2a - Drought early warning	Annual Updated Early Drought Risk Warning	Less than 70% of average precipitation by January 31st for that water year = high risk of drought	Calculated percent of normal precipitation received by January 31st for that Water Year	PRISM OSU
	RC2b - Wildfire risk	Modelled current risk maximum for each Census Block Group	Use CalFire Scoring HAZ_CODE: Moderate (1)= .33; High (2)= .67; Very High (3) =1; no score =0 (no or low risk); Took max for each Census BG with spatial	CalFire Wildfire risk	CalFire

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Group	Risk Factor	Indicator	Metric (measure)	Dataset	Data Source
			join in ArcGIS		
Environmental Conditions and Stressors	RC2c - Geology	Fractured Rock Area	Communities in Fractured Rock Areas (1) or not (0)	DWR per B118 upcoming 2020 update	DWR
	RC2h – Increasing water demand	Projected population growth	Census data estimates of growth rate between 2016 to 2021, estimated by service area	DWR/Private Vendor Census data estimates	DWR
	RC2i- Water quality in shallow aquifer	Domestic well water quality risk (includes areas outside of alluvial basins)	Indication of likelihood that groundwater likely accessed by domestic wells may contain concentrations of constituents above regulatory levels.	Division of Water Quality GAMA Groundwater Information System	SWRC B
Alluvial Basin Conditions	RC2d – Basin subsidence	Record of subsidence	Documented Impacts #7.b Subsidence Points; recoded to 0,.5,1 from original points of 0,3,10, then associated to Block groups	SGMA 2019 Basin Prioritization	DWR
	RC2e – Basin salt	Record of salts	Documented Impacts #7.c Salt Intrusion Points	SGMA 2019 Basin Prioritization	DWR

Drought and Water Shortage Risk Scoring:
California’s Small Water Supplier and Self-Supplied Communities

Group	Risk Factor	Indicator	Metric (measure)	Dataset	Data Source
Alluvial Basin Conditions	RC2f – Overdrafted basin	Critically overdrafted groundwater basin	Yes (1)/no (0) of whether area is in critical overdraft	SGMA 2019 Basin Prioritization	DWR
	RC2g - Chronic declining water levels	Declining groundwater levels	Documented Impacts #7.a - Declining GW levels Points	SGMA 2019 Basin Prioritization	DWR
	RC2j - Surrounding land use	Presence of irrigated agriculture in surrounding basin	Irrigated Acres Priority Points	SGMA 2019 Basin Prioritization	DWR

Events and Environmental Conditions

RC2a. Drought Risk

What: Current Year’s Early Warning for Risk of Local Drought (must be updated annually)

Data source: Oregon State University PRISM Climate Group

What does it represent: Current drought risk based on percent of average precipitation already received for first part of the current Water Year.

What do want it to indicate: Annual Forecasted Risk of Local Drought

Location of data: <http://www.prism.oregonstate.edu>

Metric to generate: Score those areas under 70% =1 (high risk);
Score those areas over 70% = 0.

Notes: The level of precipitation received by the end of January is a good indication of how well the water year will be for a local supply. Domestic wells can be sensitive to levels of annual precipitation in their region. Those with under 70% of average for their area by January 31st each year are considered ‘at risk of drought’ for that water year. The metric used to indicate annual drought risk is percent of average precipitation received by

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

January 31st in that water year. **This needs to be updated annually.** Because legislation requires this risk list be produced by January 2020, we will use Water Year 2019.

The original PRISM precipitation is in raster (grid) format in GIS. We calculated the original PRISM data for the months of interest (Oct 1 2018 - Jan 31 2019, <http://www.prism.oregonstate.edu/recent/>) and divided by the average precipitation (reference to as "30-year normal" on website) between years 1981-2010 (provided by PRISM website, <http://www.prism.oregonstate.edu/normals/>). We used ArcGIS raster calculator for summing the months and then the division for the calculations. Then to associate the values in the grid to the Census BG polygons, we used the Spatial Analyst Tool Zonal Statistics (where the input zones were service area polygons). Adjusted the cell size in the raster calculator ('environment' menu in tool) to be 0.0001 so that all Block groups were captured.

.00 = "Drought risk absence – Local precipitation by January, 31, 2019, was above 70 percent of average precipitation."

1.00 = "Drought risk presence – Local precipitation was less than 70 percent average (of a water year)."

RC2b. Wildfire as present threat to water shortage

What: Current Risk of Wildfire

Data source: CalFire

What does it represent: Fire Hazard Severity Zone maps for State Responsibility Areas in November 2007, as recognized by CalFire

What do want it to indicate: Severity of current wildfire risk

Location of data: <https://osfm.fire.ca.gov/divisions/wildfire-prevention-planning-engineering/wildland-hazards-building-codes/fire-hazard-severity-zones-maps/>

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Metric to generate: rescaled to 0-1 scale with extreme severity as 1.
Category scores rescaled as follows: Moderate (1) = .33; High (2) = .67;
Very High (3) =1; no score =0 (no or low risk).

Notes: This may be updated soon by CalFire

Source Environmental Conditions and Stressors

RC2c - Fractured rock area

- Indicated by areas not in alluvial groundwater basins as marked by Bulletin 118, developed by DWR North Regional Office as part of upcoming Bulletin 118.
- Scoring = 0/1 binary scale so that all areas outside of these basins are scored as 1 (high risk)
- Completed

RC2h - Population Growth in immediate region

Impact on risk: Increasing population growth rates in surrounding region could lead to increased demand and thereby increasing risk of water shortage

Data source: Census, private vendor for demographic data

What does it represent: Population growth projected between 2016-2021

What do want it to indicate: Near future increasing water demands

Location of data: DWR

Metric generated: Rescaled population growth rate from a proportion to 0-1

Notes:

Alluvial Basin Characteristics

RC2R. Groundwater Basin Vulnerability

What: Presence of one or more risks observed in the groundwater basin

Data source: Aggregated multiple risk factors from the SGMA basin prioritization dataset, including presence of subsidence in basin (RC2d), presence of salt in basin (RC2e), record of critically over drafted basin (RC2f), record of chronic declining water levels (RC2g), and presence of irrigated agriculture (RC2j)

What does it represent: Groundwater basin vulnerability based on multiple risk factors.

What do we want it to indicate: A single score to represent one or more of the issues that commonly make a groundwater basin more vulnerable during a dry period.

Location of data: DWR

Metric to generate: Took the maximum score (0-1) of the recoded scores of the five combined factors that were associated to each small water supplier. Max score was used as the score to represent this aggregate indicator.

Notes: Complete.

RC2d. Presence of Subsidence in Basin

Impact on risk: Higher susceptibility = higher risk

Data source: SGMA 2019 Basin Prioritization

What does it represent: "Documented Impacts #7.b Subsidence Points"

What do want it to indicate: subsidence problems and risk

Location of data: DWR GIS server

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Metric to generate: recoded to 0,.5,1 from original points of 0,3,10, then associated to Block group

Notes: Completed. Incorporated as part of Alluvial Basin Conditions score.

RC2e. Presence of Salt in Basin

Impact on risk: Block Groups in basins with documented salt issues may have increased challenges of dealing with challenges of saline groundwater

Data source: SGMA 2019 Basin Prioritization

What does it represent: "Documented Impacts #7.c Salt Intrusion Points"

What do want it to indicate: areas that have been documented to have problems with salt in basin

Location of data: DWR

Metric to generate: rescale SGMA points of 0 and 5 to our risk indicator scoring of 0 and 1.

Notes: Technical workgroup (SGMA) suggested alternative scaling, but don't see any other options besides binary. Completed. Incorporated as part of Alluvial Basin Conditions score.

RC2f. Critically Overdrafted Basin

Impact on risk: If local groundwater is in decline, this would increase risk of water shortage and drought.

Data source: Phase 2 and 1 of SGMA Basin Prioritization

What does it represent: Determinations of critically over drafted groundwater basin or not

What do want it to indicate: Local groundwater vulnerability

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Location of data: DWR Phase 2 update, combined with Phase 1

Metric generated: Yes (1)/no (0) of whether area is in critical overdraft

Notes: Technical workgroup (SGMA) suggested alternative scaling, but only have binary for this so there is not other optional scaling. Incorporated as part of Alluvial Basin Conditions score.

RC2g. Chronic Declining Water Levels

Impact on risk: Declining level indicates surrounding increased risk

Data source: Documented Impacts #7.a - Declining GW levels Points

What does it represent: Groundwater level change in elevation 2011-2015

What do want it to indicate: Declining water levels

Location of data: DWR

Metric to generate: Associated rescaled score of sub-basin to the Census BGs.

Notes: This is included in addition to the overdraft indicator above because it is assumed that having this as more specific location data could be helpful to indicate more specific risk to water shortage during a drought. Incorporated as part of Alluvial Basin Conditions score.

RC2j. Presence of irrigated agriculture in surrounding basin

Impact on risk: May indicate competing demand on groundwater supplies, which could create higher risk for small suppliers during a drought or water shortage event.

What does it represent: Presence of irrigated agriculture in surrounding basin

What do want it to indicate: Competing demand on water use

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Location of data: DWR

Metric generated: Associated rescaled score of sub-basin to the Census BGs.

Notes: Complete. Incorporated as part of Alluvial Basin Conditions score.

RC2i. Source Water Quality Risk

Impact on risk: Presence of constituents at elevated concentration = increased risk

Data source: State Water Boards Division of Water Quality GAMA Groundwater Information System

What does it represent: Quality of groundwater likely accessed by domestic wells, based on the last 20 years of available data (from DDW, DWR, USGS, GAMA, and ILRP datasets) for each PLS section.

What do want it to indicate: Potential water quality problems in groundwater within the Census Block Group

Location of data: SWRCB

Metric generated: Five risk indices were developed for this metric: 1 (highest value) indicates an average historic or recent MCL exceedance for two or more constituents, 0.8 indicates an average historic or recent MCL exceedance for one constituent, 0.5 indicates historical average water quality between 0.5 and 1 times the MCL, and 0 indicates an historical average of less than 0.5 times the MCL for all constituents. -999 indicates where no data was available on water quality for that section.

Notes: Water quality data from Division of Water Quality at SWRCB. More detailed methodology involved in generating these risk indices will be posted to the Division of Drinking Water Needs Assessment website once complete.

5.2 Vulnerability of Self-Supplied Communities

We quantify vulnerability using a series of social and physical factors as they relate to groups of self-supplied residences. These groupings spatially are represented by US Census Block Groups. As done for the small water supplier vulnerability, self-supplied community vulnerability is quantified using three main components: (RC3) physical and (RC4) social vulnerability factors. Available data is sparse about households on their own supplies, so all information is estimated based on spatial associations to domestic wells within the Census Block Groups. No data was identified as readily available to represent those households that rely on private surface water intakes.

Note: As with the small water supplier assessment above, *vulnerability* is not a tangible, measurable concept; it is only relative as a comparison to others.

5.2.1 Physical Vulnerability

Physical vulnerability seeks to indicate the susceptibility of water shortage and drought for a self-supplied community. Two indicators developed using the depth of domestic wells compared to the depth of public wells are used to represent this component.

Table 8 Physical Vulnerability indicators for Self-Supplied Communities

Factor	Metric	Dataset	Data Source
RC3a - Well depth flag	Well-depth flag – if any portion of the groundwater unit(s) that intersect with the Census BG has relatively domestic wells, marked whole BG as ‘1’ (high risk) (0,1)	Well Completion Reports, processed by GAMA SWRCB	OSWCR-DWR
RC3b – Well depth proportion	Proportion of Public Land Survey Sections in Block Group where the max depth of domestic wells is shallower than max of public wells (0-1)	Well Completion Reports, processed by GAMA SWRCB	OSWCR-DWR

RC3a - Shallow Depth of Domestic Wells Part 1

Impact on risk: Increased risk when domestic wells in the area are shallower than public supply wells

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Data source: OSWCR DWR

What does it represent: Areas that could go out first, earlier than others during a dry year and are more shallow than public supplier wells in the surrounding area.

What do want it to indicate: higher risk when domestic wells are shallow

Location of data: DWR, processed by DWQ SWRCB group by Public Land Survey Section and then attributed to each groundwater unit. These groundwater units were then associated to Census Block groups for this analysis (by DWR).

Notes: Complete

RC3b - Shallow Depth of Domestic Wells Part 2

Impact on risk: Increased risk when wells are shallow, captures the proportion of area that is estimated as having shallower domestic wells (compared to public supply wells)

Data source: OSWCR DWR

What does it represent: Areas that could go out first, earlier than others during a dry year and are more shallow than public supplier wells in the surrounding area.

What do want it to indicate: Higher risk where domestic wells are shallower than public supplier wells, capturing extent of the risk

Location of data: DWR, processed by DWQ SWRCB group by PLS Section and then attributed to each groundwater unit. These groundwater units were then associated to Census BGs for this analysis (by DWR).

Notes: This is a proportion scale.

5.2.2 Socioeconomic Vulnerability

Social vulnerability factors associated with self-supplied communities includes 14 variables. The list of demographic variables selected to gauge social vulnerability of self-supplied communities is based on the CDAG input combined with Flanagan et al. (2011), a report written by several scientists at the Center for Disease Control to document its commonly used set of socio-economic population characteristics used to estimate social vulnerability. These population characteristics are the currently accessible factors they recommend using to calculate social vulnerability for disaster management, though we have omitted race and ethnicity factors given that these do not drive the population to be at higher risk. Race and ethnicity data can be offered as additional layer for post-scoring analysis given that they are characteristics of populations that often are exposed to higher risk.

Impact on risk: Demographic and socioeconomic characteristics examined are known to be more impacted during emergencies and disasters, following Cutter et al. (2003) and Flanagan et al. 2011.

Data source: US Census 2010 and American Community Survey 2012-2016

What does it represent: Social vulnerability of population within Census Block groups

What do want it to indicate: Social vulnerability of population within Census Block groups that may indicate households' varying capacity to manage their private water source when exposed to drought and shortage conditions.

Location of data: US Census/DWR Demographer

Metric to generate: Method of Center for Disease Control

Notes: Complete

Table 9 Indicators and datasets chosen to represent social factors (adaptive capacity) that contribute to increased risk to water shortage and drought for self-supplied communities

Variable	GIS Variable Names	Brief description of what variable is	Data Source
Per capita income 2016	PERCAP	Average per capita income for all block groups (BG)	ACS 2012-2016
Mean household income	AvgMHI	Average Median Household Income (MHI) for all BGs	ACS 2012-2016
Percent persons 65 year of age or older	Q65yr	Percentage of population of 65 and older of all BGs	ACS 2012-2016
Percent persons 17 year of age or younger	Q17yr	Percentage of population of under 17 years of all BGs	ACS 2012-2016
Percent persons 5 year of age or younger	Q5y	Percentage of population of under 5 years age of all BGs	ACS 2012-2016
Percent mobile homes	Qmobile	Percentage of mobile households of all BGs	ACS 2012-2016
No vehicle available	QnoVeh	Percentage of households with no vehicles of all BGs	ACS 2012-2016
Percent persons with no high school diploma	Qedu	Percentage of population over 25 years age with no high school diploma of all BGs	ACS 2012-2016
Percent population with single parent	Qparent	Percentage of population with single parent with children under 18 of all BGs	ACS 2012-2016
Percent population unemployed	Qunempl	Percentage of population of civilian unemployed of all BGs	ACS 2012-2016

Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

Variable	GIS Variable Names	Brief description of what variable is	Data Source
Percent of population who speak English less than well	Qlang	Percentage of population who speak English less than well of all BGs	ACS 2012-2016
Percent of population in group quarters	Qgroup	Percentage of all census block population with Group Quarters (GQ)	Census 2010

Following the Center for Disease Control's method of calculating social vulnerability index, we used the following groupings of the socioeconomic variables.

Socioeconomic status:

- MHI
- Per capita income
- Percent under poverty level

Household composition and language (this is revised from Center Disease Control's method to account for not having disability data and not using race data):

- Percent 65 years and over
- Percent under 5 years
- Percent single parent households
- Percent of unemployment among employable age
- Percent without a high school degree among those over 25 years
- Percent of population who speak less English less than very well

Housing and transportation:

- Percent of households with no vehicle
- Percent living in group quarters
- Percent renters
- Percent living in mobile homes

Drought and Water Shortage Risk Scoring: California's Small Water Supplier and Self-Supplied Communities

The percentile ranking was calculated for each variable. Then these ranking were summed within each of their corresponding themes above. Then the percentile rank was calculated for each theme. Then the sum of the theme's percentile ranks was calculated to create an overall vulnerability score. This was rescaled using percentile rank to include as a variable in the Self-Supplied Communities Risk equation (see here for more information on this method (<https://svi.cdc.gov/publications.html>, and here: <https://www.youtube.com/watch?v=REKFHOryflA&feature=youtu.be>).

5.2.3 Record of Shortage

RC5a – Reported household outages on domestic well

Impact on risk: Increased risk in areas that have already experienced outages.

Data source: DWR <https://mydrywatersupply.water.ca.gov/report/>

What does it represent: Presence of one or more households with reported outages in Census BG (0,1)

What do want it to indicate: Areas that may experience outages again due to combinations of aquifer sensitivity/fluctuations and shallow wells.

Location of data: DWR, processed by DWQ SWRCB group by PLS Section and then attributed to each groundwater unit. These groundwater units were then associated to Census BGs for this analysis (by DWR).

Notes:

RC5b – Reported household outages on private well

Impact on risk: Increased risk in areas that have already experienced outages.

Data source: DWR <https://mydrywatersupply.water.ca.gov/report/>

What does it represent: Proportion of households with reported outages in Census BG (compared to total households in BG) (0-1 scalar)

What do want it to indicate: Areas that may proportionally experience outages again due to combinations of aquifer sensitivity/fluctuations and shallow wells.

Location of data: DWR Southern Regional Office

Notes: Complete

5.3 Method of Aggregation for Scoring Communities

To aggregate the risk factor variables described above, we use simple calculation that weights each variable within its given component of the framework. Then we aggregate the weighted component scores together. This offers a transparent, interpretable, and communicable method for calculating risk based on the many variables identified.

To combine variables, we use the method illustrated below. All variables are rescaled in 0-1 numbers, which then is combined with the variables in their respective component. Scales were adjusted when necessary so that all scales indicate higher risk on the higher end of the scale (1 is the highest, zero is the lowest). As described in Indicators Section above, each indicator has a different scoring done to make it applicable for this project.

Each group of variables is combined with the other groups' scores for that component (components are Exposure, Vulnerability, and Observed Shortage).

We examined 5,000 Census Block Groups, selecting those that had at least one domestic well drilled between 1970-2019 (from DWR Well Completion Reports) and had at least one household on record by the US Census. The following map indicates the spatial coverage of the analysis.

7.0 References

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Drought and Water Shortage Risk Scoring:
California's Small Water Supplier and Self-Supplied Communities

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