Guidebook

California Water Course

Science, Policy and Management

by Dr. Samuel Sandoval Solís

Main Collaborator: Dr. Laura E. Garza Diaz
Contributors: Ivan Senock
Edited by Dr. Erik Porse, Dr. Sooyeon Yi and Dr. J. Pablo Ortiz Partida

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Course Description

Objective: Provide relevant and applied education of water science, management and water policy to residents, businesses, community water advocates, and entry level professionals in California.

Audience: People working in the water sector (entry level) or people interested in water in California

Minimum requirements: Course enrollees should have basic knowledge of arithmetic and algebra.

Student learning objectives: At the end of the course, the student will be able to

- **identify** the natural and human-made components of their water system and recognize how they are connected
- **evaluate** the current **water management** in their region of interest,
- **distinguish** the **water policies** that apply in their region of interest and
- **critique** and **propose** alternative **water management alternatives** for their region of interest be able to understand the scientific and policy context of Water in California

Length: 40 hours self-guided + 16 to 24 hours in person

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Contents

Module 1: Water Systems

What are water systems?

A water system is a **group of natural and human-made elements** in a **basin** that are linked naturally or because of human intervention where the **water cycle** occurs. All water systems have a spatial component, an area where water is collected, diverted, used, treated and disposed. Let's start with the natural boundaries of water systems: **a basin**.

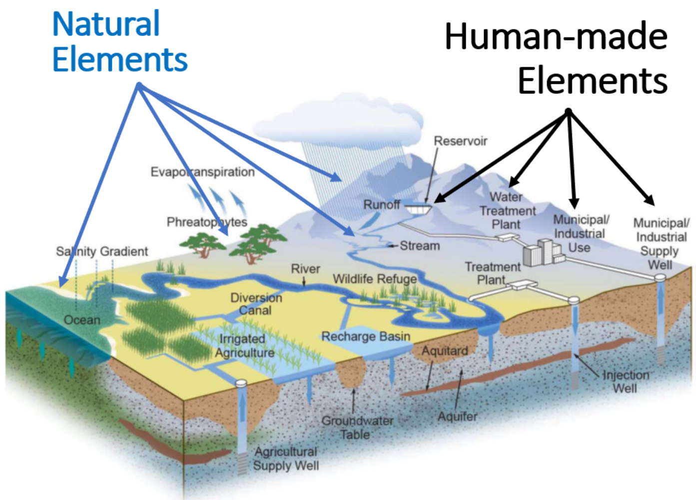
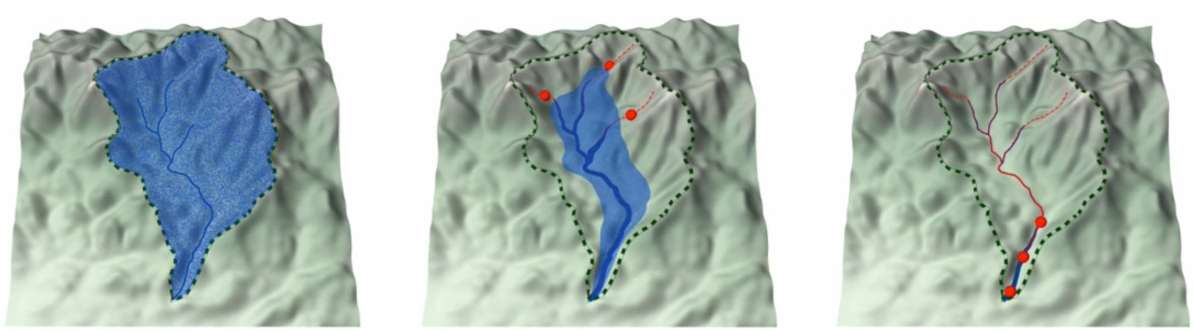


Figure 2-2, DWR (2020). Handbook for Water Budget Development

Figure 1 – Natural and human-made elements in a water system

What is a basin?

A basin is the area where all the rain is drained at a single point, it is the spatial delimitation of the water cycle in the landscape. Rivers in a basin drain into major river systems, a lake, or ocean. **Basin** and **watershed** sometimes are used interchangeably, when referring to the **drainage area of a point along the stream**. The correct term used in hydrology to refer to the drainage area is watershed; however, the term **basin** is more frequently used than watershed, and in this course, we will use those terms as synonyms. A basin includes all surface water (e.g. rivers, lakes, wetlands) and groundwater (aquifers) resources. Think of it as the area of influence of rainfall, meaning that when it rains all the water is collected and exited at a single point.



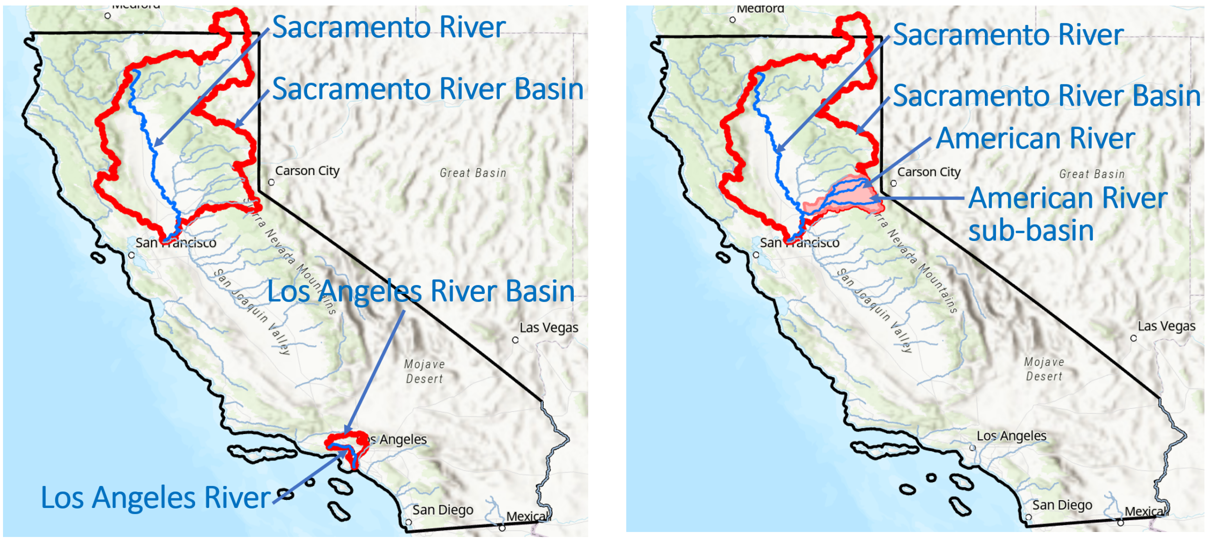
a) Basin under a precipitation event

b) Precipitation is been drained as surface runoff

c) Runoff has reached the outlet of the basin

Figure 2 – Description of runoff in a basin

Basin are named using the main river that drains them (e.g. Sacramento River basin or Los Angeles River Basin). Because the main river is fed by tributaries (i.e. smaller rivers), the drainage area of those tributaries is called sub-basin, for instance, the American River is a tributary of the Sacramento River, and thus the American River sub-basin is part of the Sacramento River basin.



a) Example of two basins: Sacramento River Basin and Los Angeles River Basin

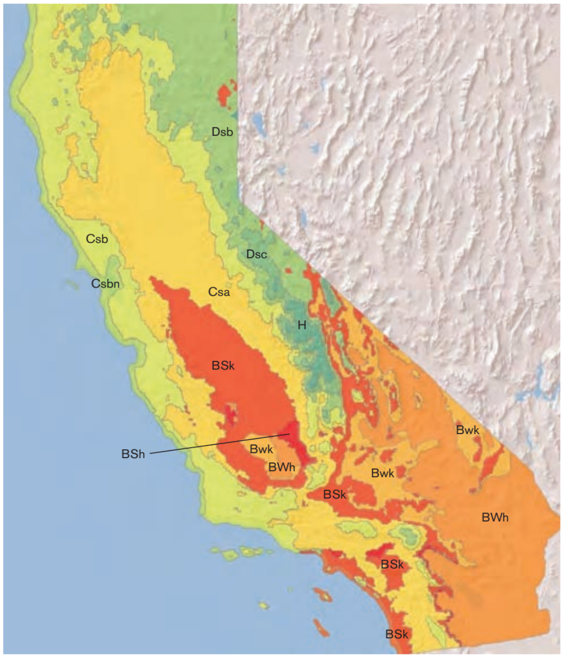
b) Example of sub-basin: the American river is a sub-basin of the Sacramento river basin

Figure 3 – Examples of Basin and Sub-basin

What are the natural elements of a water system?

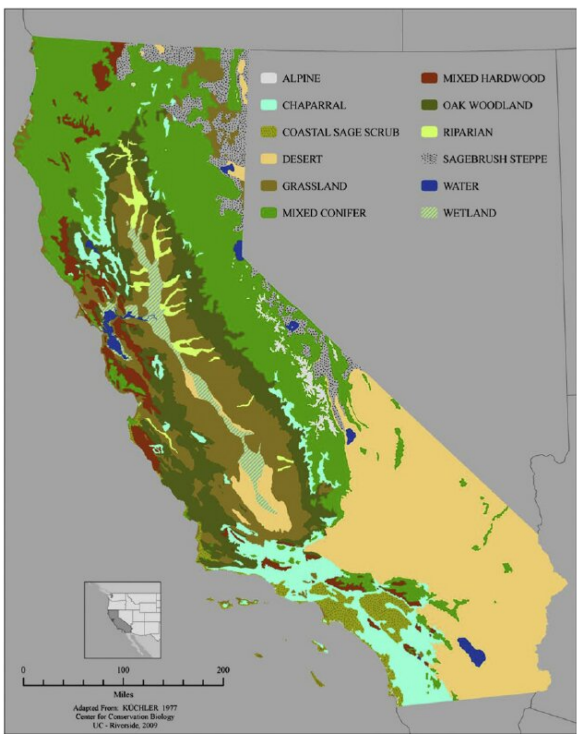
The ***natural elements*** of a water system are those related with the natural:

- **landscape** (e.g coast, desert, mountain),
- **orography** (e.g. foothills, valleys, range),
- **soils** (e.g. bedrock, alluvial, clay, silt)
- **land cover** (e.g. forest, brushland, native vegetation),
- **climate** (e.g. Mediterranean climate, desert climate, monsoon climate),
- **ecosystems** (e.g. terrestrial, riparian and freshwater ecosystems, some specific "the Mojave desert ecosystem")



Map of Climates in California

Map of more prominent landscapes in California



Map of land cover and vegetation in California

Map of bioregions in California

Figure 4– Natural Elements of a water system

What are the human-made elements of a water system?

Human-made elements are those **human interventions** done to the natural system due to (a) an **economic activity** (e.g. building dams to store water for agriculture or generation of energy; or land use change from forest to agriculture) or (b) **those interventions for human needs** (e.g. drilling a series of wells, treatment plant and drinking water network (a bunch of pipes) to supply water for domestic or municipal use).

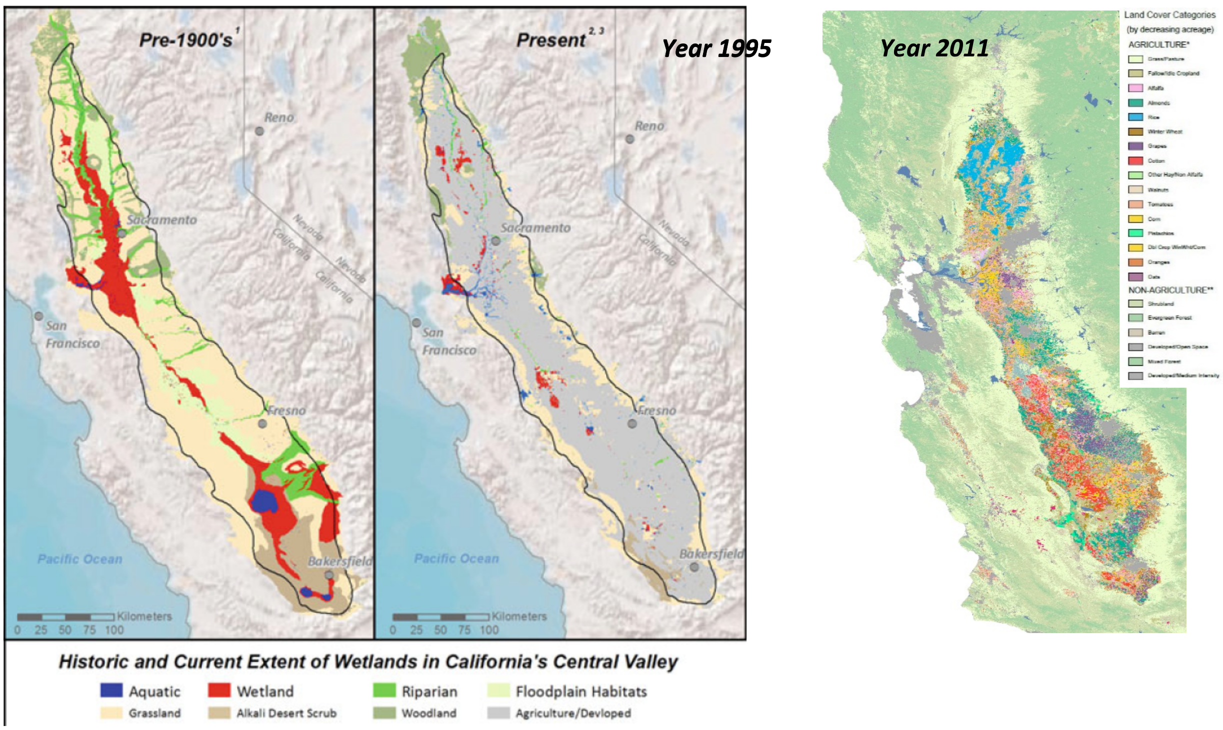


Figure 5 – Land use change in the Central valley over a century

Land use change of California's Central Valley for an economic activity: Agriculture. Figures adapted from Reid et al. 2018 from CSU Chico. Wetlands of California's Central Valley. (Springer Nature) and Land Use from DWR.

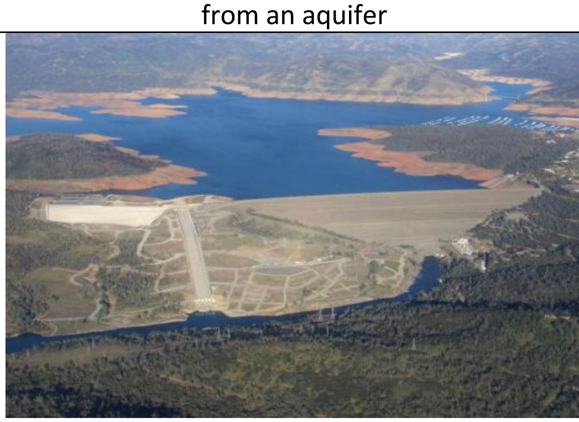
Those human-made elements are related with:

1) **water diversions**, e.g. wells that extract water from aquifers, weirs that divert water from rivers, pumps that divert water from rivers, water intakes in lakes or dams that divert water to cities far away.
2) **conveyance facilities**, e.g. aqueducts that move water through long distances, canals that move water from the diversion points to fields, pipes that move water from rivers to houses or drinking water treatment plants,
3) **water storage**, e.g. dams along rivers to store water for later use for cities, ponds to store water for agriculture or for cattle, tanks to store water, water barrels at home to store water, etc.
4) **point of use,** e.g. cities where water is used for homes, industry and commercial buildings; agricultural fields where water is used to grow food, feed for animals or crops for highly processed food. Many of the points of use require a land use change, for example from wetlands to agriculture, or from forest to residential development

5) **water treatment**, e.g. drinking water plants to treat water for safe human consumption, wastewater treatment plants to treat water for its disposal or reuse,
6) **climate infrastructures**, e.g. levees for flood management, floodwalls, coastal barriers and seawalls are built to protect communities from flooding and to withstand the impacts of climate change.
7) **power generation**, e.g. hydroelectric power plants often involve diverting water from rivers or reservoirs to pass through turbines, generating electricity

Water diversion: a well extracting groundwater from an aquifer

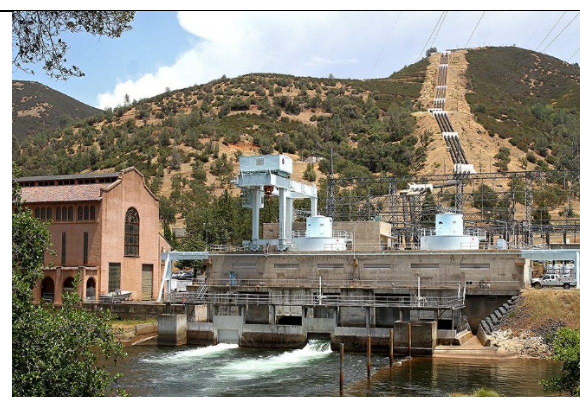
Conveyance facility: Delta Mendota Canal (left) and California Aqueduct (right)



Water Storage: Oroville Dam supply water to Southern California cities and farms in the Central Valley

Point of use: use of water in the City of Los Angeles, Exposition Park Rose Garden

Water Treatment: drinking water treatment plant for the cities of Davis and Woodland



Power generation: Mocasin Hydropower Station, Hetch Hetchy Water System

Figure 6– Examples of human-made elements of a water system

What are key events of the water cycle to remember?

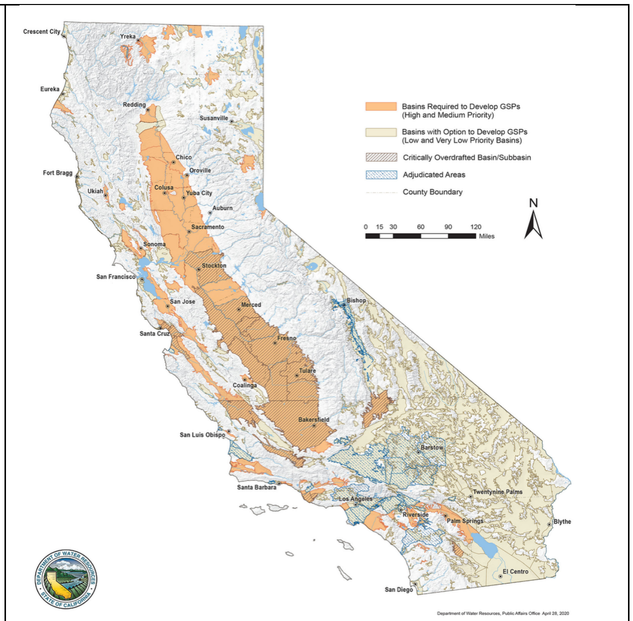
The events of the water systems are rooted in the **water cycle** which is the continuous movement of water in space and time through the atmosphere, earth, and water bodies. Here is how these events that will occur naturally:

- **precipitation** (e.g. snowfall, rainfall, hail, fog, and dew)
- **interception** from vegetation canopy
- **evaporation** the sun heats up water from the soil and from lakes, ponds, etc,
- **Transpiration** from plants, crops, trees, grass.
- **Evapotranspiration** which is the coupled process of evaporation of water from the soil and the transpiration of water from plants. It's used to estimate how much water is used by crops, trees and natural vegetation.
- **runoff** is overland flow reaching rivers, AKA as streamflow
- **infiltration** of water from the surface into the soil
- **percolation** water moving through the soil into the water table, an aquifer, or even to a stream
- **aquifer** recharge and storage
- **storage of water** in the atmosphere (clouds, vapor), in the surface (rivers, lakes, ocean, glaciers, icebergs) and in the ground (soil and aquifers)

a) Precipitation in form of snow

b) Evapotranspiration from crops

c) Runoff



d) Aquifers

Figure 7 – Key events of the water cycle

Figure 8 – Storage of water in the landscape. Hetch Hetchy Valley, California

How human activities and climate change are affecting the water cycle?

Regardless if the elements of the water system are natural or artificial, the water cycle will occur. However, recently the accumulation of human activities and climate change have modified these natural processes:

- **Altered precipitation patterns** - Climate change is altering when and how intensely rain and snowfall occur. In certain areas, the rainy season has become shorter, but when it does rain, it's often more intense. (This leads to longer dry spells between rainfall, impacting water availability and potentially leading to drought conditions.)
- **Modified interception** - Deforestation and land use change have decreased the interception of precipitation increasing runoff
- **Increased evaporation and transpiration** - As the temperature of the Earth increases, so does the evaporation from the soil and transpiration from plants.
- **Augmented runoff rates** - Land use changes and erosion lead to higher runoff rates causing risks of flooding.
- **Reduced infiltration and percolation** - Changes in ground such as soil compaction reduces infiltration of water into the ground which eventually disrupts the groundwater movement.
- **Changes in water storage** - the creation of artificial infrastructure in surface water storage such as dams, reservoirs, and canals have modified the flow and form of rivers. And the over extraction of groundwater can sink down the ground.

How many water systems are there?

In general, there are three types of water systems: natural, human-made and mixed. In reality, nearly all water systems are mixed, as us, humans, have exerted a great influence on the landscape, so there are very few places untouched by the human kind. We should definitely feel part of a water system, so we can protect and take charge of it. For the purpose of this course, it is easier to explain these two water systems separate (natural and human-made), so, later we can mix them up and see how they interact. It is like building a lego figure, where some pieces are natural and others are human-made.

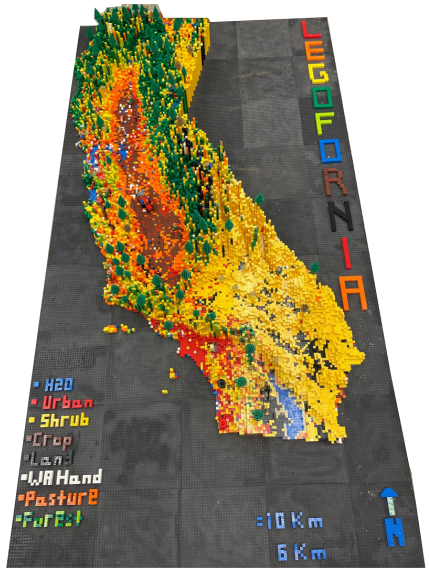


Figure 9 – Elevation model of California using Lego's blocks

How natural water systems work? How water moves naturally in California?

Water moves in different ways, depending on the state that water is (liquid, solid or gas) and the place on earth where is located, within the continent, in the ocean, in the ice caps, etc. For the purpose of this course **we will focus in the movement of surface water and groundwater in the continent**. We will not discuss how water moves in estuaries, the ocean or glaciers, we will focus on movement of freshwater in the continent.

For **surface water**, we have three main classes rivers: (1) snowmelt driven rivers, those occurring mostly in high elevations, (2) rainfall driven rivers, occurring at mid-elevations, and (3) rainfall and aquifer driven rivers in valleys and lowlands, occurring at low-elevations.

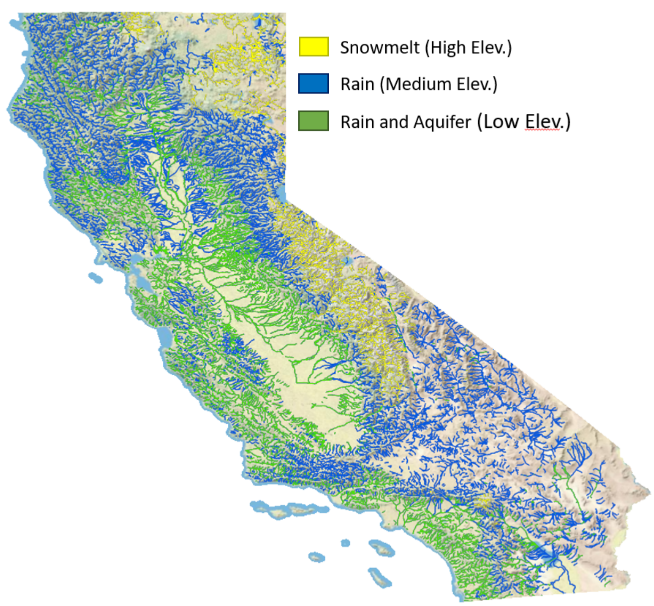


Figure 10 – Natural Streamflow Classification of California

Snowmelt driven rivers (High-elevation).

Typically, these rivers are located in the headwaters (where the rivers starts) and in elevations of 7,500 feet above sea level (2,200 m). They receive precipitation mostly as snowfall during winter, and that snow is stored, or if you will "frozen in time", until the snow is melting when temperatures rise later in spring and summer; or because of the melting of snow due to rainfall. These rivers are called snowmelt driven rivers, and have a specific signature (or flow regime) where the amount of water flowing increases when melting start, and it will keep increasing up to a point to the peak of snowmelt, and then starts decreasing once all the snow has melted, leaving only a small discharge from water that is slowly released from the soil. Typically, these rivers are located where the underlying soil is bedrock, covered by a layer of 2 to 10 feet of soil. Water in these river may end up stored in the soil, evaporated by the vegetation, or exited as runoff, that's why they are called "rainfall-runoff rivers". These rivers are at the mercy of climate, if there is a good winter with plenty of snowfall, then there will be a good amount of water coming from these rivers; but if not, then the ecosystems, people and industries that depend on them will be at risk. In addition, snowmelt-driven rivers are in danger of extinction because of climate change, as temperature rises, we are receiving more precipitation in terms of rain and less as snow, not only changing drastically their flow signature (flow regime) but also losing the storage of water in form of snow to be used later in the season.

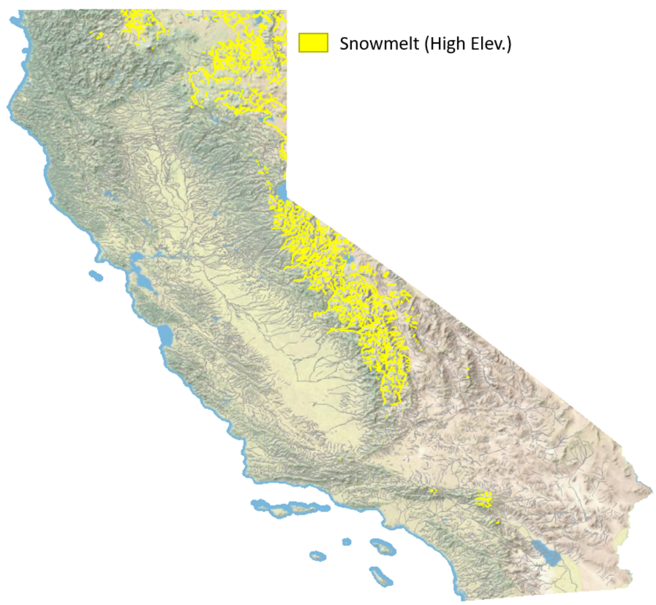


Figure 11 – Snowmelt-driven rivers in California

Rainfall driven rivers (Mid-elevation).

Typically, these rivers are fed by snowmelt rivers upstream of them, or their headwaters are located in elevations between 7,500 and 3,500 feet above sea level (2,200 to 1,000 m). They receive precipitation mostly as rain during winter, and that rain is stored in the soil, evaporated by the vegetation, or exited as runoff, they are also called "rainfall-runoff rivers". These are temperamental rivers that can increase their discharge when rain or an atmospheric river occurs and their flow can decrease rapidly as the rain is gone, leaving only a small discharge from water that is slowly released from the soil. Also, rainfall-driven rivers are located where the underlying soil is bedrock, covered by a layer of 2 to 10 feet of soil in the mountains and foothills. Rainfall-driven rivers are becoming more dangerous because of the increased in precipitation intensity due to climate change. If precipitation occurs with higher intensity, the flow in rivers can increase rapidly creating flash floods, increasing risk of flooding and erosion, affecting the habitat of freshwater ecosystem and people living close to river that can experience flooding. There are two types of rainfall driven rivers: (a) perennial, meaning hat they have an all year around flow "perennial flow", and (b) ephemeral, meaning they have flow during a certain period of time.

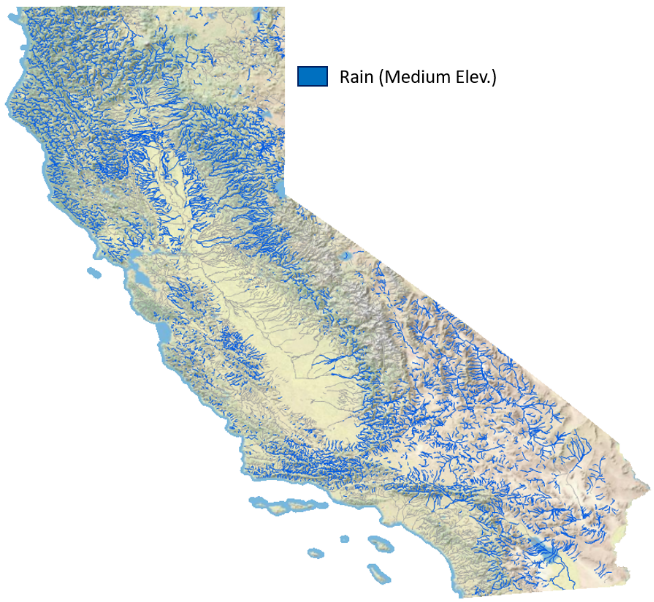


Figure 12 – Rainfall-driven rivers in California

Rainfall and aquifer driven rivers in valleys and lowlands (Low-elevation)

They are located in valleys throughout the state of California (Central Valley, Salinas Valley, Los Angeles Valley, San Fernando Valley, Owens Valley, Santa Maria Valley, Paso Robles, Imperial and Coachella Valley, Ukiah Valley, Alexander Valley, Napa Valley, Sonoma Valley, and so on). Typically, they are located in elevations below 3,500 feet above sea level (1,000 m). The main characteristic of these rivers is that the underlaying layer is not bedrock, but a series of deep sediment layers that can store water within their porous, called aquifers. They receive precipitation mostly as rain and fog during winter and that water is stored in the soil filling it, and then passes through the soil to recharge the aquifer underneath, filling it. They also receive water from snowmelt and rainfall-driven rivers upstream of them. Later in the year, during spring and summer, the aquifer discharges its water into these rivers maintaining them with a permanent (perennial) flow. Because of all of these interaction, they are also called "rainfall-aquifer-runoff rivers". These rivers are at the mercy of climate change and human mismanagement. If there is a drought or rivers upstream did not receive a good year of precipitation because of climate change, then there will be a small amount of water flowing through them. If humans over-exploit the amount of water taken from the underlaying aquifers, then we can lose the aquifer river connection and the river may run dry, affecting the freshwater ecosystem and people living that depend on them.

Figure 13 – Rivers located in Valleys throughout California

Groundwater movement underneath the valleys.

There are three main definitions to know first, groundwater which is water in the ground, second, aquifer which is the container that stores groundwater, and third, water-table which is the elevation of groundwater in the soil, we measure this elevation with using a “piezometer”. We will focus on groundwater stored in aquifers underneath the valleys, there are comprehensive maps of aquifer location throughout California. The first rule is that groundwater fallows gravity, it will try to move downwards. However, as it is moving downwards it is an obstacle race because water is moving around all the soil particles that are in their way, thought the “porous space”. Once groundwater reaches the aquifer, it will increase the water table of the aquifer, it will increase the level of the groundwater. However, precipitation does not fall even throughout the valleys, thus, in some places more precipitation will fall and increase the water table on those places, and in other places, there may not be any rain and thus not increasing the water table. Similarly, if a well is turned on and groundwater is extracted, it will leave a depression or lower elevation of the water table, and groundwater from the surrounding are will move towards that place to fill it up. Thus, groundwater can also move laterally trying to level itself, meaning to have the same water table elevation throughout the aquifer. When the water table in an aquifer is at higher elevation than the water level in a river then the aquifer will discharge into the river, and when the water table of an aquifer is at lower elevation than the water level of the river the opposite occurs, water from the river recharges the aquifer.

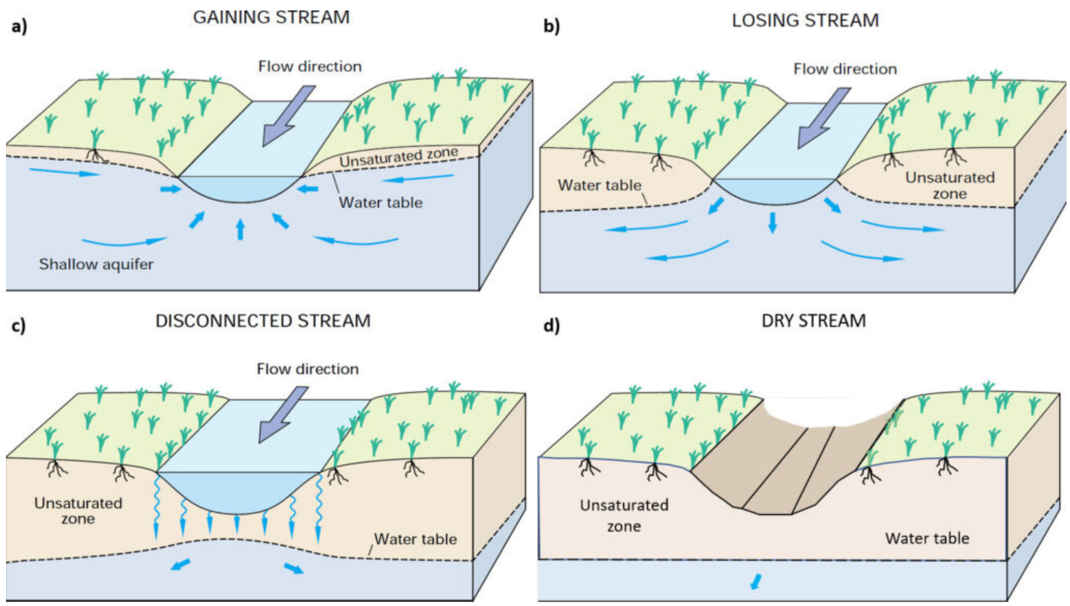


Figure 14 – River and Aquifer interactions

How human-made water systems work?

Urban (and industrial) systems

Drinking water supply systems consist of a water diversion or intake (for example, an intake in a dam, a pump extracting water from a river or an aquifer), then a conveyance facility to a drinking water treatment plant, after that another conveyance facility to move the water into the water supply network to bring the water to all houses. Then, water is used, roughly, half of it is used indoors and the other half outdoors, then there is a grey water sewer system to collect water, a waste water treatment plant and their discharge either into another water body (rivers, aquifers, or the ocean) or to another facility for its reuse (purple pipes that reuse the treated water). Now, not all the drinking water supply systems are the same.

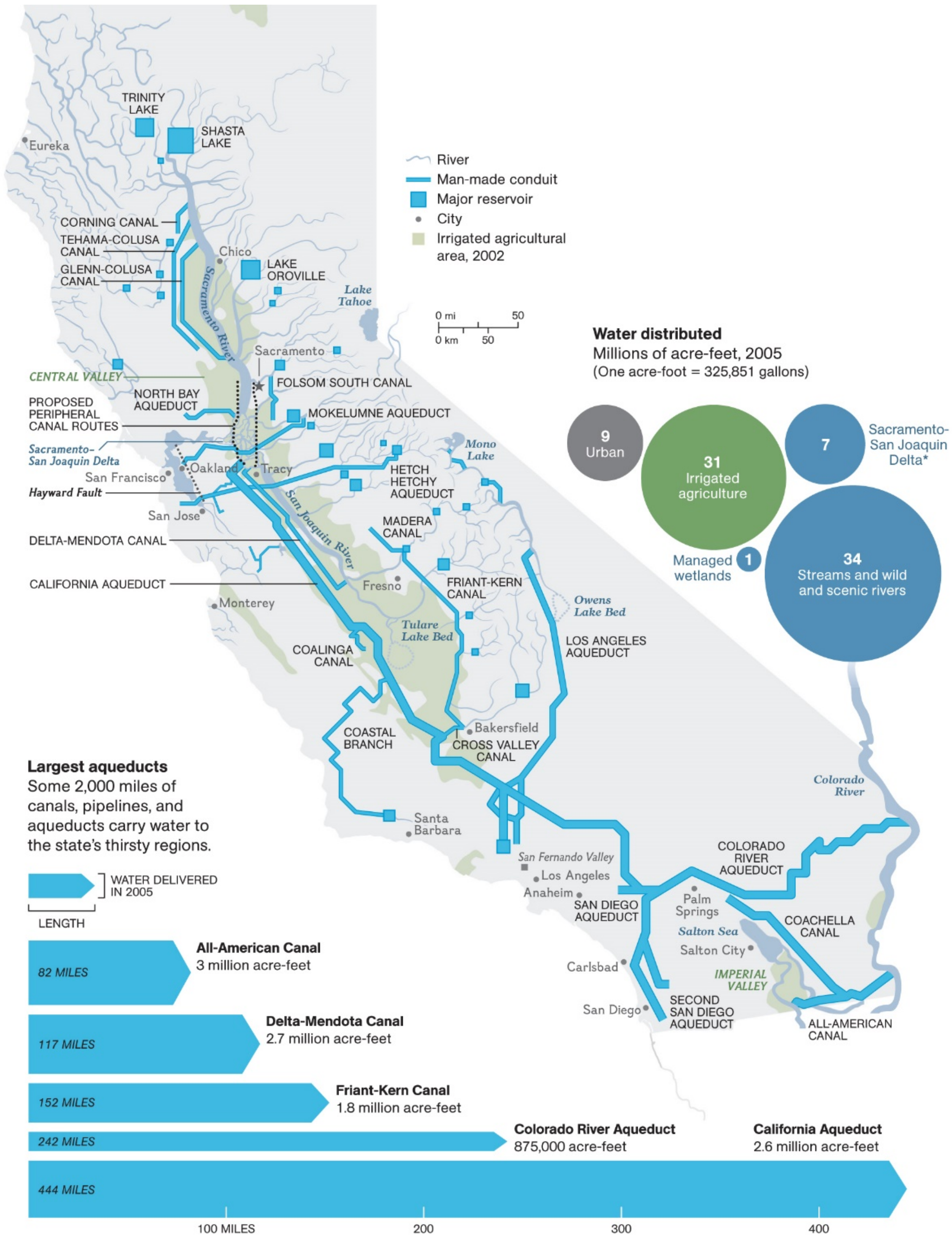


Figure 15 – California Large Water Infrastructure Schematic. Source: National Geographic.

- **For Large cities**, typically they exhaust all the local water resources in the early 1900 and looked for water resources far away, since then they have been importing water. This is the case of Los Angeles, San Francisco, the Bay Area, San Diego, Marin, Santa Barbara and San Luis Obispo counties, just to mention a few. Now, not because everyone did it, it means it was ok to do it, this strategy of importing water dispossessed water resources to the communities from which water is imported, including indigenous and rural communities. Think of this, "would you like that a city far away from where you lived come and take the water available in your surroundings?" If your answer is no, then this same answer and feeling of the people from where water is been exported. Also, agencies importing water have an important challenge to treat the large amount of waste water for its adequate discharge to other users downstream and the environment.

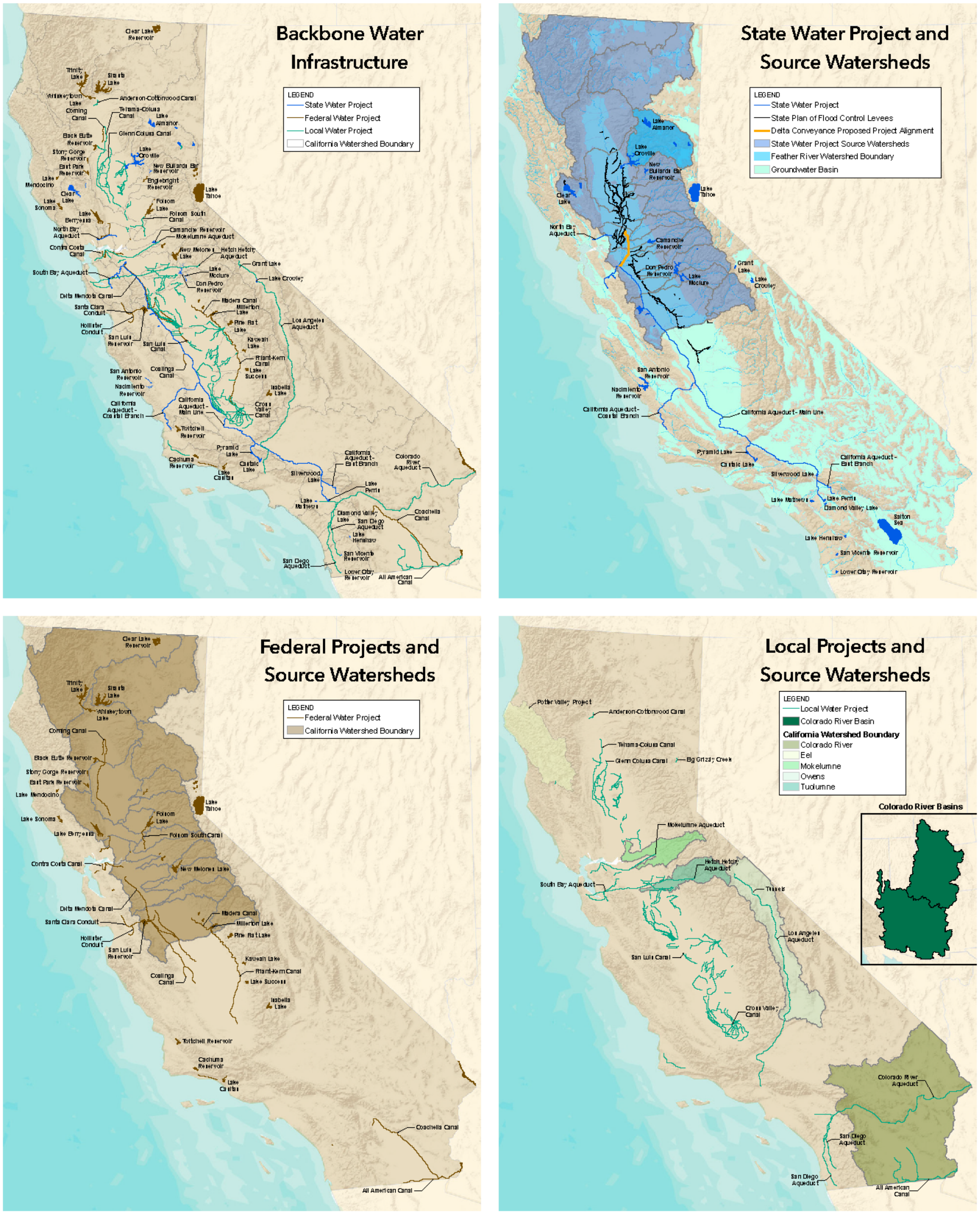


Figure 16 – Map of large water infrastructure systems in California (Source: Water Plan Update 2023)

- **For rural cities**, typically rely in local water resources, such as rivers or aquifers. They have a problem of collecting enough funds to keep a drinking water supply and waste water treatment system up to date for the need of their community at an affordable price.
- **For individual houses and small communities**, typically they rely on domestic wells for their water supply. These systems have several issues. First, in terms of water quantity, they are competing with other nearby wells that may use a lot more water, let say wells for irrigating a walnut, almond or pistachio orchard. In fact, during droughts, thousands of domestic well have gone dry because of this competition with other water users. Second, in terms of water quality, they may be extracting water that is naturally contaminated (e.g. arsenic) or man-made contaminated (e.g. nitrogen coming for synthetic fertilizers or pesticides), and they may not have the resources to treat that water or to keep up with the maintenance for the treatment. Finally, the majority of the people or communities relying on domestic wells are disadvantaged communities (i.e. low income families) that struggle with economic resources.

Agricultural systems

Agricultural water supply systems consist of a water storage system (reservoirs, aquifers, the snow), a water diversion (for example, a weir that diverts water into canals or a series of wells), then a conveyance facility that typically are canals, a turnout (a large valve) that diverts water from the canals into the agricultural fields, then an irrigation systems, that can be from furrows, all the way to a drip system or moving sprinklers, then a drainage system for the excess water, and finally a discharge into another water body (rivers, aquifers, or the ocean). Similarly, not all the agricultural water supply systems are the same:

- **Conventional agricultural systems**, that considers water only as one part of the inputs for food production and economic profit, typically these systems bring water from far away (reservoirs, canals), do not rely or account for rain in their irrigation calculations, use synthetic fertilizers for soil nutrition, use chemical pesticides for getting rid of pests because they plant a monoculture, they do not use cover crops and use as practice bare soil for their practices. In summary, this type of agriculture creates a man-made ecosystem with the philosophy that it is possible to control nature, rather than working with nature in a respectful and responsible way.
- **Sustainable agricultural systems (organic, sustainable, and biodynamic food products)** , these are part of the regenerative agriculture movement that considers the agriculture as an activity positive to the environment with water, soils, sun and air as key elements for food production and environmental protection. Typically, these systems collect water locally (in the soil), use water from the rain and fog as part of their water inputs, use cover crops, manure and compost for soil nutrition, integrated pest management, mechanical, and biological controls for managing pests, they use cover crops for soil health and for water infiltration in soils and aquifers, just to mention a few. This type of agriculture integrates agricultural practices with the local ecosystem with the philosophy that we are part of nature, respecting and taking care of it.

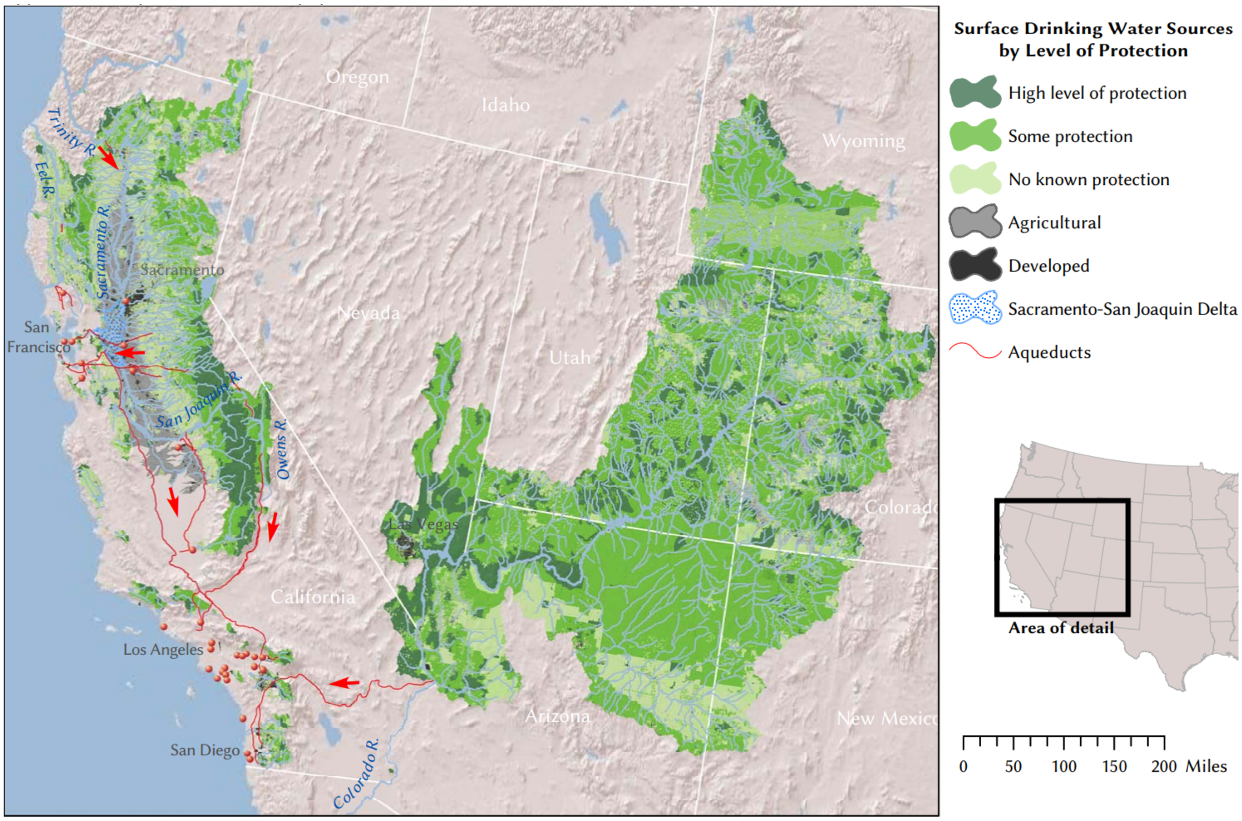


Figure 17 – Surface drinking water sources for California (Source: The Nature Conservancy 2012)

Hydropower

Hydropower systems were built with the purpose to generate electricity, they consist of an intake, a conveyance system to the turbines, the turbines to generate electricity, and a conveyance system for the discharge. There are two main types of hydropower systems: (1) those with a reservoir to store and regulate water and head for electricity production, these plants may produce electricity permanently throughout the year, and (2) those without storage that use a portion of the flow in the river to produce electricity, these plants, called runoff the river, they may produce intermittent electricity throughout the year. The main issue with hydropower plants are: (1) they are located at the entrance of the headwaters and thus blocking the access to high quality habitat for migratory fish, (2) they alter the flow regime, they produce electricity for the peak time of electric consumption in the morning and afternoon (called hydro-peaking) thus, altering the flow drastically within a day, a condition that species are not used to, and (3) they alter the sediment transport regime, they withhold sediment behind the dam and the rivers below does not have any sediment making then unsuitable for good habitat. In many cases, hydropower dams were built to raise funds for irrigation districts and agricultural projects that were not economically feasible (for the production of certain low value crops, such as alfalfa), thus, they were built to subsidize agricultural projects. Now that those projects have been re-paid, and that the society is paying for the environmental restoration of rivers, it comes into question “why should we keep those dams?” There are many of those dams that are been decommissioned and demolished, such as iron gate in the Klamath River.

Flood protection

Flood protection systems were built with the purpose to protect cities/towns and economic activities (industrial plants, agriculture, etc.) from the impact of rare but devastating flood events. They consist of storage and controlled flow release infrastructure (dams that have flood control storage and spillways, detention ponds, etc.), conveyance infrastructure (canals, rivers, bypasses, culverts, pipes, etc.), and containment infrastructure (such as levees, floodwalls, etc.).

The main issue with flood protection infrastructure is: (1) this infrastructure was designed for a quick drainage of flood event in canals and rivers, frequently increasing discharge and with this, greater sediment erosion, and more danger to communities that live along the river corridor, (2) this water can't be utilized for other purposes; because flood water pass fast in the system, this water can't be captured as it occurred naturally, reaching floodplains and infiltrating water into the aquifers, (3) a false sense of security, many communities (low income, communities of color) are built close/behind levees or downstream of reservoir with a fault sense of security. Flood plains are now used for agricultural production, these create a fault sense of security and while flood are rare events, once they happened they create enormous damage. All this infrastructure was designed with last century climate and hydrologic records that at this point are outdated considering a changing climate. Climate change is stressing these systems with more intense precipitation, in infrastructure that have lacked maintenance.

What are key Water quality parameters to be aware off?

For practical purpose, we will divide water quality parameters for drinking water and freshwater ecosystem health.

Drinking Water Quality

For drinking water we have drinking water standards that are monitored using the maximum contaminant levels (MCLs) to meet public health goals (PHGs) (comparison with EPA federal MCLs)

- Primary MCLs: Inorganic Chemicals (Arsenic, Chromium, Nitrate, Cyanide, Fluoride, Mercury, Nickel, etc.), Cooper and Lead, Radiological and Radionuclides (Radium, Uranium), Volatile Organic Chemicals "VOCS" (products derived from oil and gas such as Benzene, Ethylbenzene, Toluene, etc.), Non-Volatile Synthetic Organic Chemicals "SOCs" (Pesticides, such as Atrazine, Glyphosate, 1-2-3 TCP - Trichloropropane), Disinfection byproducts (Bromate, Chlorite), Micro-biological contaminants (Total Coliforms rule, E. Coli)
- Secondary MCLs: They are set are set on the basis of aesthetic concerns: Color, Odor, Turbidity, Total Dissolved Solids, Chloride, salts,
- Unregulated contaminants for which there are health-based advisory levels, that when exceeding those levels, it prompts certain requirements and recommendations. For instance: 1,4-dioxane (stabilizer for solvents that are carcinogenic), hexavalent chromium (heavy metal that has been used in industrial applications and found naturally occurring, MCL 2011: (0.02 µg/L)), nitrosamines (rocket fuels), microplastics, and "PFAS" or Forever chemicals (Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS))

Environmental Water Quality

- Temperature
- DO – Dissolved Oxygen, which is the oxygen available in the water column, the presence of a sufficient concentration of dissolved oxygen is critical to maintaining the aquatic life and aesthetic quality of streams and lakes
- BOD – Biochemical Oxygen Demand, which is represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature.
- Total Suspended Solid (TSS) are particles that are larger than 2 microns found in the water. Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solid concentration.
- Total Dissolved Solids (TDS) are all particles that are smaller than 2 microns found in the water (mg/liter,) combine the sum of all ion particles as well as other compounds such as dissolved organic matter. Depending on the ionic properties, excessive total dissolved solids can produce toxic effects on fish and fish eggs.
- Turbidity – nephelometric turbidity units (NTUs) – it measure of relative clarity of water.
- PH – measures the acidity of water
- Salinity –is the total concentration of all dissolved salts in water (chloride, sodium, magnesium, sulfate, calcium, potassium, bicarbonate and bromine) measured in Electrical Conductivity

Website: https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/#Turbid4

What is a key principle that all water systems follow?

Any water systems follow a very basic principle: there is a water source (Inflows), water may (or may not) be stored in the water system (storage) and water leave the water system (outflows). Think of a small piggy bank (cash box), where you are putting money in, storing money there, and taking money away. At any moment on time we can estimate how much money is saved, in other words, calculate a bank statement. In our case we can do a water balance, where we estimate how much water come into the water system (inflows), how much water was used (outflows) and how much water was stored for a given period of time, this is a very useful principle to know.

Module 2 – California Water Policy

What policies apply at all times in California?

Well, in reality, all policies apply at all times. However, there are several policies that are not dependent on the type of water source (e.g. surface water, groundwater, recycled water, etc.), economic practice (e.g. agriculture), or community (e.g. tribal communities in reservations). Thus, the following policies apply at all times California: beneficial and reasonable use of water, water is owned by all Californians, public thrust doctrine, clean water act, safe drinking water act, and the human right to water.

What are the conditions to use water in the state of California?

Beneficial and reasonable use of water. The California constitution (Article X, Section 2) and the California Water Code (§100) state that: "… water resources [should] be put to beneficial use … and that the waste or unreasonable use water be prevented...". This law mandates that waters from the state should be used for a beneficial purpose. Including water use for environmental purposes, and that waste or unreasonable use should be prevented. This law is implemented by the State Water Resources Control Board (SWRCB).

Whose water is it?

Water is owned by all people living in Californian. The California Water Code (§102) states that "… all water within the State is the property of the people of the State, but the right to the use of water may be acquired by appropriation in the manner provided by law." This means that, the state holds water in trust for the public; individuals and organizations may acquire a right to use water (usufructuary right), and these rights are subject to beneficial and reasonable use. This is why in California the state provides a "water right permit", meaning that individuals or companies are permitted or allowed to use water but they are not the owner of the water. This law is implemented by the State Water Resources Control Board (SWRCB), Water Rights Branch.

How the state of California protects public water uses (e.g. navigation, recreation or the environment)?

The Public Thrust Doctrine states that water must be preserved in trust by the state for public use (e.g. navigation, fishing, recreation, environmental protection and restoration). This doctrine is intrinsic of the legal systems of California and can limit or modify water diversions (i.e. curtail water permits to water right holders), protect river ecosystems, and maintain recreational and scenic values. There is no specific place where this law is stated, because it is imbedded in the legal system, however, it is based in California Constitution Article X Sec. 4.; California Civil Code §670; National Audubon Society v. Superior Court.

What law protects any water body (rivers, aquifers lakes or wetlands) for being contaminated?

The Clean Water Act – Porter-Cologne Water Quality Control Act. The Porter Cologne Water Quality Control Act is a law that protects the water quality of **all** California waters, including rivers, lakes, aquifers, estuaries and bays (i.e. surface water and groundwater resources). This law is administered by 9 Regional Water Quality Control Boards, that protects water quality of all water bodies at the regional and local level. For instance, this law sets water quality standards in rivers, and regulates point and non-point pollutant sources, among other. This law is specified in California Water Code, Division 7: Water Quality; and administered through 9 regional water quality control boards.

What law protects drinking water?

Safe Drinking Water Act. This law protects drinking water by ensuring its safety, establishing standards, mandating the supervision of public water systems, ensuring compliance, monitoring and reporting. This law establishes the drinking water standards by specifying Maximum Contaminant Levels (MCLs) (primary and secondary MCLs, and unregulated contaminants) which are thresholds of maximum concentration of natural or human produced pollutants for safe drinking water. This law is specified in California Health and Safety Code § 116270 and the California Code of Regulations, Title 22 (Safe Drinking Water Laws), and it is administered by the State Water Resources Control Board (SWRCB), Drinking Water Branch.

Does every Californian have the right to drinking water?

Human Right to Water. In California, "every human being has the right to safe, clean, affordable and accessible water adequate for human consumption, cooking and sanitary purposes." This is known as the human right to water in California established in 2012 by the California Assembly Bill 685. This law also specified that "… it requires that all relevant agencies to consider this policy when revising, adopting or establishing policies and regulations pertinent to the use of water …" This section of the law is important because it mandates all agencies to consider the human right to water when establishing policies and regulations; for instance, when: (1) the SWRCB establishes curtailments of water during droughts, or (2) the California Department of Water Resources (DWR) implements the Sustainable Groundwater Management Act (SGMA), or (3) a Groundwater Sustainable Agency establishes minimum thresholds to avoid undesirable results, just to mention a few. In any case, the law is administered by state water agencies [statewide (SWRCB, DWR), regional or local] that are "revising, adopting or establishing policies and regulations pertinent to the use of water", so the law is administered by several water agencies throughout the state and it is up to all Californians to make sure these agencies follow the law.

What laws protect all animal and plants species living in California waters?

Endangered Species Act (ESA) and California Endangered Species Act (CESA). This environmental laws protect all animal and plant species in California's rivers, lakes and estuaries by: [1] listing them as *endangered, threatened* or *candidate* species and protecting them (16 U.S.C. §1533, CFG §2068); [2] designating, restoring and conserving *critical habitat locations* along rivers so these species can have access to good habitat conditions (16 U.S.C. §1533(a)(3)); [3] a "Take Prohibition" that makes illegal to harm, harass, kill, or significantly modify habitat in a way that injures any animal or plant listed as endangered, threatened or candidate (16 U.S.C. §1532 §1538, CFG §86 §2080); and [4] mandating federal, state agencies, individuals and companies to ensure their actions does not "jeopardize the continued existence" of a listed species, or negatively affect its critical habitat, which in practice include requiring agencies to provide environmental flows, and restore/maintain critical habitat along the river corridor and other restoration measures during water resources management. The ESA is one of the main reasons why major water projects in California must balance water supply with salmon runs, riparian plant survival and ecosystem health. You can find the list of endangered, threatened or candidate in this website of the California Department of Fish and Wildlife.

This law is specified in the federal ESA statute (16 U.S.C. 1531-1544) and in the California state CESA statue California Fish and Game Code - Section 2050-2116, and it is administered by the U.S. fish and

Wildlife Service for terrestrial and freshwater species, the National Marine Fisheries Service for anadromous fish (e.g. salmon and steelhead) and the California Department of Fish and Wildlife for any expanded rules defined in the CESA.

What policies apply according the type of water source (e.g. surface water, groundwater or recycled water)?

There are specific policies that apply according to the water source that is used: **surface water, groundwater and recycled water**. Please remember the laws and water allocation policies that will be described below must comply with all the laws aforementioned. Thus, the following policies apply according to the source of water: surface water right permit (riparian and appropriative), groundwater allocation (through adjudication of SGMA), and recycled water permits (through laws and regulations).

How can I use surface waters?

Primarily, there are two primary types of **surface water rights** in California: riparian rights and appropriative water right permits.

What is a riparian water right?

Riparian Water Rights. A riparian water right is the right to use the **natural flow of water** on land that directly touches a river, stream, creek, or lake (*riparian land*). Because the right is tied to land ownership, an individual, company, or institution does not need to apply for a permit to exercise this right. However, a Statement of Water Diversion and Use must be submitted to the Water Boards. These are some key characteristics of riparian rights:

- Water can only be used on the parcel that touches the watercourse and drains back into it. It cannot be transferred to non-riparian parcels.
- Riparian rights apply only to the natural flow. Imported water or stored reservoir releases cannot be claimed under a riparian right.
- Water cannot be stored for use in drier periods; diversions must match the natural flow available at the time.
- Riparian rights are not lost by non-use because the right is attached to the property.
- All riparian users along a stream share shortages proportionally. In times of conflict, domestic uses such as drinking, cooking, and bathing are typically given highest priority.
- Riparian water rights are superior (have higher priority) to appropriative water rights.
- Water must be used for a beneficial purpose (e.g., irrigation, municipal supply, fish and wildlife), and waste or unreasonable use is prohibited. California Constitution (Article X, Section 2).

A more detailed explanation is provided by the Water Boards (What is a riparian right?) and in Lux v. Haggin, 69 Cal. 255 (1886).

For example: imagine a family farm located directly on Putah Creek in Yolo County. The farm has a riparian right to divert natural creek flow to irrigate crops on that parcel. However, the family cannot build a reservoir to store water for later use in August, nor can they pipe the water to another field across the road that does not touch Putah Creek.

What is an appropriative water right?

Appropriative Water Rights. Appropriative water rights allow individuals, companies, or institutions to **divert water** from a river, stream, or lake **for use on lands not adjacent to the water source**. These rights are based on the principle of **"first in time, first in right",** meaning that the first person to put water to beneficial use has priority over later users. Appropriative water rights must submit an application, obtain a **water right permit** (and later a license) from the Water Boards, unless the use predates 1914 (*pre-1914 water rights*) or is a small domestic or livestock use exempted by law (California Water Code, Title 23, Division 3, Ch. 2.5, request form,) . These are some key characteristics of appropriative water rights:

- First in time, first in right. Senior appropriators (those with older rights) are entitled to water before junior appropriators in times of shortage.
- Use it or lose it. Appropriative rights can be lost if water is not used for a period of five consecutive years (California Water Code §1241).
- Water storage. Appropriators may store water in reservoirs and use it later.
- Permit requirements. Appropriative rights must specify the amount, timing, and place of use.
- Place of use flexibility: Appropriative rights are not tied to riparian land; water may be conveyed to non-riparian parcels.
- Pre-1914 vs. Post-1914. Pre-1914 appropriators do not require water right permit, Post-1914 appropriators require a water right permit.
- Beneficial and Reasonable use. Water must be used for a beneficial purpose (e.g., irrigation, municipal supply, fish and wildlife), and waste or unreasonable use is prohibited. California Constitution (Article X, Section 2).

For example: The city of Davis and Woodland obtained a permit from the SWRCB to divert water from the Sacramento River into its municipal water supply system. Even both cities are located miles away from the Sacramento river, its appropriative right allows the diversion because the water is put to beneficial use. However, if the river runs low during a drought, their water right may be curtailed if senior appropriators need the water.

Other Examples. All California's large water projects rely on appropriative water rights, including the Central Valley Project, State Water Project, Los Angeles Aqueduct, San Diego Aqueducts, Hetch Hetchy Aqueduct, Mokelumne Aqueduct, Colorado River Aqueduct, All American Canal, etc.

How can I use groundwater?

In California, groundwater may be extracted and used as long as it is for a **beneficial** and **reasonable** purpose (California Constitution Article X, Section 2). There are two primary types of groundwater rights: **overlying rights** and **appropriative rights**. The legal framework that applies depends on the location: in some areas, groundwater use is governed by court decrees (***adjudicated basins***), while in other areas it is managed under the **Sustainable Groundwater Management Act (SGMA)** (California Water Code §§10720–10737.8).

What is an overlaying groundwater right?

Overlaying Groundwater Rights. Overlying groundwater rights belong to landowners whose property lies directly over a groundwater basin (aquifer) *Katz v. Walkinshaw*, 141 California 116 (1903). These are some key characteristics of overlying groundwater rights:

- Place of use. Groundwater can only be used on land that overlies the basin from which it is pumped (*Katz v. Walkinshaw*, 141 California 116 (1903), page 2-3).
- Correlative sharing. All overlying groundwater users share the "safe yield" of the basin (the amount of water that can be extracted without long-term overdraft). Their allocation is proportional to the size of each property or the reasonable beneficial use on that property.
- Not lost by non-use. Because the overlying groundwater rights are tied to the land, they are not forfeited by non-use.
- Priority: Overlying groundwater rights are superior (have higher priority) to appropriative groundwater rights.
- Beneficial and reasonable. All groundwater use is subject of the constitutional standard of beneficial and reasonable use (California Constitution, Article X, Section 2).

For example: An almond grower owns land directly overlying the Tule Groundwater Sub-basin in the southern San Joaquin Valley. The grower has an overlying groundwater right to pump water from the aquifer to irrigate pistachio trees on that property. However, the grower cannot transfer that right to a separate parcel located outside the Tule Subbasin (they can transfer/sell it within the sub-basin), nor can they sell the right independently of the land. The grower must share the basin's "safe yield" proportionally with other overlying landowners, even if this means reducing irrigation.

What is an appropriative groundwater right?

Appropriative Groundwater Rights. Appropriative groundwater rights apply when groundwater is extracted and used on lands that do not overlie the basin where the water is pumped. These are some key characteristics of appropriative groundwater rights:

- Subordinate to overlayers: Groundwater appropriators may only use groundwater after overlying users' water needs are met first.
- First in time, first in right. Senior groundwater appropriators (those who first diverted water to beneficial use) are entitled to water before junior appropriators in times of shortage.
- Use it or lose it. Groundwater appropriative rights can be lost if water is not used.
- Permits and adjudication. While groundwater rights are generally established by use rather than permits, appropriative claims may be limited or defined through adjudications or SGMA planning processes.
- Beneficial and reasonable. All groundwater use is subject of the constitutional standard of beneficial and reasonable use (California Constitution, Article X, Section 2).

According to SWRCB, the following counties have some policies that may allow the exportation and transfer of groundwater outside of the county: Shasta, Tehama, Butte, Glenn, Colusa, Sutter, Yolo, Sacramento, Yuba and Solano.

For example: An alfalfa grower in Shasta County that has been using groundwater from the basin to irrigate its Alfalfa field obtained a permit to export water outside of Shasta county from the chief engineer of the Shasta County Water Agency for 3 years. This alfalfa growers fallows its land and sell the water to a pistachio grower in the Westside San Joaquin using the Tracy Pump Station and the Delta-Mendota canal. This use qualifies as an **appropriative groundwater right** because the water is being applied to non-overlying land.

What are the laws in California that I need to know to use **groundwater**?

There are two primary laws (i.e. legal frameworks) that apply for groundwater use, they are location dependent: groundwater adjudication and Sustainable Groundwater Management Act (SGMA) (California Water Code §§10720–10737.8).

How can I use water if I am located in an adjudicated groundwater basin?

Groundwater Adjudication. In groundwater adjudicated areas, the amount of groundwater (i.e. groundwater allocation) that can be used by a user was defined by a court decree. There are 27 groundwater adjudicated areas administered by a watermaster (See California Water Policy Map, pink hatched polygons). In these areas, all the available groundwater has been adjudicated meaning there is no groundwater available for a new groundwater user. You need to contact the watermaster to identify groundwater users, and later contact an adjudicated groundwater user to see if you can get access to groundwater.

These areas have to do a periodic reporting to the Water Boards, but they are exempt to submit a Groundwater Sustainable Plan (GSP), however, SGMA requires the submission of their groundwater levels, groundwater extraction, recharge and storage (Water Code 10720.8). Groundwater adjudicated areas are managed by the State Water Resources Control Board (SWRCB) Division of Water Rights, Adjudicated Areas.

How can I use water if I am located in a groundwater basin managed by SGMA (Sustainable Groundwater Management Act)?

In groundwater basins managed by SGMA (See California Water Policy Map, light pink polygons), groundwater allocations are determined by the local Groundwater Sustainability Agency (GSA).

To find out how groundwater is managed in your area:

1) Locate the GSA. Use the SGMA Data Viewer to identify the GSA on your area of interest (Reference layers/Groundwater Sustainability Agencies).
2) Identify the Groundwater Sustainability Plan Area (SGMA Data Viewer, Reference layers/Groundwater Sustainability Plan Areas).
3) Download and review the Groundwater Sustainable Plan (GSP) (GSP portal) for your region of interest. This plan outlines groundwater allocations, strategies and actions to meet with SGMA requirements.
4) Contact your GSA directly and ask what is needed to use groundwater in your area of interest.

What is SGMA (Sustainable Groundwater Management Act)?

Sustainable Groundwater Management Act (SGMA). The Sustainable Groundwater Management Act (SGMA) is a legislation passed in 2014 for managing groundwater in California, whose objective is:

"*It is the policy of the state that groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits.* ***Sustainable groundwater management is best achieved locally through the development, implementation, and updating of plans and programs based on the best available science***" (SGMA act, page 6).

SGMA requires the formation of **Groundwater Sustainability Agencies (GSA)**, which are local water agencies in charge of administering the implementation of SGMA. There are more than 250 GSAs in California (SGMA Data Viewer, Reference layers/Groundwater Sustainability Agencies). SGMA also requires the development of a **Groundwater Sustainable Plan (GSP)**, which is a series of strategies and actions to prevent the occurrence of those **6 undesirable results**. In addition, there are regions where local agencies have been working towards groundwater sustainability before SGMA, these agencies can submit an **Alternative Plan**. Sustainable groundwater management requires preventing **6 undesirable results**:

- There are four undesirable result related to preventing groundwater overdraft: *(1)* Chronic lowering of groundwater levels, *(2)* reduction of groundwater storage, *(3)* seawater intrusion, and *(4)* land subsidence
- (5) Degradation of water quality
- *(6)* Depletions of interconnected surface water and groundwater that affect beneficial uses of surface water

According to the best management practices for SGMA (page 2):

"***sustainable conditions within a basin are achieved when GSAs meet their sustainability goal and demonstrate the basin is being operated within its sustainable yield. Sustainable yield can only be reached if the basin is not experiencing undesirable results***"

How Groundwater Sustainability Agencies (GSAs) manage groundwater?

To meet SGMA requirements, GSAs take the following steps:

- Develop a **water budget**. A water budget is a diagnostic of the conditions of their basin where inflows, outflows and change of aquifer storage are analyzed.
- **Prepare a Groundwater Sustainable Plan (GSP)**. Then, the agency develops a plan, which is a series of strategies and actions to prevent the occurrence of those 6 undesirable results
- **Identify undesirable results, measurable objectives, and minimum thresholds.** Each GSA have identified what are the undesirable results that apply to their region of interest, then associates a measurable objective and a minimum threshold and develop a monitoring plan for that measurable objective so progress can be tracked over time.
- **Reviewing progress every 5 years**. Plans are reviewed at least every 5 years. Each measurable objective is compared with the minimum thresholds to evaluate whether the basin is on track.

If the first submission of the GSP is deemed incomplete, or if the 5-year review shows insufficient progress, then the state Water Resources Control Board (SWRCB) can intervene temporarily and impose corrective actions until the basin return to a path of sustainable groundwater management.

Are groundwater laws related with surface water?

Yes. Due to the one of the undesirable result of SGMA groundwater and surface water regulations are tight together:

"*Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water*"

Beneficial uses of surface water include: environmental use, agriculture, municipal and domestic uses, etc. This undesirable result tight together groundwater management with:

- Environmental flows, because the environment is an important beneficial use of water,
- Riparian water rights, because they depend on the natural flow of water and groundwater provide baseflows during the dry periods when water is so vital for meeting their water needs
- Appropriative water rights because groundwater extractions can lower the groundwater table below the river bed elevation, creating a losing river. When water is conveyed in rivers to meet appropriative water rights, water can be lost through aquifer recharge, and thus affecting the amount of water that an appropriator can receive.

While none of these concepts has been tested legally yet, surface water - groundwater interconnections affect surface water and groundwater availability for their beneficial water uses and this undesirable result provides an avenue for conjunctive surface water and groundwater resources.

What is the legal framework of recycled water use in California?

Definition. Recycled water is defined as: "water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource" (California Water Code. Div. 7, Ch. 2, Sec. 13050(n), page 85).

Policy of the state: prevent waste of water. It is the policy of the state California that "using potable water for non-potable uses (e.g. watering cemeteries, golf courses, etc.) is a waste or unreasonable use if recycled water is available …" (California Water Code, Div. 7. Ch. 7, Sec. 13550(a), page 134).

Beneficial Uses. Recycled water may be used for a wide range of **beneficial purposes**, including:

- Non-potable uses, such as irrigation (crops, landscapes, golf courses, and parks), cooling, other industrial purposes (California Code of Regulations, Title 22, Div. 4, Ch. 3, Art. 3),
- Direct and indirect potable re-use (California Water Code, Div. 7. Ch. 7.3, Sec. 13560, page 156), among others.

Water Quality Standards. The California Code of Regulations Title 22 establishes the water quality standards (e.g. disinfected tertiary recycled water) for a given beneficial use (e.g. water for irrigation) of non-potable uses (Div. 4, Ch. 3, Art. 3), and for Indirect potable reuse (Div. 4, Ch. 3, Art. 5). The SWRCB provide clear guidance on the different water quality treatments for non-potable reuse.

Reporting. The SWRCB Recycled Water Quality Policy (Section 3) requires wastewater treatment plants and recycled water producers to report monthly volumes of influent and effluent each year from the previous calendar year every April. Reporting includes treatment level and discharge type and, as applicable, recycled water use by category (Resolution No. 2018-0057 and Fact Sheet).

Legal Framework. California law strongly encourages the use of recycled water to offset demand for potable supplies (California Water Code, Div. 7. Ch. 7, Sec. 13550(a), page 134). The **Porter–Cologne**

Water Quality Control Act (Cal. Water Code §13000 et seq.) establishes the State Water Resources Control Board's (SWRCB) authority over water quality, while **Water Code §13550–13557** declares that the use of potable water for non-potable purposes "is a waste or unreasonable use" if recycled water of adequate quality is available. The **Recycled Water Policy** (adopted by SWRCB in 2009, amended in 2018) provides statewide goals and uniform requirements for recycled water production and use.

Resources: The SWRCB provides two key documents:

(1) a compilation of all the statutes governing recycled water across different agencies, and
(2) the SWRCB recycled water quality policy, which describes statewide goals, reporting requirements, and permitting.
(3) The Water Recycling Funding Program administered by the SWRCB

What are the agencies that regulate recycled water in California?

State Water Resources Control Board (SWRCB) Division of Drinking Water Branch – adopts statewide recycled water policies, issues water quality permits, and oversees recycled water projects under the Porter–Cologne Act.

The Regional Water Quality Control Boards (RWQCBs) issue and enforce Waste Discharge Requirements (WDRs) or water reclamation requirements for local projects.

The California Department of Public Health (CDPH, now Division of Drinking Water within SWRCB) – develops health-based standards for the use of recycled water, particularly for potable reuse.

Local water agencies – operate and distribute recycled water systems under permits and regulations established by the SWRCB and RWQCBs.

How can an individual or an institution gain access to recycled water in California?

Recycled water use **does not require obtaining a new water right** from the SWRCB, since the water has already been lawfully diverted and used. To gain access to recycled water, an individual or institution must connect to a **recycled water supplier** (e.g., a municipal utility or water district), establish agreements between water recycle supplier and user through contracts, and comply with all permit requirements and use restrictions (California Water Code. Div. 7, Ch. 2, Sec. 13050(n), page 85).

The proponent(s) of a recycle water project should pursue a **Recycled Water Permit** which is an order adopted by a regional water board or the SWRCB prescribing requirements for a recycled water project, including but not limited to:

- water recycling requirements pursuant to public health and safety (Water Code section 13523),
- master recycling permits pursuant to Recycled Water Permit (Water Code section 13523.1),
- National Pollutant Discharge Elimination System permits pursuant to the Federal Water Pollution Control Act and Water Code section 13377,
- waste discharge requirements (Water Code section 13263), and
- waivers of waste discharge requirements (Water Code section 13269).

What policies apply to protect the **environment**?

In California, there are five legal frameworks to obtain a water right for the environment (an instream flow) for protecting or restoring riparian and freshwater ecosystems at risk:

(1) the California Wild and Scenic Rivers Act in 1972. It designates certain rivers and river segments as "wild and scenic" (see California Water Policy Map, rivers in green), protecting them from new dams or major diversions and ensuring their free-flowing condition is preserved for ecological, recreational, and cultural values (California Public Resources Code §5093.50 et seq.).
(2) the Endangered Species Act (ESA) in 1973 and the California Endangered Species Act (CESA). These regulations protect all animal and plant species in California's rivers, lakes and estuaries listed as endangered, threated or candidate species, designating critical habitat locations and mandating federal, state agencies, individuals and companies to ensure their actions does not jeopardize their continued existence. (ESA 16 U.S.C. 1531-1544, CESA CFG Section 2050-2116)
(3) Section 5937 of Fish and Game Code. This statute requires dam owners to release sufficient water to keep downstream fish "in good condition," making it one of the strongest tools for protecting riverine ecosystems. Smith (2014) provides a good description of this statute.
(4) Federal Energy Regulation Commission (FERC) Hydropower Relicensing. When hydropower dams undergo relicensing with the FERC, environmental reviews and biological opinions can impose instream flow requirements to reduce ecological impacts and restore fish habitat.
(5) Public Trust Doctrine. This doctrine obligates the State of California to protect public resources such as fish, wildlife, and recreation in navigable waters, which may require limiting or modifying water rights (*National Audubon Society v. Superior Court*, 33 Cal.3d 419 (1983)).

How can I obtain an instream flow?

To obtain an instream flow in California, you typically must file a Water Code section 1707 petition to dedicate a water right for instream flow purposes through the State Water Resources Control Board (SWRCB), which will consider the petition and any protests before making a decision. This practitioner's guide to instream flow transactions describe specific steps and things to consider for obtaining an instream flow.

How much water is needed to sustain adequate ecological conditions in rivers?

We are lucky! A group of scientist have determined environmental flows for every river in California! The California Environmental Flows Framework calculated instream flows for at every 600 feet reach for every river in California. CEFF is a process that recommends instream flows based on functional flows of the natural hydrology of California (read executive Summary). The functional flows for each reach of your water system can be downloaded from the natural flows database (click on map). This video describes Functional Flows for California and this video shows how to download and understand environmental flows for Pajaro Valley.

What are the ecological components that I should consider for instream flows?

There are four main components to consider when determining environmental flows (see this video):

- Water Quantity: timing of flow-events related with change of seasons, duration of flow events that determine how long seasons last , magnitude of the flows, frequency in terms of their yearly occurrence and rate of change meaning how fast or slow flow change through time

- Water Quality: it involves good water quality conditions for freshwater and riparian ecosystems. It considers different water quality parameters such as: temperature, ph, Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), heavy metals, salinity typically collected as Electrical Conductivity (EC), among others.
- Habitat: it involved how the river channels looks like (geomorphology) referred as channel forms (pools, riffles, cascades, meanders, etc.), sediment transport and deposition, sediment composition meaning the size of sediment in a given river reach, and woody habitat.
- Connectivity: longitudinal connection of rivers from their headwater to the ocean, transversal connectivity from left to right river banks and floodplains, and vertical connectivity that connects surface water and groundwater.

How can a **tribe** use water in California?

Tribes can use water through a legal instrument named: **Federally Reserved Right**.

Background. Tribes are sovereign nations that exist separately from United States and California State authority but tribes are subject to the rules of the Federal government. Tribal sovereignty and statutes are historic and legally framed. Tribes hold water rights through treaties, sovereign status, federal laws and mandates, allotments, and court cases. In California, the historical treatment of Tribal communities and the mixed water rights system that exists complicates Tribal Water rights.

Tribal water rights are within the larger category of **Federally Reserved Rights**. Federally reserved rights are connected to Federal land and operations that are reserved for specific purposes. Examples of this are Rancherias (the Californian name for an Indian Reservation) or Individual and group land allotments. These Tribal water rights are held by the Tribal Government, overseen by the Federal government, and managed in conjunction with the State of California's various agencies.

[Text provided by Ivan Senock, Tribal and Indigenous capacity building advisor. Ph.D. Native American Studies, UC Davis]

What is the legal framework of tribal water rights (federally reserved rights)?

The policies and methods of accessing tribal water rights initially encompass: (a) two Federal legal doctrines, (b) California state policies on beneficial use and water quality, and (c) agreements between Tribal Governments and Federal/State agencies. It is essential to note that these paths are lengthy and require a concerted effort to secure water rights, and do not address the necessary infrastructure investment for utilizing such rights.

- Federal legal doctrines. The two legal doctrines are the Winters Doctrine (Winters v. U.S. 1908 and Overview) and Winans Doctrine (Winans v. U.S. 1905,), which are precedent-setting Supreme Court cases regarding Tribal rights. The Winters case established the precedent that the Federal Government set aside lands for Tribes and that water was included in this reservation. The Winans case set forth that Tribal Rights, unless a tribal right is explicitly removed in a treaty, still hold rights to those practices, which include water.
- State policies. Tribal Beneficial Uses (TBUs) are a beneficial use, in accordance to beneficial and reasonable use as defined by the State of California and the SWRCB (California Constitution Article X, Section 2). Tribes comply with federal and state water quality standards through the Clean Water Act, Porter Cologne Water Quality Control Act, and their respective Regional Water

Quality Control Boards. These are two ways in which Tribes engage with the State of California in terms of water management.

- Agreements between Tribal governments and Federal/State Agencies. Other way Tribes gain access to water rights are through co-stewardship, co-management and co-governance agreements with either or both federal and State agencies of land, watersheds and water. These are negotiated and enforced by many tribes throughout the state of California.

[Text provided by Ivan Senock, Tribal and Indigenous capacity building advisor. Ph.D. Native American Studies, UC Davis]

What are the agencies that regulate tribal water (federally reserved rights) in California?

The managing agencies are: SWRCB: Division of Water Rights, Adjudicated Areas, Applicable Regional Water Quality Control Boards, Department of the Interior-Secretary's Indian Water Rights Office (SIWRO), Bureau of Indian Affairs, and the Bureau of Reclamation.

[Text provided by Ivan Senock, Tribal and Indigenous capacity building advisor. Ph.D. Native American Studies, UC Davis]

How can a Tribe gain access or hold a water right?

There are several ways in which tribes can gain access or hold water rights.

- Access through Winter rights. Tribes must undergo a quantification of the water rights, which can be achieved through two channels: litigation of water rights or a water rights settlement.
- Access through negotiated co-management agreements of Federal or State lands.
- Access through ownership. Tribal properties that holds state water rights within the water right system.

Keep in mind that water rights, like all other areas of natural resources, have complex and nuanced aspects that are continually being negotiated and revised.

[Text provided by Ivan Senock, Tribal and Indigenous capacity building advisor. Ph.D. Native American Studies, UC Davis]

What other policies apply to agricultural land to prevent contamination from fertilizers (Nitrate) and salinity?

Unfortunately, legacy and current agricultural practices put at risk the contamination of surface and groundwater due to the use of fertilizers, and the importation of water that has high concentration of salts. There are two policies that apply to agricultural land in addition to the previous regulations to prevent contamination from fertilizers (nitrates) and salts:

1) Irrigated Lands Regulatory Program (ILRP).
2) Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS).

What law prevents prevent contamination from agricultural products (e.g. fertilizers, pesticides)?

The Irrigated Lands Regulatory Program (ILRP) objective is to protect surface and groundwater by regulating discharges from commercial irrigated agricultural lands (e.g., from irrigation, runoff) from pollutants (pesticides, fertilizers, salts, and sediment), which can harm aquatic life or make water unusable for drinking water or agricultural uses. The program is implemented by California's Regional Water Quality Control Boards under the authority of the State Water Resources Control Board (SWRCB) and the relevant Central Valley Regional Water Quality Control Board (CVRWQCB) in the Central Valley region. This factsheet provides a very good description of the program

according to the water source that is used: **surface water, groundwater and recycled water**. Please remember the laws and water allocation policies that will be described below must comply with all the laws aforementioned. Thus, the following policies apply according to the source of water: surface water right permit (riparian and appropriative), groundwater allocation (through adjudication of SGMA), and recycled water permits (through laws and regulations).

Module 3 – Water Budgets

[Module in progress]

Module 4 – Water Advocacy

[Module in progress]

Module 5 – Tribal Autoethnography

What is Ethnography?

Ethnography is the scholarly and critical work of documenting the lived experience and perspectives of communities and culture. Ethnography is used by cultural anthropologists and other social scientists to document, engage, and studies cultures and cultural processes. Ethnography does have a historical connection to colonialism in regards to work with Indigenous communities. This relationship should be acknowledged, and efforts are made to ensure community based participatory research is conducted.

The first step to any ethnographic work is paper and historical work. To engage deeply in research or topics ethnographers often do extensive research, planning, and reading on previous research and locations they work in. Here we are not asking you to do extensive previous knowledge, we are asking you to do basic knowledge of the community and landscape which you are a descendant of. The key to this work will be skimming and general knowledge. You can start by thinking about this questions:

- What waterways are there?
- What has been written about your community?
- Where has your family or community been and been placed?

What is Indigenous Ethnography (IE)?

It is a reimagined and improved methodology for ethnography. The major tenants of indigenous ethnography include: Respect, Relevance, Responsibility, Reciprocity, and Relationship. You can look at the work done by Rosalina Diaz for reimagining any ethnographical framework. These are some steps for you to acknowledge and consider for your indigenous ethnography work:

1. Transparent acknowledgement that Anthropology, as a discipline, has been historically utilized as a tool of the colonial agenda
2. Dismantling of the false dichotomy, hierarchies, statuses, and roles that create unequal interactions between ethnographer and informant
3. Engaging informants as collaborators and partners in knowledge production, respecting their inherent authority to tell their own stories from their unique standpoints
4. Providing open access to a platform for the gathering, sharing, and presenting of their stories and experiences
5. Re-focusing the teaching of ethnography, so it promotes an engaged and non-hegemonic methodology

What are the main steps to do my Indigenous Ethnography (IE)?

There are 7 steps to do your indigenous ethnography module:

1. Identify the sources of information that you may have available
2. Develop a knowledge map
3. Identify people for interviewing
4. Obtain the consent for each people you are doing a semi-structured interview
5. Define ahead a list of objectives and questions for your interview
6. Repeat steps 4 and 5 for every person that you interview
7. Analyze and synthesize the story

What are the sources of information that I should be aware of?

Sources of knowledge for indigenous communities are located in a multitude of places. The shared commonality for Indigenous communities is Elders or Cultural Practitioners and Community/Cultural Oral histories or stories. Elders and cultural practitioners are living reservoirs of knowledge that are a continuity of community who have a shared space of historical experience and communal experience with ancestors who have passed on. Another source of knowledge is the archives and previous research conducted by anthropologists, social scientists, revitalizationists, and other community members.

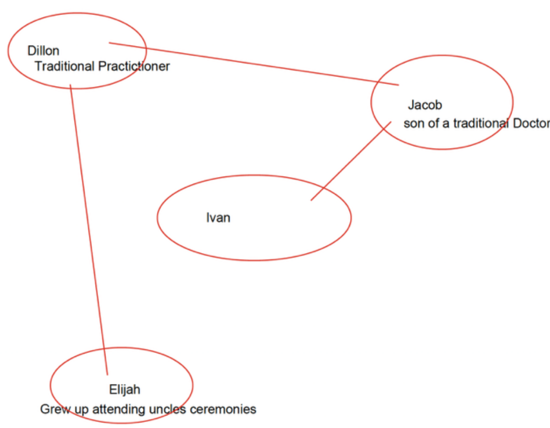
What is a knowledge map?

A Community knowledge map is a key ethnographic technique for mapping out social relations as well as where oral history lives and flows from. This is often the first exercise completed when planning out in depth research or even visits to other places. This will guide and inform what knowledge and what sources you wish to use and document. Remember relations and connections are living things that change over time as one learns and engages. So do not seek perfection, but instead seek a guide.

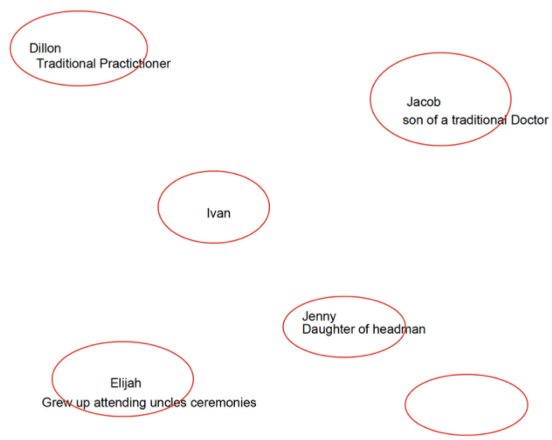
How can I make a Knowledge Map?

There are many ways to make a *Community Knowledge Map.* Here we provide some basic step for you to follow. The names and examples that are provided below correspond to the author of this module, Ivan Senock. We have changed the other names to protect his interlocutors and friends.

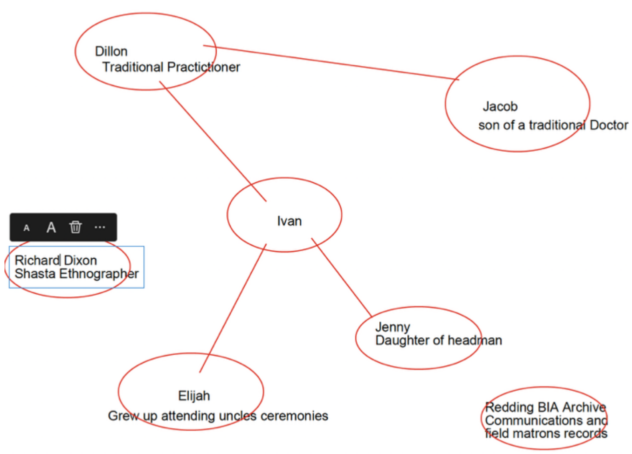
Step 1: start by centering yourself (remember we use the name *Ivan* as an example) and your relations that first come to your mind when you think about your research topic (Figure below).



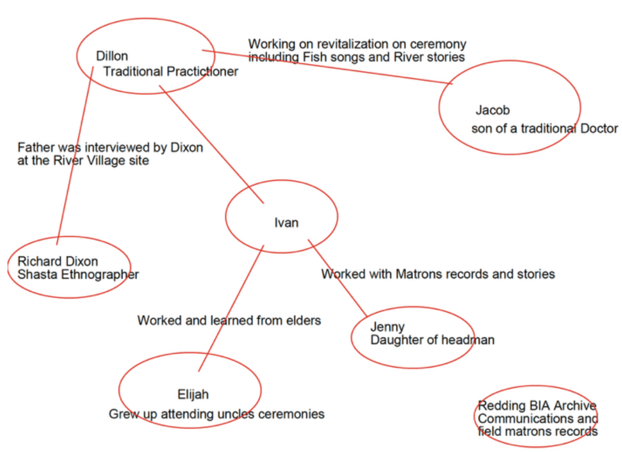
Step 2: label their knowledge or experiences with the topic under their name (See image below).



Step 3: you should also add any person, archive, or source you found outside of your community (see figure below). As you fill this out you will start to see patterns and connections.



Step 4: draw the connections and continue to add detail (see step 4).



Do I need to get consent for my ethnographic work for every person I interview?

Yes. One of the most critical ethical considerations for anyone doing ethnography is the understanding of consent that relies in three characteristics: (1) free-willing, (2) prior to the study and (3) informed description of the reason for obtaining, using and archival of the knowledge.

You should start by asking yourself the following question: Do I have permission to engage or tell a story? This is core tenant of community based participatory research. Here ethnographers talk to participants about their research and area of study and ask for permission to take notes, write about, and publish (if you want to) the work you conduct with a community. Consent must be given before any work is done or any notes are taken. Consent can be revoked at any time. Indigenous communities have a horrible history of colonization and invasion which includes anthropologists and other taking stories, information, and even material culture from communities. **YOU MUST PREVENT THIS AT ALL COSTS**. That being said, there are ways to ensure people, communities, and cultures are respected. The instructors will not retain any information you collect.

1) Inform interviewee about the project. For example:
   "Hi Elder/Knowledge holder, I'm taking a water course to learn about water. The laws, the government agencies responsible for water, and our own connection to water."
2) Ask permission to talk with them and to take notes or record them. For example:
   "I am learning about water and though you would have some knowledge or experience with it. Would you be willing to talk with me about this or _______ story? May I take notes or record. "
3) Explain the notes and what the information will be used for. For Example:
   "*I am taking notes and reading knowledge. No-one will be keeping this information. I may discuss this information with my instructors, but they will not keep a copy.*"
4) After interview or notes follow up with consent checkin. For Example:
   "*Hi Elder/Knowledge holder. I am checking in to see if you are still okay with me using our discussion, interview, or story for this project.*"

Important note: The information you gather with only be held by you and your community. You shall not provide a copy of this information with any of your instructors.

What are good guidelines for conducting a guided interview?

Interviewing is taking a conversation and guiding the flow of thought(s) through particular a topic(s) seeking the depth within each stop. Interviewing is on a spectrum from Yes and No with direct questions and answers to semi structured interviews that have open questions and prompts to an open-ended conversation that has no questions or set topics. In this course, you are aiming for a semi structured interview where there is a set list of questions that open up into areas of experience, knowledge, and perspectives. Typically, ethnographic interviews tend to stay away from two major points of questions. First, the simple "yes" and "no" questions because in seeking perspectives and experiences, the words and description are the data you will use and analyze. Second, the leading questions. You do not want to lead our collaborators or interlocutors to answers you know but for them to articulate in their own words their knowledge. For each question you develop and use, you should have a follow up question(s) that expands the previous statement or answer from your interviewee. Follow up questions all stem from the concept of tell me more and can be crafted on the spot.

Here is a starting list of questions that you can build upon:

- How do you know water? Or what is a significant memory of water?
  Follow up: Were you taught this? And by whom?
- What you know water from?
  Follow up: Is it a place that we (the tribe) have connection to?
- What are you interested in about water?
  Follow up: Tell me more your interest?
- How does water affect you?
  Follow up: How do you connect or continue this?
- Do you know any knowledge and stories about water?
  Follow up: Is this a personal, familial, or community story?
  - Do you have or know any cultural attachment to water?
    Follow up: How did you come to learn it?

What is storywork and oral?

Stories, oral histories, world view, and cosmology are a foundational part of the human experience. The western world used to call these histories myths, legends, and folklore but Indigenous ethnography situated the indigenous experiences and perspectives foundations in these important sources of information and identity. Ethnographic methods analyze storywork and oral histories by reflecting on the significance, patterns, and in community knowledge. Analysis begins with recording, translating, transcribing, or bringing back from archives community stories then examining within the text patterns, structures, morals, positionality, or context. This method of examination is a particular form of literary analysis often paired with questions or guided by community members familiar with the stories or oral histories.

What is the importance of storytelling?

Stories and oral histories have a long relationship with human culture and communities. They are one of the oldest forms of community gathering and knowledge production. In many cultures, storytelling predates human where animal folk, spirits, or the previous worlds tell stories to teach others, build the world, and convey connections (see Dine, Miwok, and many other communities oral traditions). Here we as ethnographers and social scientists understand the validity and time depth of such stories and knowledge. Mark Riftkin summed up the importance of Storywork and Oral histories by stating: "*Often referred to as the oral tradition, Indigenous patterns of making and circulating stories could be construed as a set of relatively authoritative texts through which peoples' histories and philosophies are transmitted across generations.*" (Riftkin 2014, 34). This is the significance of stories and oral histories for Indigenous Ethnography and the work you are doing. We are continuing the circulation and transmission of knowledge about water. You are not only the guardian of water itself, but also the its stories.

How can I collect stories?

Collecting stories and oral histories comes in many forms. Stories in oral histories can be collected through ethnographic interviews and participant observation during events. For example, storytelling events within community, archival documentation done by previous anthropologist or other social scientists, and continued telling and retelling of such oral knowledge in group or individual settings. The collection of oral histories and stories begins with the simple prompt of having the storyteller explain or tell the story and recording the story either through audio recordings or written, depending on translation and availability. The second step is to have the storyteller listen or read through the recording of the story or oral history to double check and correct any misinterpreted or misrecorded sections of the story. This should be done at least once and continued throughout the collection process as story tellers could remember critical parts of stories or information tied to the story.

How can I analyze the stories (the storywork)?

Indigenous story work is a methodology developed by Jo-Ann Archibald as a way to understand, critically interpret, and take serious the knowledge and information held within indigenous storytelling, and oral histories. Indigenous story work begins by acknowledging that elders and stories hold wisdom and knowledge that are gained through live experience and a deep connection to ancestors that have lived in their traditional homeland since time in memorial. From this position, we take seriously, the four core values of research in Indigenous knowledge: respect, reverence, responsibility, and reciprocity. From these four values, we can start to understand the parts roles, characters and details, held within stories and oral histories. The first step in indigenous story work is to examine the story or oral history through those four core values. It is easier when you list out the characters and their actions and describe what responsibilities they had, what kind of respect was shown, what reverence was performed or explained, and finally what reciprocity occurred in the story. The second step is understanding what specific teachings come out of the story and come out of the characters' actions, reactions, or positionality. Further analysis can expand and extrapolate from the four Rs to other dimensions of storytelling such as ethics, morals positionality, perspective, and relationality.

Step 1: List out characters and entities in a story
Step 2: List out characters and entities actions or reactions in a story
Step 3: List out the respect, reverence, responsibility, and reciprocity expressed in the story.
Step 4: List out the lessons learned or taught in the story
Step 5: List out the forms of relations in the story

How can I synthesize the indigenous knowledge?

Indigenous storywork done in the previous question can then be accumulated into a summary that synthesizes the knowledge held within the stories or oral histories. Here is where the Indigenous storywork core values come out again. At the core of collecting and synthesizing stories, key questions arise: How do we respectfully convey the knowledge within a story? How do we show reverence to the knowledge held within a story or oral history? And how do we have responsibility and reciprocity for a story? We start with acknowledging where the knowledge came from as in which story or whose story it is, Where the story is connected to or on the landscape, and who the stories information and lessons are for? After this summary the description of the lessons and teachings can be outlined. Then ending the synthesis with a summary of relationality taught in the story.

Step 1: Acknowledge the stories/ knowledges source
Step 2: Where is the story connected to?
Step 3: Who are the stories/knowledge for?
Step 4: Summarizes the lessons learned or taught in the story
Step 5: Summarize the relationality and forms of relations in the story
Step 6: confirm and check in with the storyteller or a knowledge holder