During a drought, California's limited water supplies should be allocated transparently, efficiently, and predictably in accordance with the priorities that flow from state and federal law. But what does this mean in practice?

What happens when there is not enough surface water to go around in a watershed? California water rights law says that certain water users must curtail their water diversions—in other words, reduce the amount of water they divert or stop diverting water altogether. Water right priority rules generally require those with the most junior, or lowest priority, water rights to curtail first. But following water right priorities is not always straightforward, and other aspects of state and federal law complicate the picture by establishing their own priorities that also influence the need for and scope of curtailment.

One of the most important roles the State Water Resources Control Board (Board) can play during a drought is providing the information and oversight needed to ensure that water users exercise their rights appropriately. Yet our historical research suggests the Board's efforts to implement curtailments have been uneven, varying significantly from drought to drought and sometimes meeting with significant resistance.

In fact, you might say curtailment is the poster child for why the Board needs to do develop a contingency-based framework to support its drought decision making.

This post provides a brief walkthrough of how the Board could approach building a decision-support framework that will help it more consistently and effectively implement curtailments. *(While I'll discuss the tasks I outlined in my last post sequentially, keep in mind that many of these tasks are closely interrelated and will need to be addressed in a coordinated or iterative way.)*

Task 1: Describe important context for curtailment-related decisions

Curtailment implementation decisions need to be made at useful spatial scales and on useful timeframes. Generally, this means at the scale of a watershed (but on the basis of finer-scale information) and as close to *in real time* as possible. But larger or smaller scales might be necessary or appropriate in some circumstances, depending on what factors are driving the need for curtailment, watershed size and complexity, and data constraints. And real-time decision making—based on current information about water supply, water demand, and impacts to people and ecosystems—is not currently feasible in most watersheds. Therefore, when

completing this task, the Board will want to address both current spatial and temporal constraints on curtailment-related decisions and how these constraints might change in the future as key data and analytical improvements come online.

Task 2: Define key objectives and related performance measures

Ensuring that water users appropriately exercise their water rights during times of shortage will involve meeting a range of more targeted objectives (see middle column of *Figure 1*). Some will be based in state water law, like water right priorities and the California constitution's requirement for reasonable use. Meanwhile others will be based in other aspects of state and federal law, such as water quality protections, public trust protections, endangered species protections, and California's human-right-to-water statute. In other words, the Board's actions related to curtailment will not just be aimed at preventing injury to water rights, but also toward protecting wildlife and safeguarding human health and safety. In turn, meeting these objectives will involve meeting additional objectives, like helping water users understand their rights and responsibilities and providing them with other information they need to prepare for and respond appropriately to water shortages.

For each objective the Board defines, it will need to identify one or more performance measures (see last column of *Figure 1*).

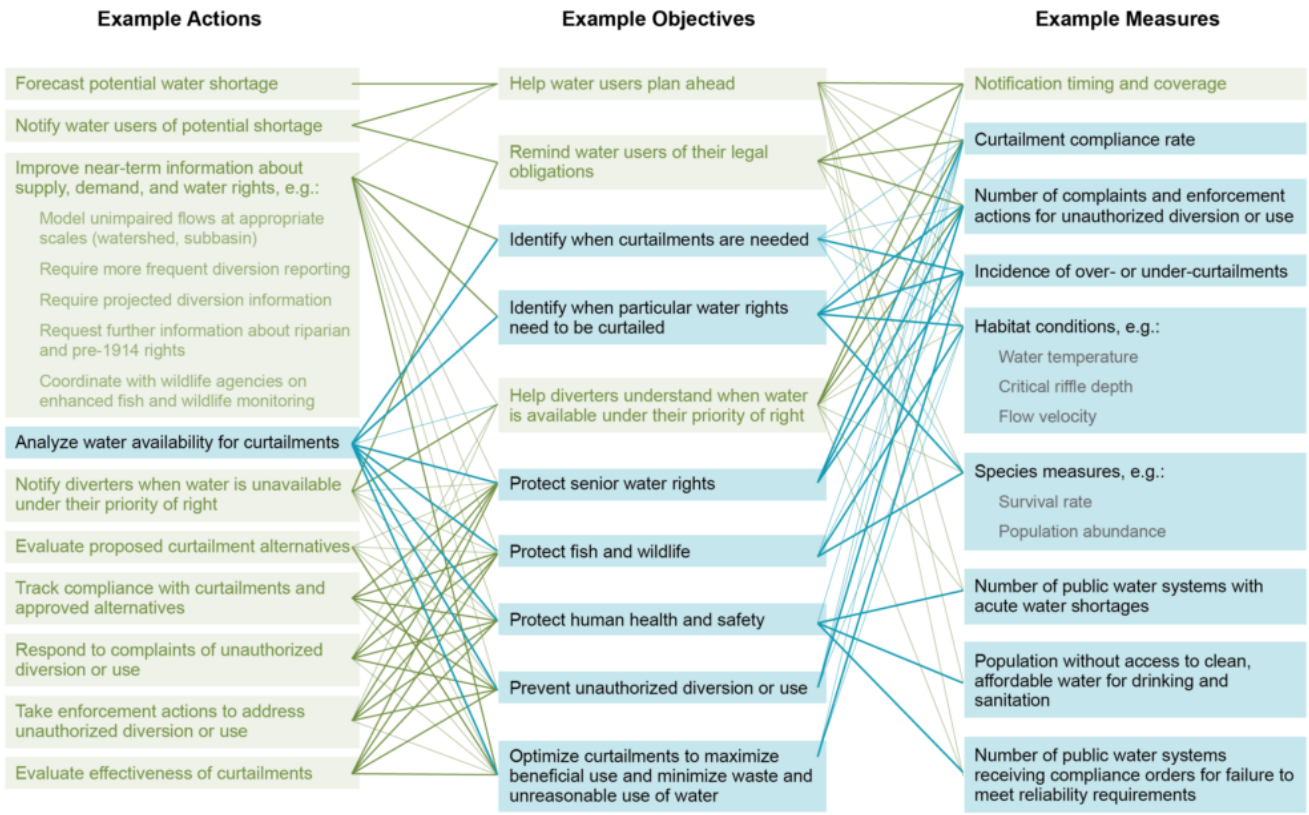


Figure 1. Potential relationships between example categories of actions, objectives, and performance measures

Task 3: Identify potential drought-response actions to meet these objectives

Effectively implementing curtailments in a particular watershed will involve a number of key categories of actions (see first column of *Figure 1*), including the following:

- *Tracking:*
  - Tracking changes in water supply and water use
  - Tracking drought impacts experienced by people and ecosystems
  - Tracking compliance with curtailments
  - Tracking the effectiveness of curtailments
- *Analyzing water availability:*
  - Forecasting the potential for water shortage
  - Determining when particular diverters need to curtail their diversions

- *Providing information to water users:*
  - Warning water users when a potential water shortage is likely
  - Notifying particular diverters when (and why) they must curtail their diversions
  - Notifying particular diverters when (and why) curtailment is not longer required
- *Enforcing curtailments:*
  - Issuing enforceable curtailment orders to diverters who fail to curtail
  - Imposing fines or other consequences for violations of orders or regulations

For each category, there could be many specific actions the Board might consider taking (for example, many different ways the Board might analyze water availability to support curtailments). Thinking through the implications of each potential action under a range of drought scenarios will help the Board identify the circumstances under which it would, or would not, promote the objectives defined in Task 2. Alternative actions might be associated with different tradeoffs for specific objectives and might carry different levels of uncertainty or risk. Choosing wisely among them in a particular drought context might require the Board to decide how to reconcile competing objectives (*a topic I'll discuss more in my next post*) and determine acceptable levels of risk.

Task 4: Select appropriate triggers for considering or taking each action

The Board can create an alert notification system for itself by setting up triggers to make sure it considers, or presumptively takes, specific actions at useful times for various watersheds. For example, watershed supply indicators (like precipitation, snowpack, reservoir levels, etc.) falling below certain thresholds might trigger an analysis of water availability to forecast the potential for upcoming water shortage. An initial analysis that suggests a water shortage is likely—or some other indication of shortage, like complaints from water users or concerns expressed by wildlife managers—might, in turn, trigger a full-fledged water availability analysis to determine whether curtailments are needed and, if so, who must curtail.

Task 5: Identify processes and procedures associated with each action

The Board will be able respond more swiftly and efficiently during a drought if it details the overall process and specific procedures it will use to decide on and implement each potential action. Developing these through a public process

between droughts will help address water users' due process concerns, reduce uncertainty, and enhance the perceived legitimacy and fairness of the Board's curtailment-related decisions (*I'll talk about this more in my next post*).

Clear procedures for determining both when curtailments are needed and who must curtail are critical. During the recent drought, the Board generally analyzed water availability to support curtailments on a coarse, watershed-wide scale by estimating total watershed-wide supply and demand, subtracting total demand from total supply, and assigning any shortfall to the most junior diverters (based on the priority dates of their water rights) within the watershed. This type of analysis might be a useful screening tool for potential water shortage, but it is less useful for identifying which water users, as a matter of law, must curtail their diversions. Instead, to more accurately characterize water availability under particular water rights, the Board needs to develop procedures that explicitly (1) account for the hydrologic connectivity (see *Figure 2*), or lack thereof, between different components of watershed supply and demand and (2) incorporate non-water-right priorities, such as instream flow requirements and minimum human health and safety protections. Recognizing these needs, the Board has funded research into formal curtailment methodologies it can now build upon.

When establishing processes and procedures, the Board will need to address what roles will be played by Board staff, by the Board itself, or by other designated entities (such as wildlife agencies or watershed-based watermasters), as well as how coordination will be handled.

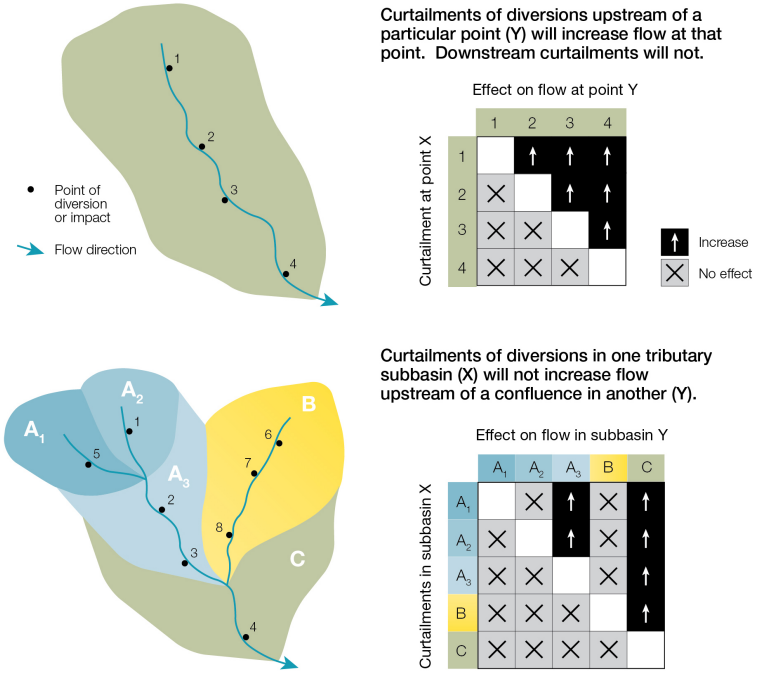


Figure 2. Effect of curtailments of diversions upstream and downstream of a particular point on a stream. *To accurately characterize water availability under particular water rights, curtailment procedures will need to account for the hydrologic connectivity between different components of water supply and demand. Because streamflow is directional, the relative locations of inflows (such as runoff, wastewater discharges, agricultural return flows, and groundwater accretion) and outflows (like water diversions and losses to groundwater) within a stream network matter. They determine whether a more junior user curtailing at one location will actually free up water for more senior users within the watershed.*

Task 6: Identify information needs

The Board will need to clearly identify the information it intends to rely on when deciding whether to take, and how to effectively implement, each curtailment-related action. For example, determining which water users in a watershed must

curtail will involve comparing estimates of water supply and demand in the context of water rights and other legal priorities. Therefore, decision-relevant information might include measured and modeled streamflow, diversion data, water right information, estimates of return flow, species monitoring data, and information about unmet human health and safety needs. The Board needs to specify how it will acquire and use each type of information in the decision-making process. Because it might not currently have access to data on the spatial scales and timeframes that would be most useful for decision making, the Board will also want to identify what information improvements it will pursue to enable more effective decision making in the future *(such as the strategic addition of stream gages in data-poor stream systems that are important for endangered species)*.

Task 7. Map relationships between framework components

The Board will need to think about how various framework components are, or should be, linked with one another (see *Figure 1*). Some components might be more effective if they are designed with explicit interdependencies, or presented as alternatives that have been optimized for different sets of circumstances. For example, the Board will need to analyze water availability for several different purposes that might require differing levels of detail. These include (1) forecasting the potential for upcoming water shortage *(requiring the least detail)*, (2) determining whether curtailments are needed, (3) determining who must curtail, and (4) demonstrating that a particular water user diverted water when no water was available under their water right to support an enforcement action *(requiring the most detail)*. The Board will want to consider the extent to which these different purposes actually require distinct data and procedures versus the extent to which they could be streamlined while ensuring that each purpose is adequately served. Where different procedures or data *are* needed, it might make sense for less detailed analyses to trigger more detailed analysis under certain circumstances.

Task 8. Establish mechanisms for learning and making adjustments

The decision-making environment is not static. A decision-support framework for curtailment shouldn't be static either. Instead, it should incorporate clear mechanisms for making improvements in response to new information, legal developments, experience gained through in-drought implementation, and the development of new strategies and tools. This will involve creating framework components (objectives, actions, etc.) that are aimed specifically at (1) gauging the utility of the framework and the effectiveness of curtailment-related actions taken

under it, (2) making in-drought adjustments to address issues the framework does not adequately account for, and (3) making between-drought adjustments. For example, the Board will want to assess how well its actions have, in fact, protected water rights, wildlife, and human health and safety in each affected watershed. These assessments can guide near-term adjustments to the framework, as well as help the Board prioritize its longer-term drought preparation and data improvement efforts.

The process of building—and using—a decision-support framework will highlight issues that, if left unaddressed, will make it harder to plan for and respond effectively to droughts. In particular, my next post will expand on the importance of making key policy decisions in advance of droughts… decisions such as how to reconcile water-right and non-water-right priorities when determining which water users must curtail their diversions in times of water shortage.

This post is part of a series that draws on a pair of recent reports published as part of California's Fourth Climate Change Assessment. In the first report, my colleagues and I analyze how the State Water Resources Control Board—a key water decision maker whose actions affect how scarce water resources are allocated among different human and environmental uses during droughts—has carried out its water rights responsibilities during past droughts. In the second report, we offer recommendations for improving the agency's future drought response capabilities. You can find both reports here.