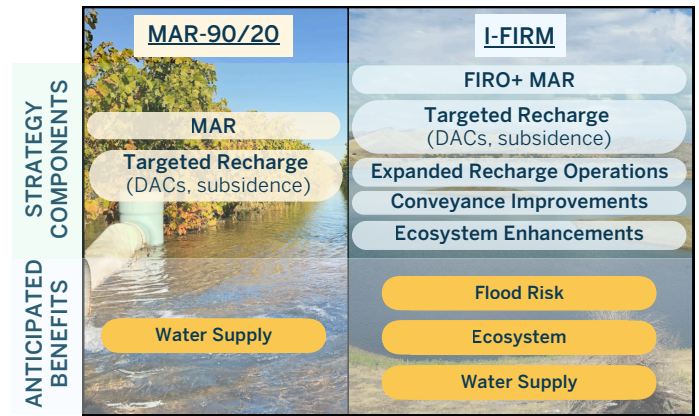




**A CHANGING CLIMATE:** By 2050, rising temperatures are expected to create more intense winter storms and reduce snowpack in the Tuolumne watershed, limiting runoff in the dry season when farms, communities, and ecosystems need it most. Warming will also increase evaporative demand and shrink surface water supplies, increasing reliance on groundwater. Without action, groundwater levels will fall, flood risks will intensify, and ecosystems will suffer.

**FLOODWATER AS A RESOURCE:** The San Joaquin Basin Flood-MAR Watershed Studies evaluated the opportunity for Flood-Managed Aquifer Recharge (Flood-MAR) and Forecast-Informed Reservoir Operations (FIRO) to mitigate the impacts of climate change. Working with growers, Flood-MAR can be scaled to capture more wet season flows in recharge basins and on farmland, thereby reducing flood risk and rebuilding groundwater stores for the dry season.



## What is Impacted by Climate Change?

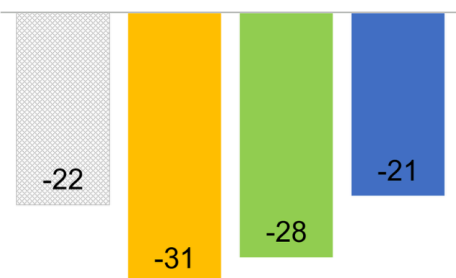
### Groundwater Supply

By 2050, average annual groundwater overdraft is expected to increase by 41% to 31,000 acre-feet per year. Groundwater levels will fall by an average of 12 feet, and groundwater levels beneath Disadvantaged Communities (DACs) will fall by 4 feet.

#### What can Recharge Accomplish?

Compared to the baseline future, MAR-90/20 would reduce annual groundwater overdraft by 10% and average groundwater levels would increase 25%. With I-FIRM, groundwater supplies increase annually, and average groundwater levels rise 7 feet above current levels. Groundwater levels below DACs rise 5 feet above current levels.

Average Annual Groundwater Overdraft [TAF/Y]



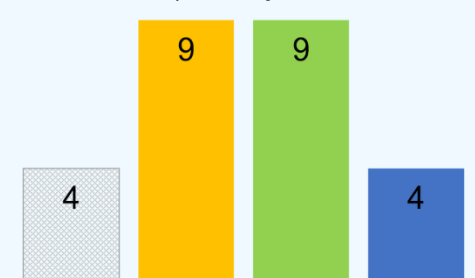
### Flood Risk

By 2050, maximum peak flow of the Tuolumne River at Modesto is expected to increase from 44,000 cubic feet per second (cfs) to 76,000 cfs, greatly exceeding the 9,000 cfs channel capacity. The number of years in which flows exceed the design channel capacity more than doubles.

#### What can Recharge Accomplish?

MAR-90/20 would have negligible impacts on maximum peak flows, frequency, and duration of flow events exceeding channel design capacity. I-FIRM largely offsets these increases in flood flow intensity and frequency.

Years Exceeding Design Channel Capacity [per 100 years]



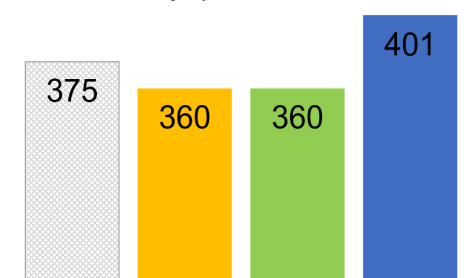
### Ecosystems

By 2050, increased winter river flows will decrease instream salmonid habitat, where salmon need low flows to lay eggs and raise juveniles. Higher peak flows could improve off-channel floodplain habitat, where salmon feed before outmigration to the sea. Climate change impacts on groundwater-dependent ecosystems (GDEs) are negligible.

#### What can Recharge Accomplish?




MAR-90/20 has a negligible impact on these shifts. I-FIRM improves in-stream salmonid habitat by diverting high flows, but reduces off-channel habitat by limiting inundation of floodplains. In any scenario, investment in habitat restoration will be needed to achieve beneficial outcomes for salmonids. I-FIRM would create new shorebird and flow-through basin habitat in the watershed.

Instream Salmonid Spawning Habitat [acre-days per linear mile]






## SCENARIO OUTCOMES




### In a Baseline Future

-  GW overdraft increases greatly
-  Flood risk increases greatly
-  Ecosystems see mixed outcomes

### With MAR-90/20

-  Increase in GW overdraft is lessened
-  Flood risk remains high
-  Ecosystems see mixed outcomes

### With I-FIRM

-  Increase in GW overdraft is offset
-  Increase in flood risk is offset
-  Ecosystems see mixed outcomes

## PLANNING FOR THE FUTURE

Strategic Flood-MAR implementation in the near-term can reduce groundwater overdraft in the region while providing additional benefits, such as supporting groundwater levels near DACs, and addressing the cone of depression. FIRO-MAR will take longer to implement, but it can mitigate some of the most severe climate change impacts expected in the Tuolumne watershed.

To achieve multi-benefit watershed-scale outcomes, collaboration will be essential. Growers, water districts, Groundwater Sustainability Agencies, reservoir operators, flood control agencies, community groups, and environmental organizations must coordinate to develop and pilot management strategies and build system resilience.

Scaled MAR will depend on greatly expanded on-farm recharge in the Tuolumne watershed, so grower involvement in project planning and implementation will be essential.

These studies help us envision how Flood-MAR can help shape California's water future. However, they rely on one set of assumptions and focus specifically on what is possible with recharge. Additional management actions such as land repurposing are not discussed in these studies but will be necessary to meet long-term groundwater sustainability goals.

Ultimately, local water and land managers, large- and small-scale growers, and residents of the Tuolumne watershed will shape real-world outcomes for the region.

Whether you are a grower, water manager, community member, environmental advocate, or another interested party, you can play a role in building resilience to a changing water future in the Tuolumne watershed. Sustainable Conservation has resources to help you learn more about Flood-MAR, and can connect you with partners to promote MAR in your area. Water managers can use a locally developed Groundwater Recharge Assessment Tool (GRAT) developed as part of the Watershed Studies toolset to plan recharge efforts that target benefits based on local priorities. Visit [suscon.org](http://suscon.org) and [groundwaterrecharge.org](http://groundwaterrecharge.org) for more information.

## SCAN FOR MORE RESOURCES

Tuolumne Watershed Full Report .....



..... Sustainable Conservation

Runoff to Recharge .....

