

From:

American River Watershed Institute
PO Box 1750
Colfax, CA 95713

April 18, 2016

To:

Lisa Francis Tassone, Board Secretary
Nevada Irrigation District
1036 W. Main Street
Grass Valley, CA 95945

Sent via email to tassone@nidwater.com

Re: Comments on the Notice of Preparation of Environmental Impact Report for the Centennial Reservoir Project

Dear Ms. Tassone:

American River Watershed Institute (ARWI) respectfully responds to the Notice of Preparation (NOP) of Environmental Impact Report (EIR) for the Centennial Reservoir Project (Project) prepared by Nevada Irrigation District (NID). ARWI was formed in 1997 by the American River Watershed Group for the purpose of stewarding education and managing projects supporting the economic, environmental and social health of the American River and adjacent watersheds.

ARWI supports the comments submitted by the Foothills Water Network. ARWI submits the following additional comments and background information to our comments made in the public meetings, and in other public venue over the past months. These comments fall into the following categories:

- **Wise decision-making and good governance.** Overview of information needed for good governance and wise decision -making which complements the environmental information addressed in the EIR,
- **ARWI protest of the process of this NOP.** ARWI was founded by the American River Watershed Group, a consensus based multi-stakeholder group, which was succeeded by the IRWM CABY. Mindful of the need to include all essential stakeholders in deliberations, mindful of full transparency in process and procedures, and mindful of the

mandate to follow the intent and the letter of the laws of the land, ARWI takes issue with the process of this NOP.

- **Traditional cultural properties.** Additional information provided ARWI by Nisenan Maidu community members during the April 3, 2016 Bear River ceremony,
- **Climate change scenarios.** Introduction to the Sierra Nevada Climate Change Calculator
- **The ARWI slide presentation references.** Background references for the ARWI slideshow on history from tree rings, climate change, and forestry runoff
- **Need for full evaluation of alternatives** on both supply and demand side. Contrary to NID's stated policy of the goal to be "self-determining", NID must be creative and extend its evaluation of alternatives to include options for partnership and collaboration. An example of this is optimizing Fordyce Dam and reservoir which would include a partnership with PG&E.
- **New technologies.** Additional information on new technologies that will impact the economic viability of the Project needed for good decision-making

ARWI Comments:

Wise decision-making and good governance.

Good governance and wise decision-making requires a thorough and complete problem-solving process. The EIR is necessarily limited in its approach to resolving complex problems. The EIR is narrowly defined by CEQA to accomplish its goal of assessing environmental impacts to a project. As a rule, the project has already been selected by the proponent, and is but one option for addressing the fundamental problem at hand. The study of alternatives and no-project alternative mandated under CEQA is not robust, and often results in a project that fails to solve the fundamental problem, because its narrow focus did not allow for a complete assessment of the problem, illuminate the fundamental interests, creatively develop a full range of options and alternatives, refine criteria for wise choice, and creatively integrate a suite of options into a flexible set of solution that allows for continual learning and refinement. Such an interest-based approach is called for in this decision-making process:

- NID's problem assessment has been lacking, and the District's approach to identifying relevant stakeholders, including them in the process, and assessing their interests and concerns has been minimal.
- Fundamental interests need to be clearly articulated, and weighed to define salient interests. NID's interest statement to date in this process has been contradictory and confusing, lacking clear priority. If this is truly a regional project as has been claimed, the stakeholder assessment will include articulation of all regional stakeholders mutual and separate interests, and how the project will meet those stakeholders' mutual and separate interests.

- A clear set of measurable and objective criteria for evaluation needs to be established and stated up front.
- A process needs to be put into place that allows stakeholders to participate in a creative brainstorm of options to solve the stated problem.
- And stakeholders need to be included in the evaluation of the options, which includes evaluation according to the established criteria as well as assessing how well the solution set meets all stakeholders mutual and separate interests.

If an interest-based problem solving process is established, NID will be able to implement a solution set that is robust and meets the interests of the entire community. NID is at present seriously handicapped by its policy to be “self-determining”, which is a conscious choice to sidestep key stakeholders in the community and their interests and concerns. The process thus far has ignored stakeholders (failure to notify key stakeholders), not provided access (failure to hold scoping sessions in critically important communities like Placer County), and has provided inadequate and contradictory information to the public and stakeholders. NID should step back, determine an elegant and thorough problem solving process, and begin again.

ARWI recommends NID initiate a multi-stakeholder, Yuba and Bear Rivers wide interest-based and professionally facilitated process to assess issues, engage in creative problem solving, and explore the solution sets to climate change, drought, and the re-invention of water delivery systems that originated in the 18th century. NID will find numerous allies in the search to ensure our community has a safe and secure water supply into the 22nd century.

ARWI protest of the process of this NOP.

Throughout NID’s project promotion period leading up to and including the NOP project description, information provided has been contradictory and confusing. An example is whether this is a hydroelectric project or not. Early it was described by board and staff on many occasions as a project that would be paid for through 20 MW of hydroelectric production at the dam site. The project was then rebranded from Parker Dam to Centennial Reservoir and Power Project (CRAPP); even the name announced the intention to include hydroelectric production. The February release of the NOP revealed an again rebranded project, which eliminated hydroelectric production and changed the name. Yet staff and board continue to state the hydroelectric portion of the project will be built, and that it will be a component that will pay for the project. Without an accurate, complete and consistent project description, it is not possible to analyze flows and impacts, and it is not possible to assess the financial viability of the project. The uncertainty of attaining a FERC license makes project viability impossible to assess.

NID has not notified key stakeholders and communities that will without doubt be impacted by this project. The project will without question affect Camp Far West (CFW), which was built in the 1960’s for the purpose of supplying surface water for agricultural irrigation, thus taking farmers off of their dependence on groundwater, and stabilizing the extreme groundwater

overdraft condition of that time. Any reduction of water supply to Camp Far West will impact the American River Subbasin. NID board and staff have repeatedly stated that NID at Centennial will divert water that is now going to CFW, because NID's water rights will be senior to South Sutter Water District (SSWD) rights, as NID claims their water rights as applied for date from 1926. An NID board member stated that if SSWD wants that water, SSWD will have to buy it from NID. The history of water sales to SSWD shows that if the price of purchased water exceeds \$20-30/AF, the farmers simply do not buy surface water, and turn on their pumps again. With the high construction cost of Centennial, NID will clearly develop new water with a cost of water a lot more than \$30/AF. The result will be farmers in Sutter and Western Placer will again turn on their pumps and deplete the American River Subbasin. NID must make a full spectrum of scenarios that show when Centennial diversions impact SSWD and CFW, as reductions in volume in CFW will almost certainly correlate with groundwater depletion in Western Placer. All stakeholders using groundwater in Western Placer County need to be notified, including farmers, and public and private water utilities, including the cities of Lincoln, Roseville, Placer County Water Agency, and the California American Water Company, who depend on stable basin groundwater for urban water supplies, peaking supplies, and emergency supplies. NID must indicate how these impacts will change the groundwater basin as described in the Western Placer County Groundwater Management Plan completed by PCWA in 2006.

The NOP process has been inadequate in describing impacts in Placer County, notifying Placer County stakeholders, and providing a public scoping meeting in Placer County where most of the negative impacts and infrastructure destruction would take place. Without that full scoping, the EIR will never be able to address the full range of impacts that only the local stakeholders can provide.

In summary, the project description in the NOP is inadequate. It is illegal under CEQA to segment or piecemeal a project. NID board and staff have clearly stated in public that the District is segmenting construction of the hydro component. In addition, the public outreach and notification of stakeholders has been inadequate, and the public scoping has been insufficient and discriminatory. NID must re-issue the NOP with a full project description, notify all stakeholders and public impacted by the project, and hold public scoping meetings in appropriate locations. The upcoming NEPA NOI process affords the opportunity for NID to do the right thing: begin again by re-issuing the NOP and NOI concurrently, with an accurate project description and a legitimate public process.

Traditional cultural properties

ARWI sponsored an event April 3, 2016 at the Bear River Group Campground, which included a ceremony by members of four local Maidu tribes: Colfax, Todds Valley, Nevada City Rancheria, and Tsi Akim. The group campground is a traditional site for the tribes. As part of the event, tribal members were interviewed in both audio and video formats. Extended comments were offered by Grayson Coney, Cultural Director for the Tsi Akim. His remarks are notable for

the NIP NOP process for the Centennial Dam EIR assessment. As part of the narrative on Native American history and practices on the Bear River Campground site, he made a distinction between Native American Heritage Sites and Traditional Cultural Properties. Grayson's comments follow:

“There is a distinction between cultural heritage sites and Traditional Cultural Properties (or TCPs). With TCPs, a member of the lineage has to be documented actually saying they continue the practice or have practiced that traditionally.

“At the Bear River Awakening ceremony April 3, because of the conversations and recording, several example of documenting a TCP occurred. One was described by Richard Johnson (Tribal Chairman of the Nevada City Rancheria) of locating cooking stones in the Bear River and side creeks of this area. These cooking stones had the unique quality of being able to be heated red hot, and then when put in cold water would not explode. These stones are unique to this area are highly valued as cooking stones in the traditional cooking baskets, were sought over millennia uniquely here, and that practice continues today. Members of the traditional cultures would travel great distances to collect these stones, because they had this quality.

“Another example is the harvesting of plants. Since 1974, I have been collecting the ceremonial and cultural materials from the Bear River at these sites: e.g. *Calycanthus Occidentalis*, (Western Spice Bush) there is only one plant on this site remaining. *Calycanthus Occidentalis* root was used by the men. The shafts were used by the men and highly valued as arrow shafts. The wood was used as perfume by the women when combed through the hair. The plant is now very rare on the river, and even rare on this site.

“I also collect Wild Iris: This was used for rope. I've made my fishing line from Iris off this Bear River Campground property.”

“Another TCP are the cobbles, the stones. At that gravel bar, the stones come out of the ancient Yuba channels that ran north/south at higher elevations. These ancient Yuba channel rocks get mixed with the other natural rocks in the Bear River, and get “re-cobbled” as they move downstream from the higher elevations where they were spawned. They get ground down to the right shape and size to be worked into utility shapes like bowls, net weights, metate, pestles, and many other material cultural implements. This was the practice of pecking stones, using one stone to ‘peck’ or chip away at the softer stone to make the utility shape needed. That gravel bar is one of the perfect locations. As the cobbles roll, the lighter cobbles come to the top as the heavier stones roll to the bottom of the gravel bar. It is the lighter stones that have the quality of being ideally worked with ‘pecking stones’. At lower elevations, even a few miles below Dog Bar, the lighter stones have been ground down and are too small in size to be used for material cultural implements. At higher elevations, the cobbles aren't rounded and shaped fully yet. Below Hwy 49 these perfect cobbles are absent. This is the “Goldilocks” zone for cobbles; this middle elevation area spawns the right tools for our cultural practices. This is the gravel bar we pick them up from, not below, and not above in the ancient river zone. This is site specific. There is no replacement for this. You can't dive for these stones when the reservoir is created. The

stones will no longer tumble and spawn. These stones come from here on the Bear, not the Yuba, not the American. The Bear is a perched river; after the Yuba captured its high elevation watershed area, water no longer incised the canyon. These conditions were created by a geologic time period. It is not a replaceable condition.

“The Prout family told the story of them bringing their babies to the river to dip in the water. You notice that Sunday they brought their medicine with them, they just didn’t have a baby with them. But they dipped themselves in the river that Sunday. Elders passed on that baby dipping practice to their children who continue it today.

“A traditional cultural property (TCP) needs to be tied to a story and a person, and documented in just the way we have done with these practices, by documenting with film, or many of us hearing the practice described directly from the person in the lineage. For example, I made a grinding bowl on the morning of our ceremony and gave it to Stan Padilla. That is an example of documenting a traditional cultural property. It is factual, and documented.

“NID must send tribes a letter, must do pedestrian surveys, must work through the heritage sites and put it in the EIR for review. Four tribes need to be contacted directly for this project: Colfax, Todds Valley, Nevada City and Tsi Akim tribes.”

ARWI, working with contacts for each of the tribes, is continuing its process of video recording the voices of the people who have stories about this reach of the Bear River. Among these interviews will be more documented TCPs from the Maidu community members. However, the EIR must investigate the many ongoing Traditional Cultural Property practices that are continuing today. As a nonprofit, ARWI cannot do a complete and thorough survey; that is the task NID. The EIR must interview current tribal members in each of the four tribes, and document these practices. The recommended methodology is to hire a trusted consultant from within the Native American community to conduct the interviews, and to compensate the interviewees. These interviews are necessary, are caused directly by the EIR process of the proposed project, and are a burden and intrusion in the lives of the living members of these tribes. It is appropriate to compensate the tribal members for their contribution to the collected history that must be part of the EIR

Climate change scenarios.

ARWI received an EPA grant in 2003 to develop a watershed yield calculator for the Sierra Nevada. ARWI contracted with John Humphreys, PhD, to create the calculator using the HSPF model. The HSPF model uses data point of hourly precipitation, hourly dew point, hourly wind speed, hourly solar radiation, and daily pan evaporation. Weather stations were chosen for three regions of the Sierra; the station chosen for the Northern Sierra was Blue Canyon. This station is very close to Bear and Yuba watersheds, and thus should provide accurate weather information for those watersheds. The hydrologic site chosen for the Northern Sierra was Duncan Canyon. Hydrology and weather data were correlated, allowing the user to calculate watershed yield under changed conditions, which will provide hydrologic conditions very close

to NID catchment conditions. The watershed yield calculator allows the user to calculate temperature changes from 1 to 4 degrees Centigrade, and precipitation changes from an increase in precipitation up to 25% and decrease in precipitation up to 25%. The EIR must use all available tools to calibrate predictions for impacts to climate change; the Sierra Climate Change Watershed Yield Calculator must be used as a tool in developing scenarios. The tool is available for download on the ARWI website <http://arwi.us/calc/index.php>

The ARWI slide presentation references and the need for full evaluation of alternatives.

ARWI has presented variations of slideshows on numerous occasions over the past year. Appended at the end of this comment letter are key slides, numbered in the upper right corner to correspond with these comments:

1. The spill at Camp Far West (CFW) reservoir is an indicator of how much of the Bear River Watershed yield has already been put to beneficial use in our region. Seven of the past nine years up to 2015 show either no spill, or minimal spill. It is simply not possible to divert and store water upstream of CFW without impacting CFW reservoir storage and irrigation water deliveries from CFW. The EIR must show the history of spills at CFW and impacts directly to SSWD and indirectly to the American River Subbasin groundwater levels. The EIR must show scenarios for future years indicating impacts from drought, climate change, the impact of increased forest evapotranspiration, and the compounding effect of the possible return of historic centennial droughts as indicated by tree ring history, and how these variable conditions impact CFW.
2. The graph shows watershed yield of NID's catchments on the Middle Yuba, Canyon Creek, Texas Creek, Fall Creek, and Deer Creek. NID has claimed in its promotion of Centennial Dam that the District relies on snowpack for storage for 120,000 AF of storage. Looking at the bar graph of total catchment yield, there are only a few years where there is 120,000 AF of yield over and above the average yield, which is approximately the same as NID storage for those catchments. The EIR must show historically exactly how many years did NID rely on snowpack for 120,000 AF of storage, and how in the future it would have used the proposed project to mitigate the loss of that snowpack had it fallen as rain rather than snow, as well as how the District would have transferred that rainfall from the Yuba watershed to the proposed project on the Bear River indicating route, volume and timing, as well as how this affected releases on the Yuba River. The EIR must show scenarios for future years indicating impacts from drought, climate change, the impact of increased forest evapotranspiration, and the compounding effect of the possible return of historic centennial droughts as indicated by tree ring history.
3. The primary thrust of ARWI's presentations has been that NID's characterization of "Ag Water" is not accurate. NID needs to clarify which customers use the raw water for commercial agriculture, which use it for landscaping, and what the total uses are for each

category. The criteria for commercial agriculture must be engagement in commercial markets. For example, how many NID raw water customers sell even a minimum of \$10,000 or more of agricultural product in the marketplace annually. Blanket surveys that allow customers to characterize their use as “irrigated pasture” do not indicate agricultural use, or any engagement in commercial exchange for agricultural products from the land. Water that is not used for commercial agriculture must fall under the category of urban water use, with all its mandated conservation practices. The EIR must develop an accurate criteria and definition for agricultural water versus urban water use in the raw water distribution ditch system. The EIR must provide accurate assessment of what is used for commercial agriculture and what is urban water use in the category now blanket labeled “agricultural water use”. This is foundational information for the determination if the District has need for an increased supply of water, or if internal investment in infrastructure change and conservation can provide the water supply safety and reliability for the foreseeable future.

4. Tree ring records now allow reconstruction of precipitation patterns for the Sacramento Valley. Roughly centennial drought cycles are the norm. Clearly we have been in a very wet cycle for the past half century until 2000. The EIR must develop future scenarios that show this past centennial drought pattern. The EIR must show scenarios for future years indicating how these centennial cycles of drought will be compounded by future climate change, including the impact of increased forest evapotranspiration.
5. New data shows that from 1980 to 2010, precipitation has decreased in our region by approximately 5% per decade. NID claimed in its presentations that future precipitation decrease over the next 100 years may be only as high as 10%; this NID estimate is understated. The EIR must reconcile the precipitation decrease of the past 30 years with the potential compounding impacts from drought cycles, climate change, and increased evapotranspiration on water supply availability through decreased precipitation. Clearly using the low figure of 10% precipitation is not adequate given the 15% decrease of the past three decades alone. The EIR must use realistic scenarios of decreased precipitation of at least 25% to predict the multiple impacts of precipitation decrease.
6. Recent studies like this USGS study are predicting precipitation decrease by as much as 34% from historic levels. The EIR must address these peer reviewed and published studies by the most reputable agencies in the US like USGS. The EIR must develop scenarios that address the lowest credible ranges of precipitation decrease, like those in this USGS study.
7. The reduced precipitation forecasts are not evenly spread throughout the watershed, with more drastic impact in the Feather and Yuba River watersheds, showing regionally concentrated precipitation reductions of up to 50% and more. The EIR must address this regionally disparate precipitation decrease, and develop scenarios that show the impact of potential precipitation reductions of 50% as indicated in the USGS study.

8. This graph repeats information conveyed in slide 6, described above.
9. NCAR and other agencies are studying drought probabilities. The EIR must include a thorough literature search and compile the most current findings of climate change studies relevant to snowpack changes, precipitation predictions, drought cycles, and all related climate change studies that impact water supply. The EIR must develop scenarios that are inclusive of the full range of predictions by credible agencies like USGS, NCAR, NOAA, and NASA.
10. NOAA and NASA have conducted a study of decadal and multidecadal drought probabilities due to climate change. The EIR must develop scenarios that demonstrate the impact of decadal and multidecadal drought on the viability of reliable water supply from the addition of the proposed project to NID's existing system.
11. This study also references the severe multi-decadal drought of the middle ages (as shown in tree rings). It is possible that millennial cycles of multi-decadal drought might be compounded by multi-decadal drought caused by climate change. This represents a convergence of two potential multidecadal drought factors--- historical pattern and future climate change. The EIR must address the possibility of the perfect storm of the impacts from the convergence of both multidecadal drought factors overlapping.
12. In this Science Magazine article, $\frac{2}{3}$ or more of the climate scenarios concur that our region at the edge of California and Nevada will see a 20-40% reduction of runoff. The EIR must address these runoff predictions, and assess the differentiation between runoff and precipitation scenarios. Scenarios must be developed to reflect these runoff predictions if they differ from precipitation decrease scenarios.
13. This NOAA scatter chart shows the trend from the 20th century (blue dots) to the 21st century (black dots) to the even more severe past four years 2012-2015. This data shows the trend identified by the study referenced in slide 5 is continuing; that is, the 1980-2010 precipitation reduction of 5% per decade has continued over the past five years, and has increased in intensity over the previous 30 year period. The EIR must address the combined impacts of temperature and precipitation forecasts in future scenarios, and must include the most recently documented trends to identify the full range of potential impact.
14. The EIR must include a full range of supply side alternatives. Optimizing existing structures must be analyzed, including the following:
 - a. Raising Rollins Reservoir. NID has studied this potential project. During the NOP comment period, NID staff and management have alternately said raising Rollins was feasible and not feasible. The study must be updated, and findings included as an update on the feasibility of this alternative to the proposed project.
 - b. The EIR must include the potential for raising Fordyce Dam. NID staff has stated that this cannot be an option because it is not owned by NID. NID must address alternatives beyond where the District owns the facility. Possible partnerships of many kinds can be developed to collaborate on mutual benefit from optimizing

existing facilities. The EIR and NID must address the partnership possibilities for collaborative projects which can meet its interests of increased water supply, which extend beyond the exclusive project ownership by NID.

- c. Downstream opportunities exist for optimizing water supply. Raising Camp Far West can increase water supply for the Lincoln area, as well as increase the potential for conjunctive use and increased groundwater supply. This area is in NID's jurisdiction, and the City of Lincoln is a primary customer partner of the District. New approaches to water supply need to be developed. The EIR must address the collaborative potential of raising Camp Far West.
 - d. The EIR must address all supply options as an integrated alternative, which includes meadow restoration, groundwater recharge, and forest management.
15. The EIR must address the full range of demand side alternatives to developing a new supply from Centennial Reservoir.

New technologies.

Numerous new technologies will be developed during the life of the proposed project. In the past 20 years, photovoltaic technology costs have dropped by a factor of five. Given the many innovations on the horizon (including nanotechnologies and bio-engineering), it is prudent to assume the costs will continue to fall, and that entirely new breakthroughs will occur. The EIR must address the technological innovations that can reasonably undermine the viability of the project.

The EIR must address the effect of foreseeable grid balancing technologies that will reduce the market value of hydro peaking revenues within the life of the project. Hydro-peaking is currently highly valued within electrical grid for its almost unique grid balancing capabilities. However, the electric power industry is in the early stages of a technological revolution on par with the emergence of the internet. A large proportion of electric power research, engineering, investment, and political will is aimed squarely at the grid balancing portion of the market. Demand management and grid scale implementations of non-hydropower and non-fossil fuel based peaking infrastructure is already underway.

Within the Centennial project time horizon, alternatives to hydro-peaking's now nearly unique grid balancing services will be commonplace. In fact, the grid peak itself will dissolve as demand management and distributed energy storage continue to take hold and grid scale storage and balancing alternatives such as large scale battery installations, molten salts, and mechanical storage continue their aggressive roll-out. At some point in the next 10-25 years, hydro-peaking will no longer be required for grid balancing services, thus, NID cannot assume that high value peaking revenues will continue when the grid peak and the current financial benefits of hydro-peaking are eliminated in the market.

References:

Pacific Gas and Electric Smart Grid Annual Report - 2013, October 1, 2013

Grid Energy Storage, U.S. Dept. of Energy - December 2013

ARPA-e GRIDS Program Overview

California ISO Energy Storage Interconnection, Issue Paper and Straw Proposal, June 24, 2014

Advancing and Maximizing the Value of Energy Storage Technology, A California Roadmap,

California ISO, December 2014

Thank you for consideration of the Institute's comments on the NOP for the Centennial Project. Please contact Otis Wollan, ARWI Board President, if you have any questions.

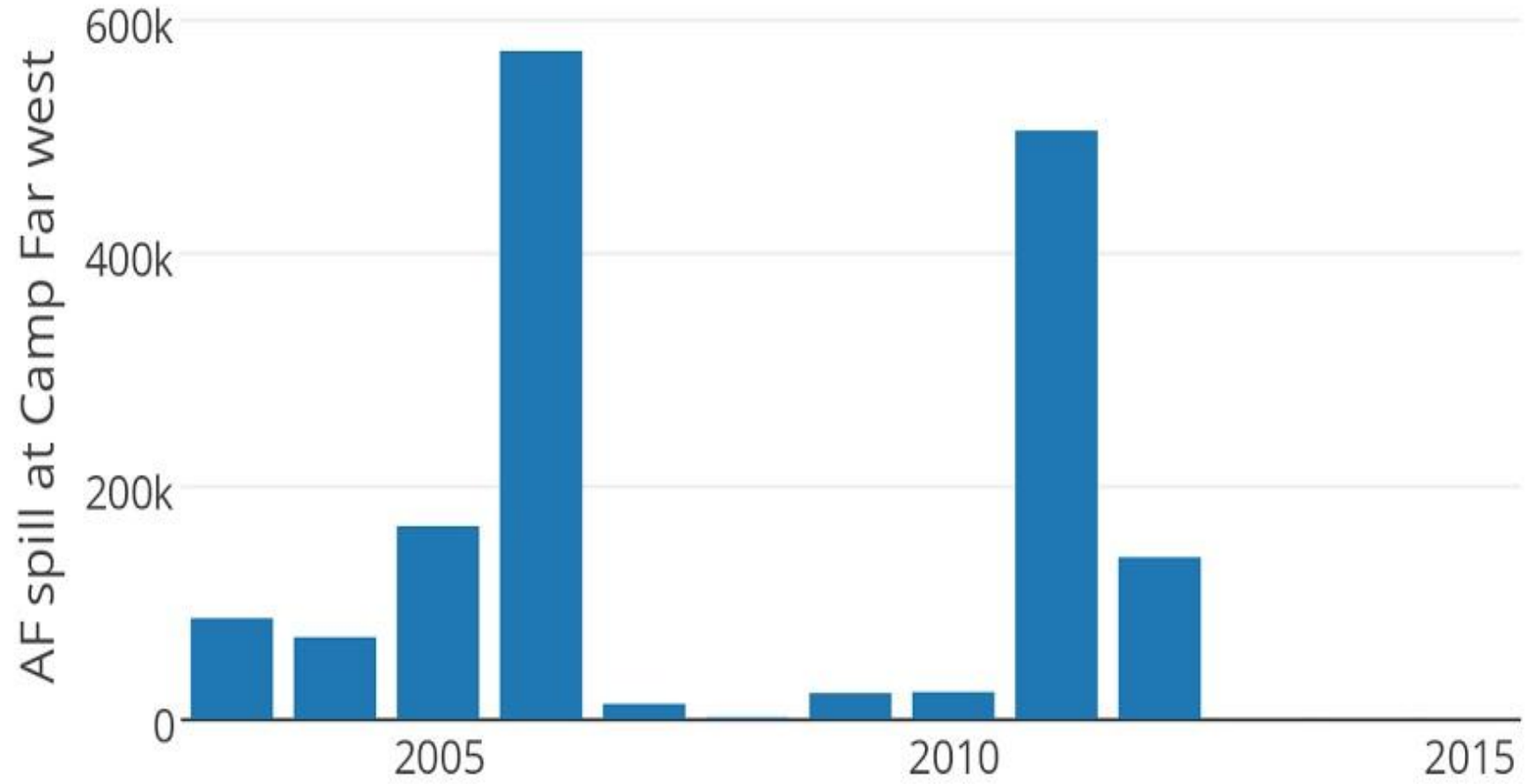
Respectfully submitted,

A handwritten signature in black ink, appearing to read "Otis Wollan". The signature is fluid and cursive, with a long horizontal stroke at the end.

Otis Wollan
American River Watershed Institute, President of the Board

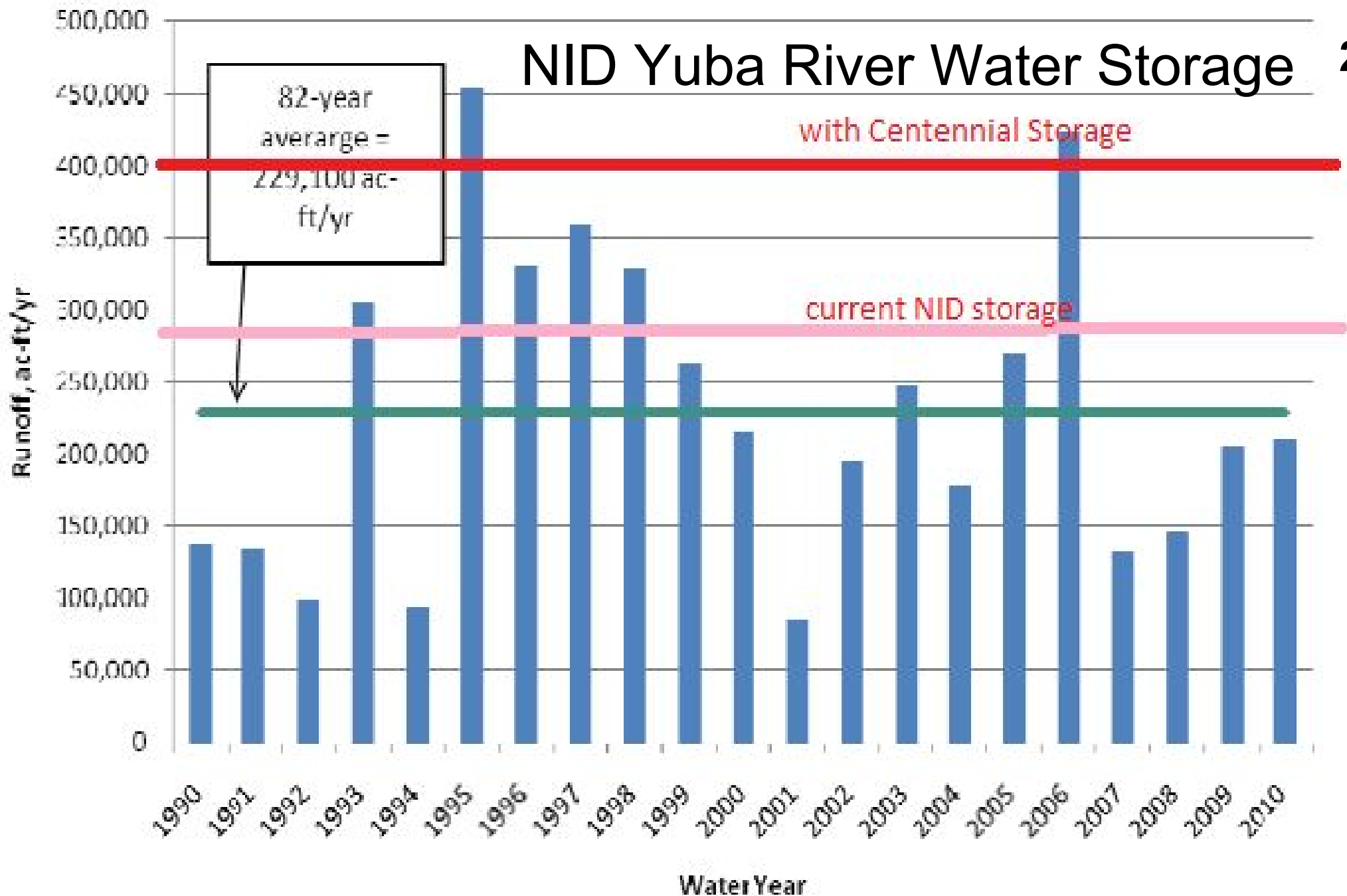
Appended: ARWI slides referenced by number above.

How much surplus water is in the Bear River System for Parker



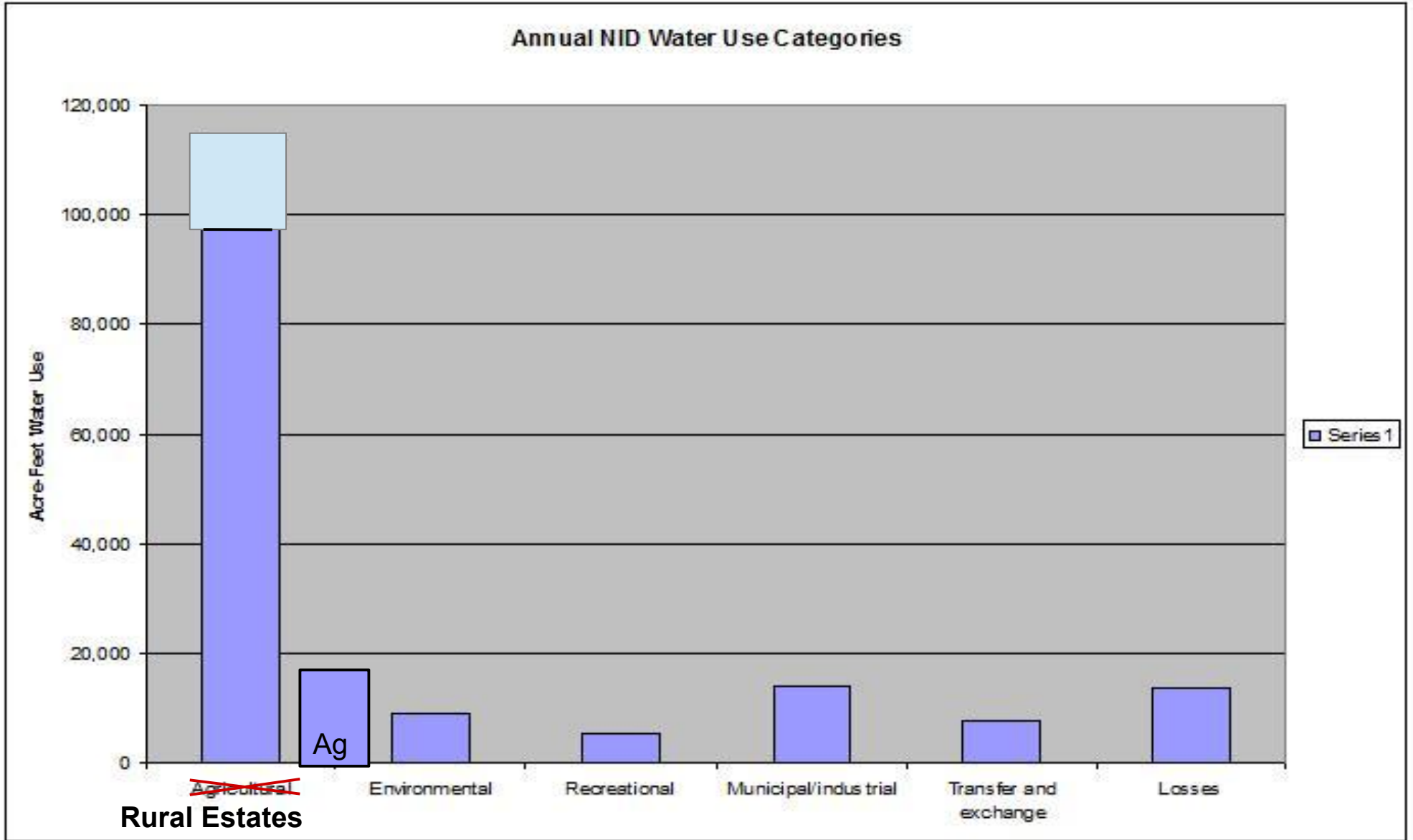
Annual spill from 2003 to present

NID Yuba River Water Storage 2



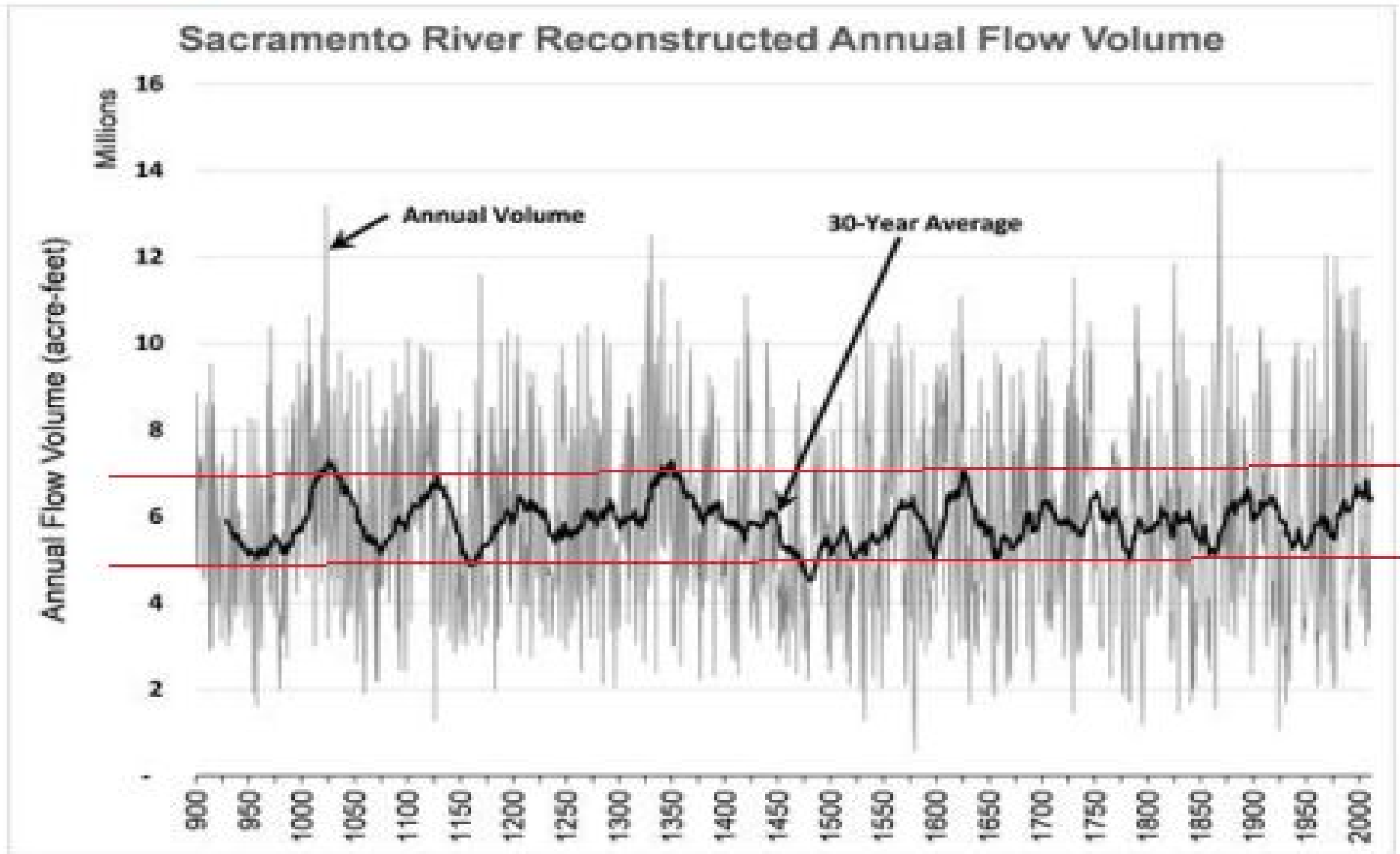
Note: Includes Middle Yuba River, Canyon Creek, Texas Creek, Fall Creek and Deer Creek. Does not include Bear River or South Yuba due to PG&E contract provisions, and hydrological and water rights considerations. Water year is from October 1 of previous year to September 30.

1 miner's inch=\$1/da=16,000 gal/da



Sacramento river historical precipitation cycles from tree rings 4

Figure 3-6 Reconstructed Sacramento River Streamflows



Source: Meko et al. 2014

From tree rings, showing 30+% variation

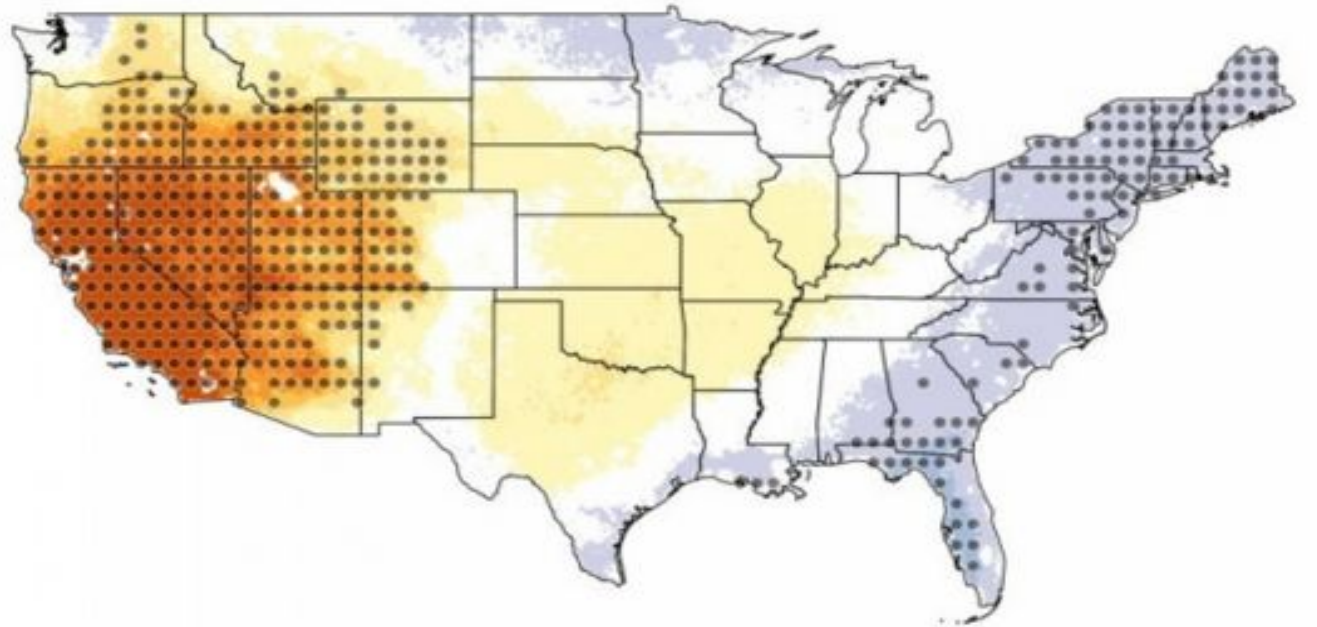
US Southwest May Be Drying Up As Wet Weather Systems Become More Rare

By [Alyssa Navarro](#), Tech Times | February 6, 6:16 AM

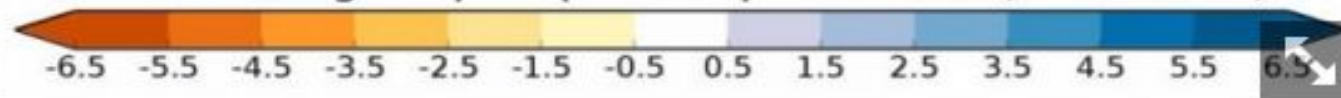
Like Follow Share Tweet Reddit 0 Comments

Drying the Southwest

Weather systems that bring rain are becoming more rare



Percent change in precipitation per decade (1980-2010)

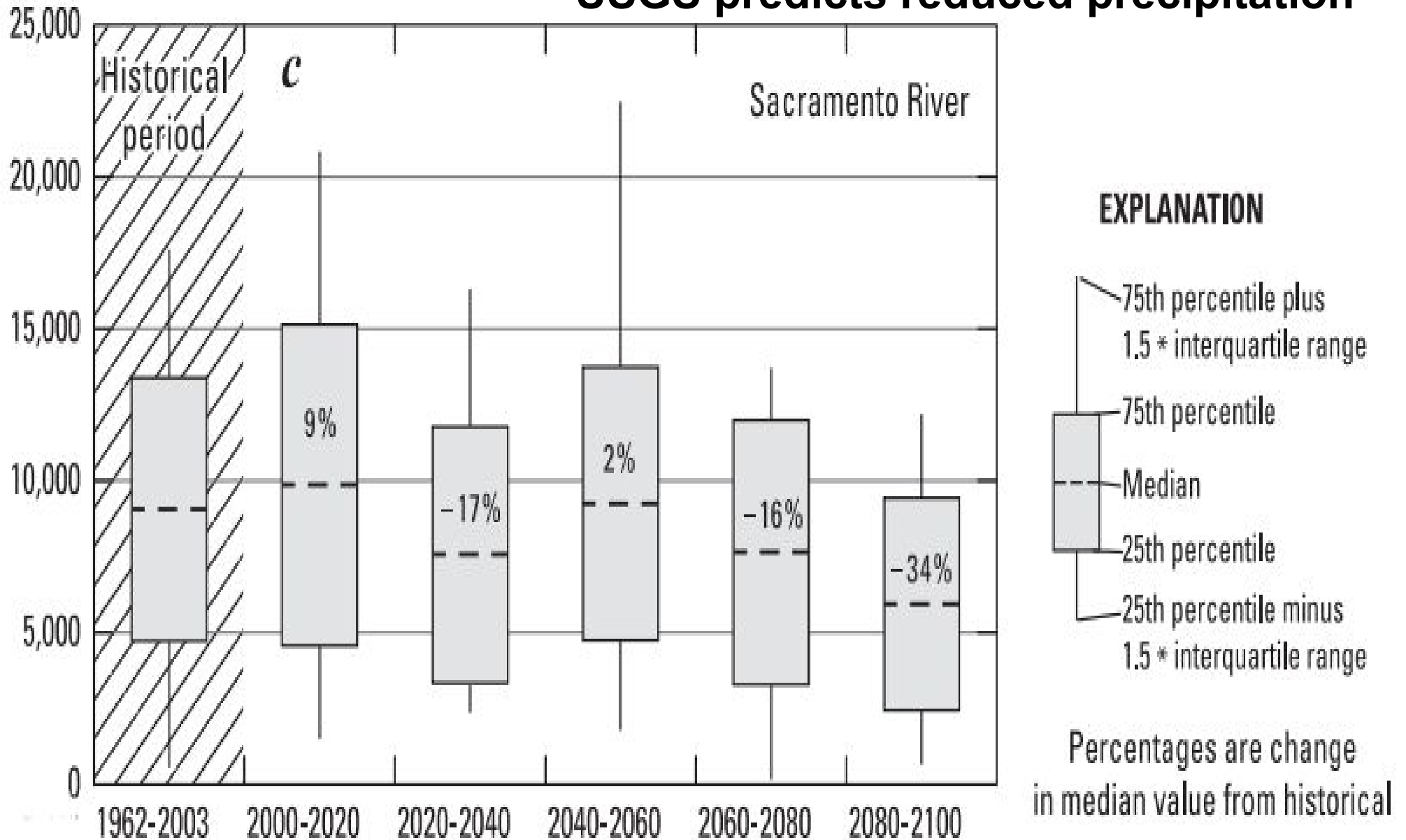


What's considered a normal year of snow and rain in the Southwest is now drier than usual, a new study revealed. Droughts in the region could become more severe in the coming years.

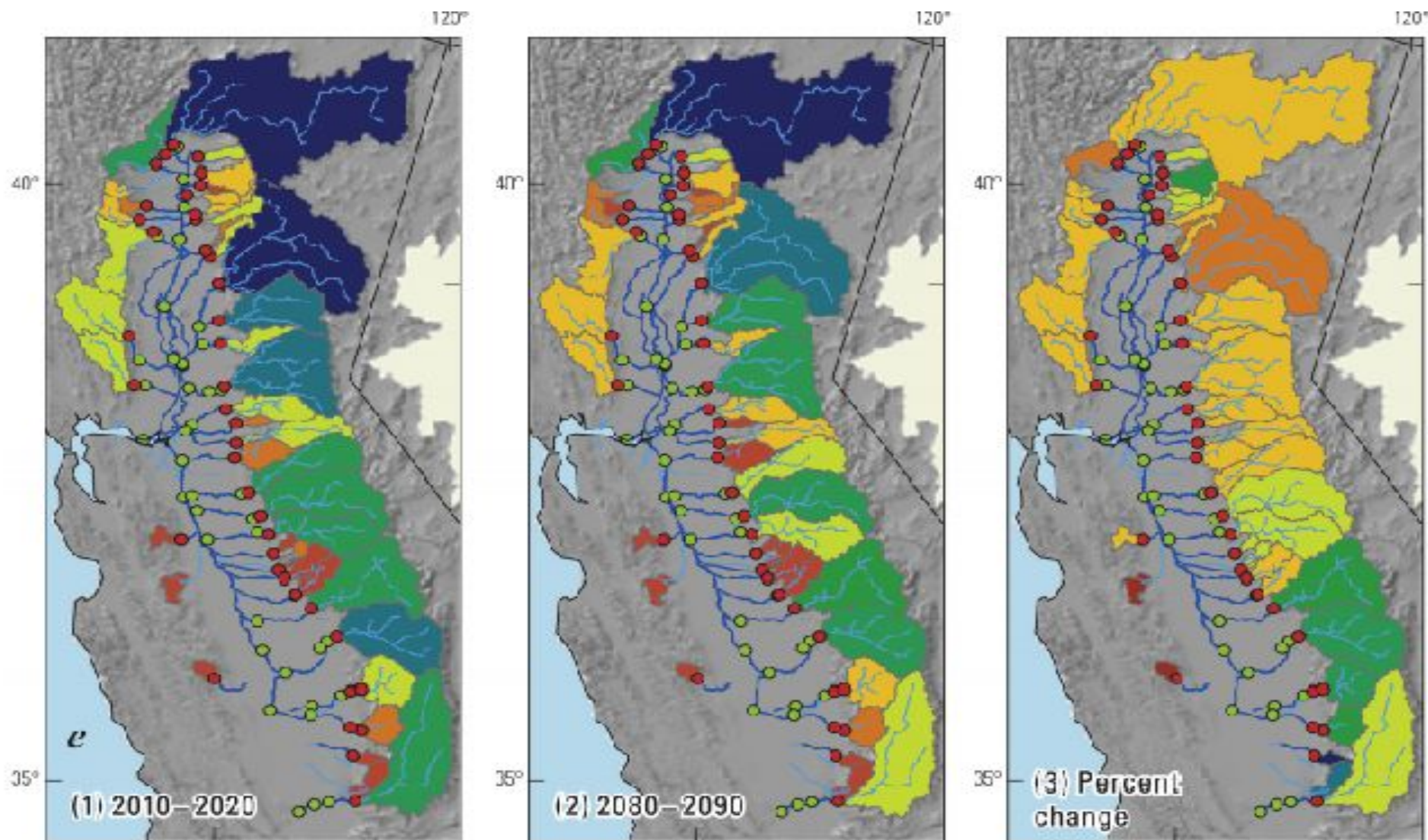
(Photo : Andreas Prein/NCAR)

The Future Climate Scenarios:

USGS predicts reduced precipitation



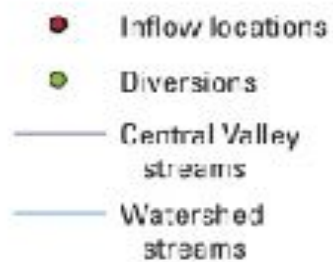
Hanson, R.T., Flint, L.E., Flint, A.L., Dettinger, M.D., Faunt, C.C., Cayan, D., and Schmid, W., 2012, A method for physically based model analysis of conjunctive use in response to potential climate changes, Water Resources Research, vol. 48, W00L08, doi:10.1029/2011WR010774



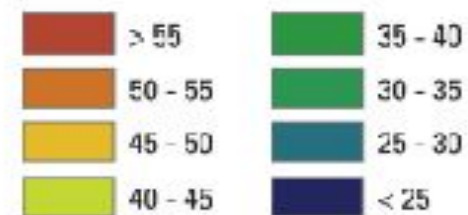
Basin discharge, in millions of cubic meters



EXPLANATION



Percent reduction from period 1 to period 2



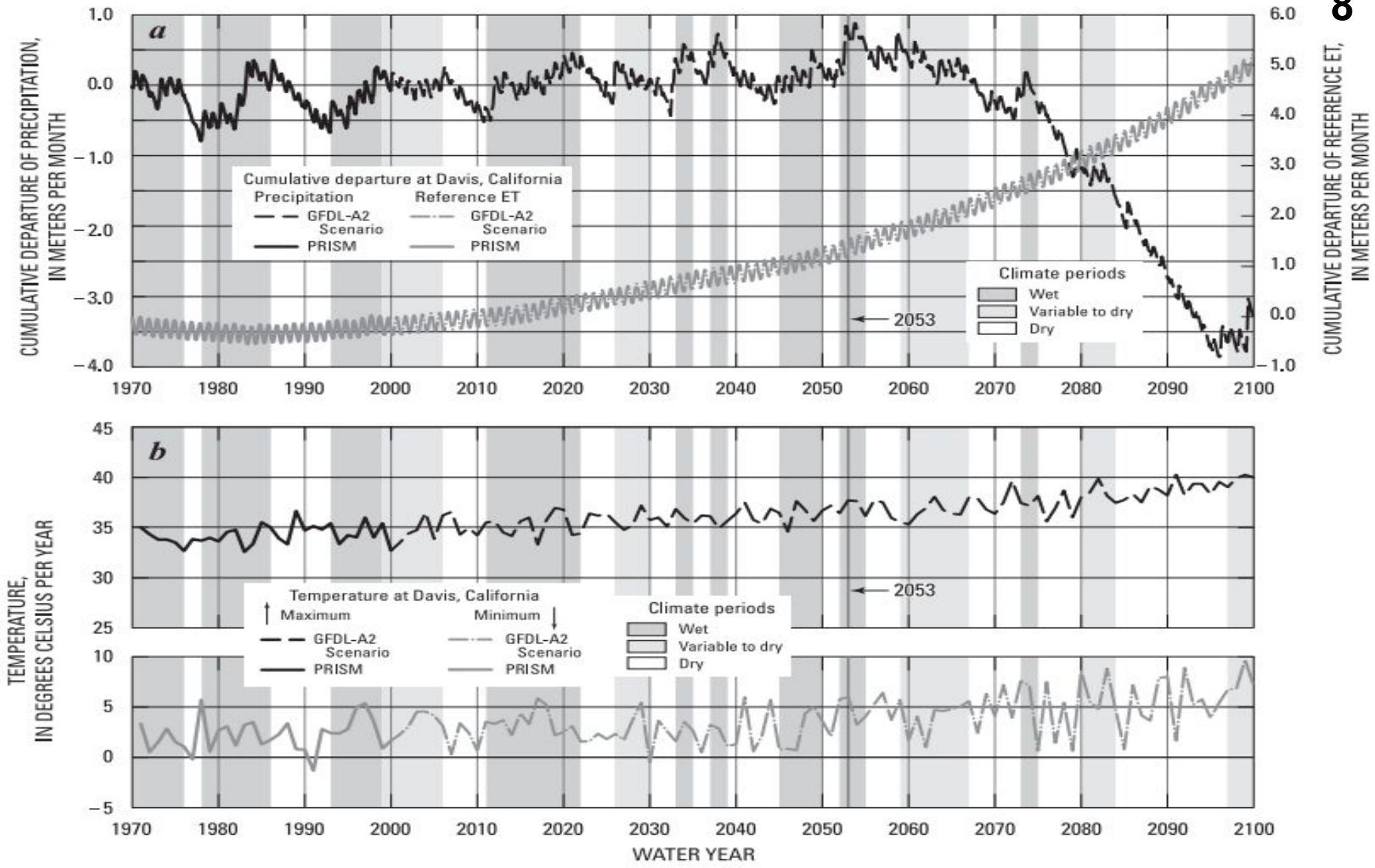


Figure 3. Graphs showing (a) historical and future cumulative departure of monthly precipitation and evapotranspiration (ET) and (b) monthly historical and future cumulative departure of temperature, (c) historical and selected future streamflow percentages, (d) selected historical and future streamflow, and (e) discharge, for selected decades, from the principal surrounding watersheds of the Central Valley, California.

The National Center for Atmospheric Research & the UCAR Office of Programs

Operated by the University Corporation for Atmospheric Research

- Home
- Our Organization
- Our Research
- News Center
- Education
- Community Tools
- Libraries

About Staff Notes

Past Issues

Extral

Feedback

How to Subscribe

Search

Staff Notes monthly

9

May 2007 Study Shows 18 of 19 Climate Scenarios predict Permanent Drought in Southwest

ASP postdoc Jian Lu contributes to research

Aridity has always been the defining feature of the American Southwest, even as large-scale hydraulic engineering has allowed cities such as Phoenix and Las Vegas to burst from the desert floor.

But according to a sobering new study, the Southwest's aridity is about to get worse. Published in the April 9 issue of Science, "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America" predicts that climate change will permanently alter the landscape of the Southwest so severely that conditions reminiscent of the Dust Bowl days of the 1930s could become the norm within a few decades.

"Our study suggests a perpetual arid condition over the American Southwest," says Jian Lu, a postdoctoral researcher in ASP/CGD who is an author of the study.

Of the 19 different computer models that the research team used for the study, all but one showed a drying trend in the swath of North America between Kansas, California, and northern Mexico. The models predicted an average 15% decline in runoff for the Southwest between 2021 and 2040, compared to the average surface moisture between 1950 and 2000.

The Southwest's future droughts are expected to be of a different nature than those that have afflicted the region in the past. Scientists attribute past droughts to variations in sea surface temperatures caused by El Niño and La Niña events in the Pacific Ocean. La Niña is especially influential as it tends to shift precipitation belts north, leaving the Southwest thirsty.



As the climate warms, however, the basic dynamics of the atmosphere change, particularly in regard to the Hadley cell, a powerful circulation pattern that drives weather in the tropics and subtropics. "Our confidence in our projection is built upon our understanding of the fundamental dynamics of the Hadley cell," Jian says.

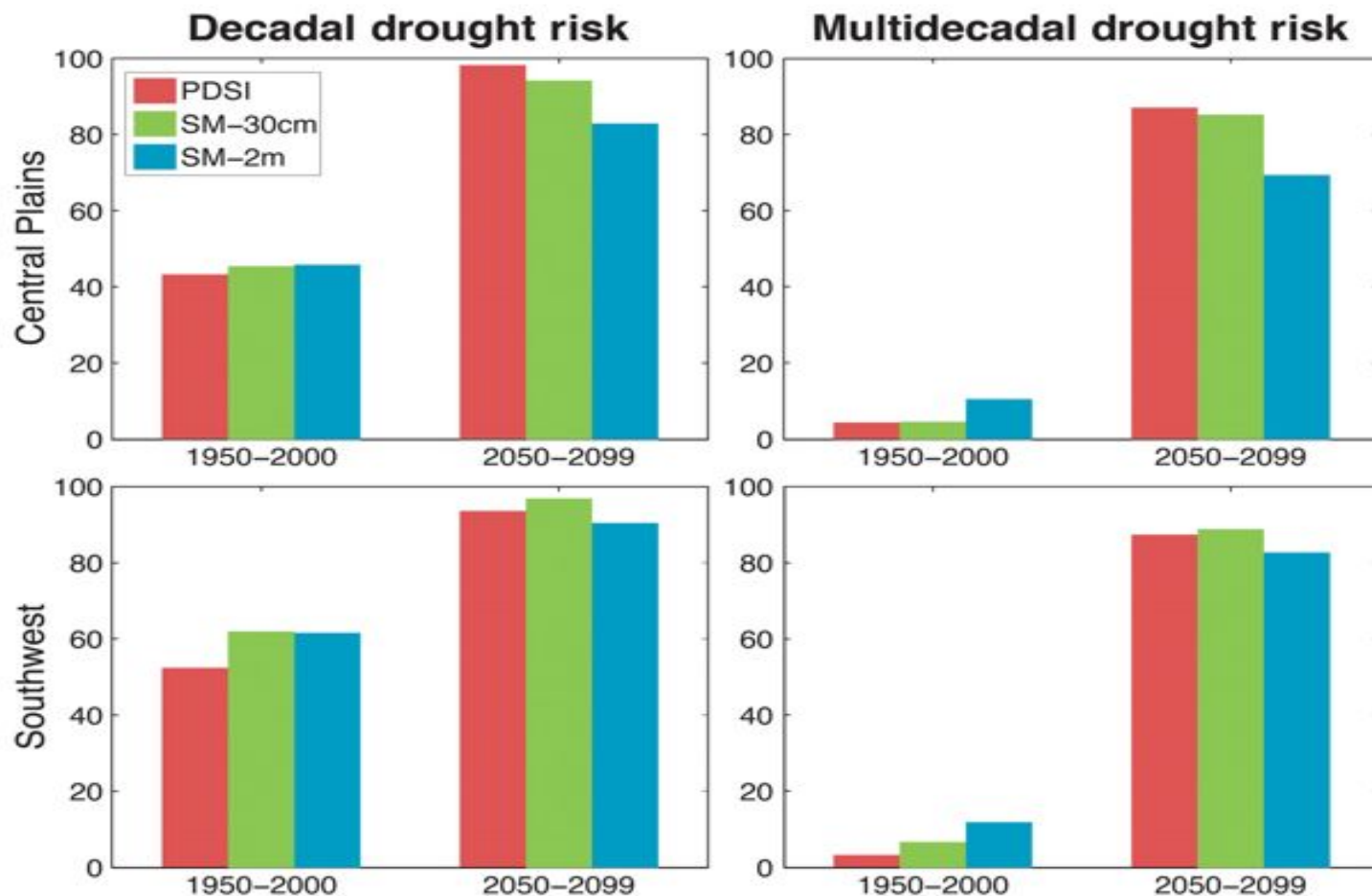
Warm, moist air from near the equator normally rises into the atmosphere until it reaches the stratosphere, the second layer of Earth's atmosphere. The air then spreads north and south toward the poles, descends over the subtropics, and flows back toward the Equator in the form of trade winds, completing the cell. Because the descending air over the subtropics suppresses rain by drying the lower atmosphere, many of Earth's great deserts are located in these regions.

As the atmosphere warms from climate change, scientists expect the Hadley cell to expand its reach, bringing hot, dry air to a larger swath of the Middle East, Mediterranean, and North America, including the Southwest. "In the future warmed climate," Jian explains, "the Hadley cell and the subtropical high should expand poleward, which tends to block rain coming through from the Pacific."



The swath of North America between Kansas, California, and northern Mexico can expect long-term drought conditions in the future due to warming global temperatures. The Southwest is already stressed from a drought that has affected the region since 1999. Here, an arroyo in northern Mexico sits dry. (Photo by Dave Gochis.)

Fig. 5 Risk (percent chance of occurrence) of decadal (11-year) and multidecadal (35-year) drought, calculated from the multimodel ensemble for PDSI, SM-30cm, and SM-2m.



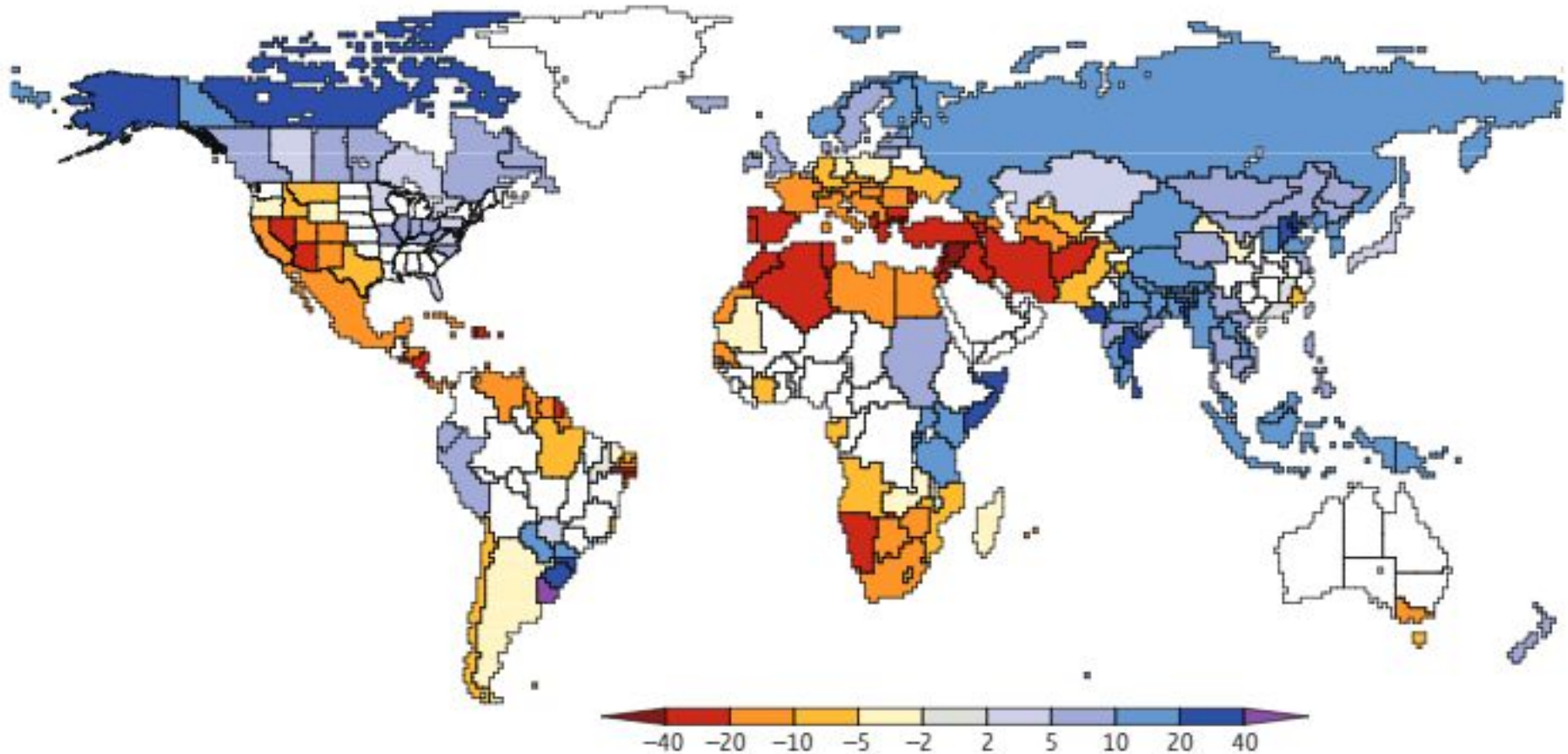
Benjamin I. Cook et al. Sci Adv 2015;1:e1400082

Abstract

In the Southwest and Central Plains of Western North America, climate change is expected to increase drought severity in the coming decades. These regions nevertheless experienced extended Medieval-era droughts that were more persistent than any historical event, providing crucial targets in the paleoclimate record for benchmarking the severity of future drought risks. We use an empirical drought reconstruction and three soil moisture metrics from 17 state-of-the-art general circulation models to show that these models project significantly drier conditions in the later half of the 21st century compared to the 20th century and earlier paleoclimatic intervals. This desiccation is consistent across most of the models and moisture balance variables, indicating a coherent and robust drying response to warming despite the diversity of models and metrics analyzed. Notably, future drought risk will likely exceed even the driest centuries of the Medieval Climate Anomaly (1100–1300 CE) in both moderate (RCP 4.5) and high (RCP 8.5) future emissions scenarios, leading to unprecedented drought conditions during the last millennium.

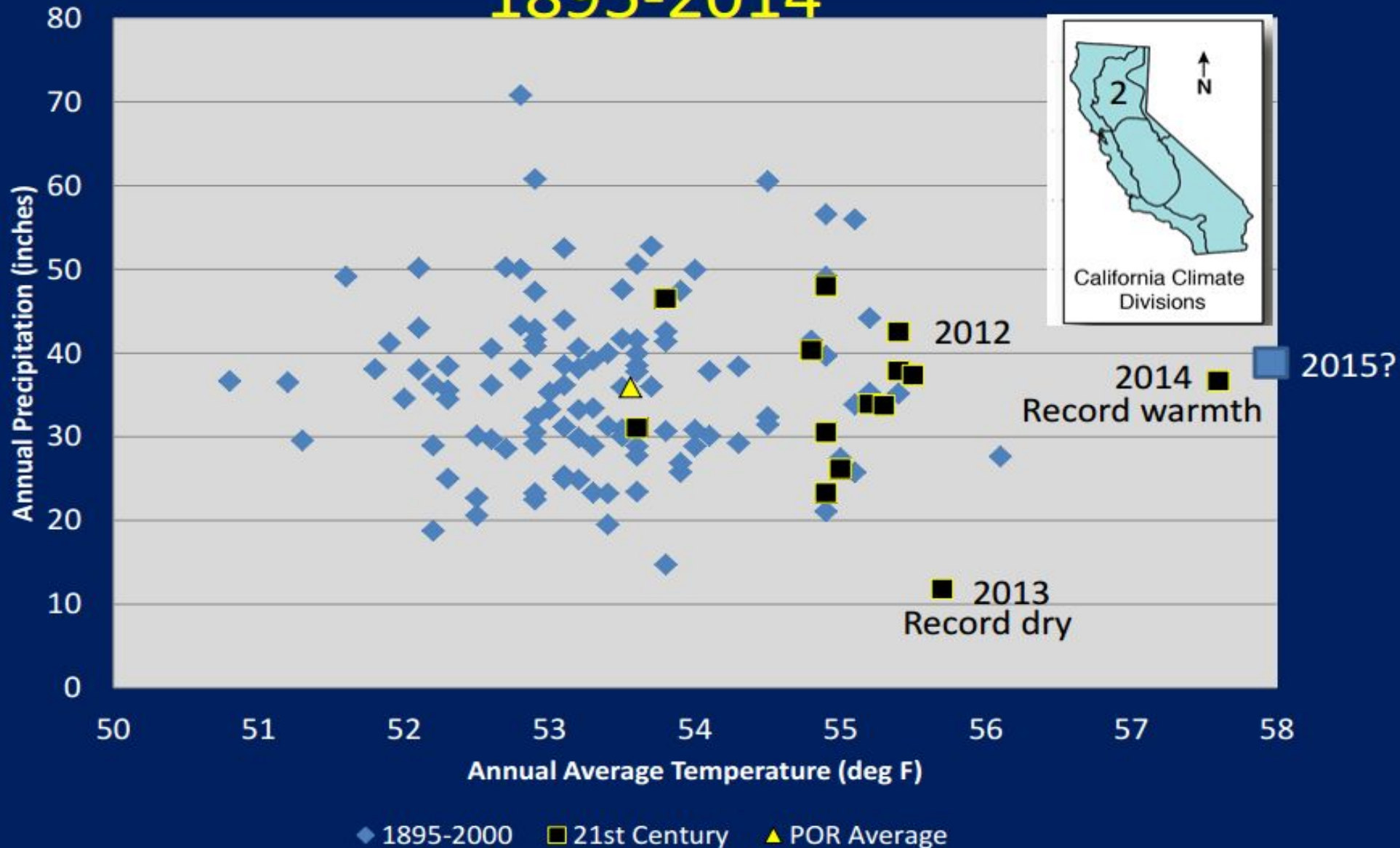
Science and Planning: Climate change undermines basic assumptions of historical water management systems.

Science Mag 2008, **Stationarity is Dead: Whither Water Management**, P. C. D. Milly,^{1*} Julio Betancourt,² Malin Falkenmark,³ Robert M. Hirsch,⁴ Zbigniew W. Kundzewicz,⁵ Dennis P. Lettenmaier,⁶ Ronald J. Stouffer⁷



Human influences. Dramatic changes in runoff volume from ice-free land are projected in many parts of the world by the middle of the 21st century (relative to historical conditions from the 1900 to 1970 period). Color denotes percentage change (median value from 12 climate models). Where a country or smaller political unit is colored, 8 or more of 12 models agreed on the direction (increase versus decrease) of runoff change under the Intergovernmental Panel on Climate Change's "SRES A1B" emissions scenario.

NOAA Climate Division 2 Calendar Year Data 1895-2014



Supply Side Alternatives

Short
List

14

Optimizing existing facilities, raise existing dams:

- .**Rollins dam**, already studied, , NID ownership, 25-40,000 Acre Feet
- .**Fordyce dam**, already studied, PGE partnership, 15-25,000 Acre Feet
- .**Silver Lake dam**, already studied, NID ownership, ? AF
- .**Camp Far West**, owned by South Sutter Water District (SSWD), under FEMA orders to re-construct spillway for flood safety concerns. Could be modified and raised. Partnership with SSWD, 15-30,000 AF

Meadow restoration options: Bear Valley, Lake Norden

Forest management for water yield and fire safety, can increase yield 10-30%, and hedge against future losses from evapo-transpiration, with biomass utilization for power generation + carbon sequestration

Groundwater recharge ponds using Mehrten Formation to increase storage of the North American River Groundwater Sub-basin.

Conjunctive Use Collaboration on existing facilities, like Camp Far West, banking the water in the American River Sub-basin, eliminating evaporation and increasing supplies for emergencies and drought.

Demand Side Alternatives Short List 15

Establish true market values for historic legacy of ditch “ag” water for now used as landscape water for “rural estates.” Ramp into true market value for water.

Lining canals or replacing with pipe. NID estimates 10 to 30% water loss from leaking canals in transmission of water to customers.

Raw water (ditch water) user-end conservation should be assessed and implemented.

Urban water conservation. NID urban use is 280 gpd, very high by state standards. 2015 voluntarily reduced consumption by 38%. Compare to EBMUD at 85 gpd and LADWP at 90 gpd. Active programs:

- Toilet replacement rebates
- Turf reduction buyout
- High efficiency landscape watering systems
- Leak detection
- Sophisticated metering with customer feedback capability
- Conservation rate structures and much more