The Water Report™
Water Rights, Water Quality & Water Solutions in the West

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Managing for Uncertainty

Snake River Basin Adjudication

& More!

DUST-ON-SNOW

IMPACTS ON SNOWMELT & STREAMFLOW

by Jeff Derry, Center for Snow and Avalanche Studies (Silverton, CO)

Introduction

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In addition to the influence of climate change, dust-on-snow events can have substantial effects. Because of the reduction of snow surface albedo (reflectance), these events can: advance snowmelt timing up to 50 days earlier; enhance snowmelt runoff intensity; and decrease snowmelt yields. The result is peak runoff is on average three weeks earlier than normal, with an estimated 5% reduction of annual streamflow in the Colorado River Basin. The movement of dust around the West has increased 300% in the last two decades alone with no signs of abating.

This article discusses the growing problem of dust-on-snow. It also covers efforts by the Center for Snow and Avalanche Studies (a Colorado non-profit) and it's Colorado Dust-on-Snow Program to monitor the high mountains for long-term climate driven changes as well as impacts from dust-on-snow on snowpack and water resources.

Center for Snow & Avalanche Studies and the Senator Beck Study Basin

Climate change researchers around the world have recognized mountains as a sensitive bellwether of global and regional change. In response, Center for Snow and Avalanche Studies was founded in 2003 to foster new research on snowpack processes and to monitor for and detect climate-driven and other changes in regional mountain snow environments. In that same year our high alpine Senator Beck Study Basin (SBB), located in the Western San Juan Mountains between the towns of Silverton and Telluride, was established. SBB is strategically located to enable monitoring and understanding of Upper Colorado River Basin (Upper CRB) warming, drought, dust-on-snow, and changes in precipitation phase. SBB is a vital science asset for: advancing snow research; development and validation of remote sensing technologies; improving hydrologic models; and informing water managers coping with year-to-year water supply variability and recently emerging system forcings.

Dust-on-Snow

Snowpack

Albedo Reduction

Bellwether

Climate Stations

High Elevation

DUST-ON-SNOW

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Highlights of our activities include:

- **Monitoring:** Long-term climate and snowpack monitoring with our three climate stations, stream gauge and intense manual snow data collection. Our highly instrumented climate stations collect the entire energy budget of the snowpack — all incoming and outgoing radiation — necessary to understand affects of dust-on-snow, snowmelt, and to facilitate hydrologic modeling. Three climate stations in the Upper CRB collect this suite of information: two are located in SBB and one is located on Grand Mesa near Grand Junction. SBB is located at the headwaters of three major watersheds: the Uncompahgre which is a major tributary to the Gunnison River; the Animas River, a major tributary of the San Juan River; and the San Miguel River, a major tributary to the Dolores River, all of which are tributaries to the Colorado River. SBB is also approximately12 miles from the Rio Grande Basin.

  The high elevation of SBB (11,030' - 13,510') also distinguishes it from other experimental watersheds. The SNOTEL station network in Colorado that measures snow water equivalent of the snowpack is located in a relatively narrow band of elevation around 10,000' elevation. Given that approximately 50% of streamflow in the Upper CRB is generated above 10,000', this fact highlights the importance of monitoring higher elevations. Our snowpack and streamflow data are especially valuable when SNOTEL stations "go blind," or melt out, and there are no longer ground measurements to base streamflow estimations from the high alpine areas the remainder of melt season.
- **Hosting Interdisciplinary Research:** Much of present day research concerning snow comes out of SBB. For example, we hosted NASA's efforts to develop a snow sensing satellite, called SnowEx, in 2016 and will do so again in 2020. Other scientists in SBB are developing new snow measurement

Dust-on-Snow

Vulnerable Ecosystem

Colorado Water Plan

Dust Source

Development Disturbance

instrumentation, some are investigating the influence of dust on the microstructure of snow, and other folks are looking at the presence of microbes in the dust/snow and its impact on the ecosystem. A full list of publications out of SBB are available on our websites, codos.org/#lit and https://snowstudies.org/.

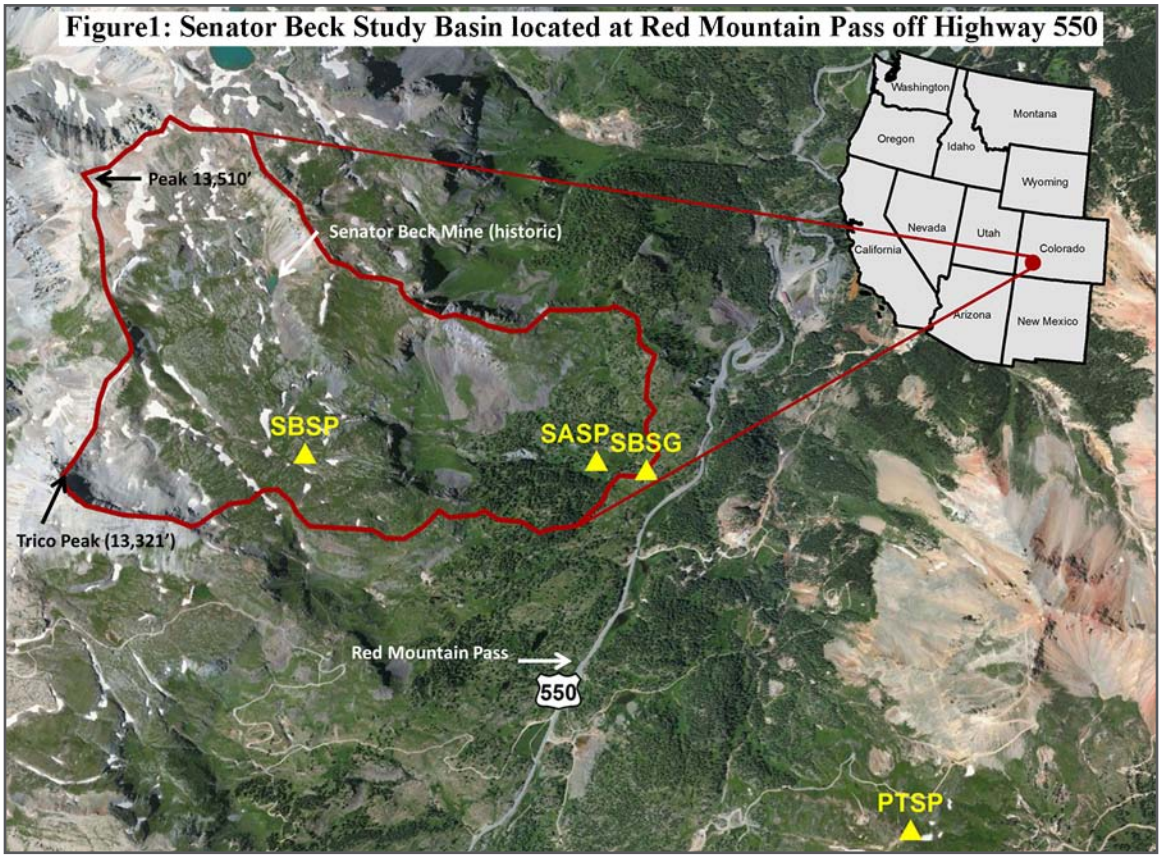
- **Long-Term Ecological Studies:** Seasonal snow amount and distribution greatly influences vegetation composition, abundance, and distribution. Alpine areas are considered one of the most vulnerable ecosystems in the face of climate change, yet there are very few sites with quantitative observations, complimented with climate and snowpack data, like exist in SBB.
- **Colorado Dust-on-Snow Program:** The Center for Snow and Avalanche Studies (CSAS) operates the Colorado Dust-on-Snow Program, an applied science program for stakeholders in the Upper CRB. Dust-on-snow is identified in the Colorado Water Plan as a major problem for reasons detailed below. (*See* www.colorado.gov/cowaterplan).

Background

This story starts not in Colorado, but in the desert Southwest. Specifically the Southern Colorado Plateau, encompassing the area of northwest New Mexico, Northern Arizona, and southeast Utah. This is the dust source area for the majority of **d**ust-**o**n-**s**now (DOS) events that occur in Colorado. Multiple lines of evidence demonstrate that disturbance of most dryland soil surfaces increases dust production both locally and regionally. While dryland soils are often relatively stable when intact, disturbances caused by recreational vehicles, energy exploration, grazing, increasing aridity, fire, and plowing, can increase sediment movement by up to several orders of magnitude, in some cases as much 40-fold. Dust emission and recovery is governed by the interaction of aridity, vegetation, soil stability, and land use.

The migration of settlers of European descent into the western US led to widespread expansion of grazing, mining, and agricultural activities in the 19th and 20th centuries. In the period following the development of railroad lines (and heavy transport capabilities for livestock) in the late 1860s, cattle and sheep grazing greatly intensified across the Western US. In the Navajo Nation tribal lands to the south and southwest of the San Juan Mountains, high-animal densities and impacts of overgrazing became a major issue by the early 1890s. By the early 1930s, two thirds of the land area in NE Arizona had been significantly disturbed by heavy livestock use. Overall, nearly 70% of the natural ecosystems of the western US have been affected by livestock grazing, resulting in the loss of soil stability and increases in wind erosion of soil.

Figure1: Senator Beck Study Basin located at Red Mountain Pass off Highway 550



Dust-on-Snow

Grazing Impact

Looking at high alpine lake sediment cores in Colorado, dust loading increased 500% with the arrival of large livestock herds and intensive agriculture at lower elevations of the western United States in the mid- to late-1800s. The extensive degradation of western US rangelands led to the Taylor Grazing Act of 1934 that imposed regulations and restrictions on grazing activities in these rangelands. As a result, dust production fell roughly a quarter as seen in lake-core samples over predisturbance accumulation amounts, coincident with a reduction in numbers of grazing animals.

Deposit Timing

During a typical winter season as storms track through this region there is potential — dependent on such factors as severity/direction of wind and soil moisture — to entrain dust and carry it towards Colorado. As the wind encounters the Colorado mountains it begins to deposit the dust on the landscape. Storms that track out of the Southwest are more common and typically more severe (and when soil conditions may be drying with approaching summer) going into the spring months of March, April, and May, as this is when we document the vast majority of DOS events. This timing is unfortunate since peak snow accumulation occurs around the April 1st timeframe, depositing the dust near/at the surface of the snowpack.

Dust Deposition

CSAS is the only entity that monitors DOS conditions on an operational basis for the water community, researchers, and stakeholders. SBB is the primary sentry site for the Colorado Dust-on-Snow Program (CODOS). Located in Southwest Colorado, it is situated in the first major mountain system downwind of the desert Southwest, making it the mountain range hit first and hardest by most DOS events. Hence, it is well-placed to monitor dust deposition on the Colorado snowpack. The CODOS program is a state-wide effort, with 11 monitoring sites throughout Colorado to assess DOS conditions and report on local snowmelt and streamflow impacts to a particular watershed.

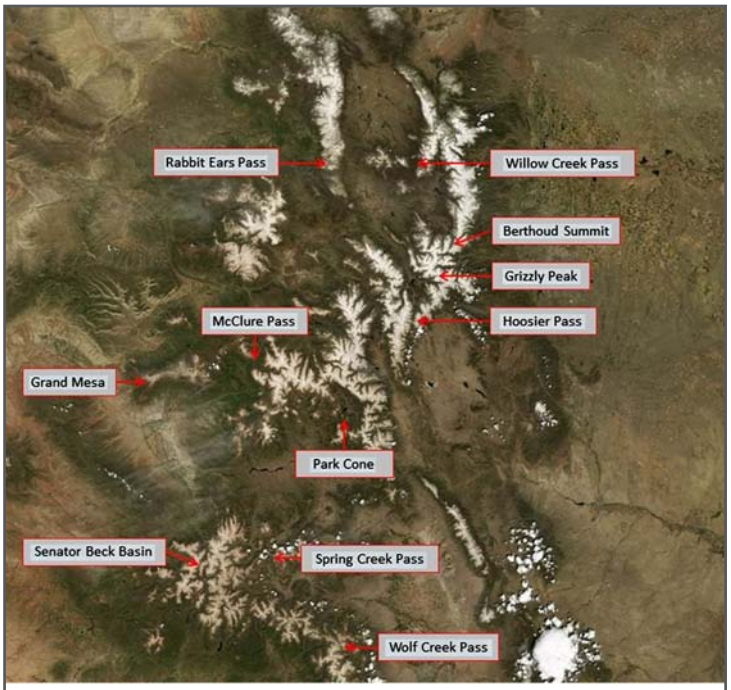


Figure 2: Arial image of CODOS sample locations.
Senator Beck Basin is our "sentry" site for DOS monitoring.
Note cleaner, more reflective snow surface north-to-south.
Southern mountains are first and hardest hit by storms containing dust.

Dust Effects on Snowmelt

Solar Radiation

The affect of DOS is dramatic. After a snow storm, typically the result is a clean, bright snow surface making us reach for our sunglasses to protect our eyes from the bright sun rays being reflected off the surface. Then in a few days after the snow grains naturally degrade, impurities have blown onto the snow surface or become exposed from underneath the surface, we notice the snow surface to be not as white and reflective. What we are witnessing is the change from a high albedo, or high reflective, to a low albedo (low reflective) snow surface. A high albedo snow surface reflects upwards to 90% of solar radiation back into space. A low albedo snow surface reflects around 30%-70% solar radiation back into space, with the rest absorbed into the snow contributing towards warming and melting the snowpack. This is significant because in Colorado solar radiation accounts for nearly all of the energy that goes towards melting the snow — as opposed to air temperature, which is a common misconception.

Low Reflective Surface

Figure 3: Snow-on-Dust-on-Snow
Every picture tells a story. A clump of snow fallen from the tree canopy rests on a dust-laden snow surface. The clean clump of snow is elevated — illustrating the different melting rates of clean and dust-laden snow.

USDA/NRCS National Engineering Handbook
Part 630 Hydrology

Chap. 11 - Snowmelt

Table 11-1
Relative Importance of Energy Balance Terms

'Heat' Term	%ΔH
SW Rad, LW Rad	60-90%
Sensible, Latent	5-40%
Ground	2-5%
Precipitation	0-1%

Figure 4. Snowmelt Energy Balance
In a continental radiative snow climate, such as Colorado, the vast majority of snow-melting energy comes from solar radiation.

This is the process that takes place across our mountain landscape when DOS occurs. A typical snow season involves hopefully many storms depositing snow in the Colorado mountains. Storms that track through a dust source area prior to entering Colorado may contain dust. It might be diffuse, intermixed with the new snow accumulation and therefore hard to see. Or it may be a definitive discreet layer, deposited just prior to snowfall on the leading edge of the storm. As the winter progresses the dust gets buried under a fresh blanket of snow. But when the dust layer nearest the surface is exposed on the surface from a lack of snowfall or spring melt, it increases the absorption of solar radiation and warms/melts the snowpack faster than it would have otherwise. This dust layer accelerates snowmelt down to the next dust layer. Since dust coalesces at the surface of the snow, the two dust layers merge at the surface and decrease albedo further, melting the snow even faster. And so on and so forth, with each dust layer merging at the snow surface with previous layers it keeps getting darker, absorbing more and more solar radiation.

The overall effect this has is making the snowpack melt earlier in the season and faster. How much earlier? Just considering dust forcing alone, depending on the number and severity of DOS events the snowpack melts 24 days early in milder dust seasons and up to 50 days early in high dust seasons. This early melt is largely *independent* of climate change, meaning the dust makes the snow melt faster in these modeled analyses, but climate change induced factors can affect soil stability in drylands and make dust storms more likely. Some studies have indicated that dust deposition increases with regional climate warming.

Dust impacts on the duration of snow cover, as well as the impacts of the dust itself, can have large effects on alpine ecosystems. Reduced snow cover duration affects plant phenology, soil processes, and fire regimes. Since stream discharge is earlier and more compressed, the result is reduced streamflow in latter summer causing increased water temperatures and stresses to aquatic life. Impacts from the dust itself can effect phenology, soil texture and processes; increase snow pH, conductivity, and ion concentration; and increase alpine lake nutrient loads by twofold to threefold. To try to understand the source and influence of dryland dust in the mountain ecosystem CODOS maintains a close relationship with the United States Geological Survet (USGS) and other researchers. CODOS collects dust samples from individual events as well as end-of-season concentrated totals for lab analyses that identify the mineral, microbe, and nutrient composition.

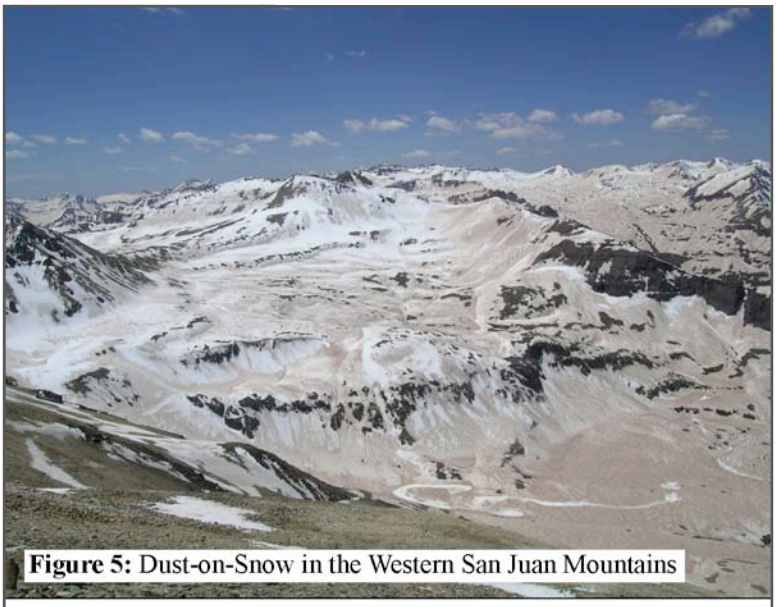


Figure 5: Dust-on-Snow in the Western San Juan Mountains

Figure 6: Storm bringing dust to Colorado. Main Street, Silverton

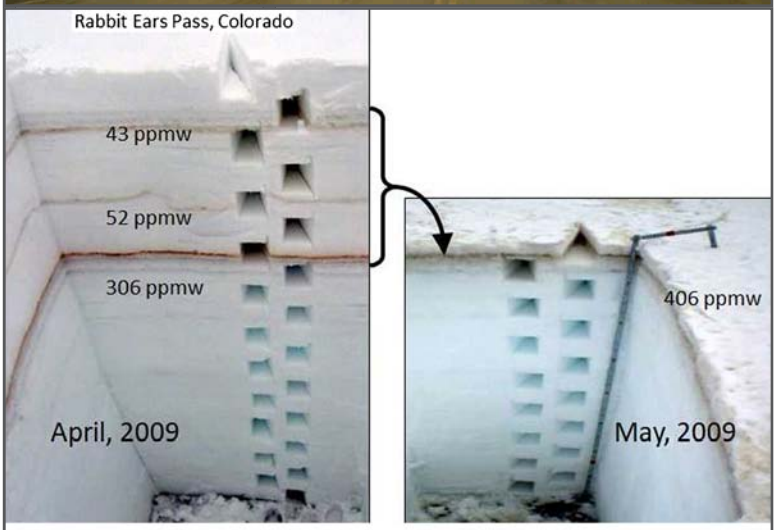


Figure 7: Impurities are strongly dominated by dust, which resist scavenging by liquid water and so coalesce on surface. Dust concentrations are linearly related to number of days of advanced melt. (Skiles & Painter, 2016)

Streamflow Response

The overall affects of DOS on streamflow are striking. Measured reductions in snow albedo have advanced Colorado snowmelt by one month on average and resulted in a higher amplitude and shorter duration hydrograph. One study looking at pre- and post-disturbance impacts of dust on albedo in the Upper Colorado River Basin across 1916-2003 found peak runoff at Lees Ferry, Arizona, has occurred on average three weeks earlier.

It would be a grave mistake to think that this is solely an Upper Colorado River Basin problem. [Editor's Note: The Upper Colorado River Basin is composed of the states of Colorado, New Mexico, Utah and Wyoming. The obligations for the Upper Basin to deliver water to Lower Basin states (Nevada, California and Arizona) are quantity specific — as long as water is delivered in the amounts required under the 1922 Colorado River Compact and various "Law of the River" agreements, their obligations are satisfied. *See* MacDonnell & Castle, *TWR* #167]. DOS can reduce the overall volume of water available for downstream users. As mentioned above, studies have shown DOS can melt the snowpack up to 50 days sooner, shortening snow cover duration. This accelerated melting exposes vegetation and soil earlier in spring. This means early season plant transpiration and increased evaporation from soils suck water into the atmosphere, water that would normally make its way into the streams and rivers. Early evapotranspiration of plants and soils decreases annual runoff in the Upper Colorado River Basin by 5% of the annual average. That's a lot of water — more than 250 billion gallons — enough to supply the Los Angeles region for 18 months. As the recently completed Drought Contingency Plans for the Upper and Lower Colorado River Basins highlight, less flows in the Colorado River will force all of us to make do with less. *See* Kowalski & Snyder, *TWR* #179 regarding Drought Contingency Plans for the Upper Basin and Lower Basin.

Dust-on-snow is a problem presenting additional complexities and uncertainties into managing water supplies. When, where, and how fast the snow melts determines streamflow response. Every winter season the snowpack amount and distribution is unique and every season the severity and location of dust across the mountain landscape and within the snowpack is unique. But each spring the variation in the Colorado snowmelt-dominated runoff hydrograph is controlled by dust radiative forcing. Dust on the surface reduces albedo, absorbs more solar radiation, and causes increased snowmelt rates resulting in an increase in streamflows. If dust gets covered by new snow accumulation and is beneath the snow surface (or non-existent) then snowmelt rates are lessened. If you view a graph of albedo (the ratio of incoming versus reflected solar radiation), you can determine what streamflow response to expect. If albedo goes up, streamflow goes down, and if albedo goes down, streamflow goes up. During a typical spring it is usually an interplay of dust exposure and weather. If it is a wet spring with regular snowfall this clean new blanket of snow provides an "albedo reset" — temporarily restoring a high albedo and hence reducing streamflows. If spring conditions are dry then when dust is exposed, it stays exposed, contributing to sustained spiking

Figure 8: May 2009 at Swamp Angel study site in SBB. Particurlarly bad Dust-on-Snow year.

streamflows. Colorado's recent back-to-back extreme winters illustrate this very well. In 2018, a very dry winter meant a very low snowpack. That spring dust quickly was exposed to the surface, and, because it was also a very dry spring, this accelerated snowmelt to where the snowpack melted at least a month earlier than normal and most rivers reached peak discharge the first half of May.

In contrast, in 2019 we had a lot of precipitation and large snowpack going into spring. These conditions continued throughout spring, not only adding to the snowpack but also providing regular "albedo resets" that kept the dust covered with a clean and highly reflective surface, resulting in a nice slow melt season that allowed streams to not get overwhelmed all at once with rapid snowmelt. In 2019 full snowmelt was approximately two weeks later than normal and many rivers peaked around June 10 but many others peaked around July l. Both years were similar in terms of the number and severity of dust layers but spring conditions greatly influenced its exposure and the roll it played in snowmelt.

Putting this into context is crucial. Knowing the magnitude and timing/intensity of snowmelt runoff requires knowing snow water equivalent *and* snow albedo. In other words, if you just want to get an idea of how much water is held in the snowpack you look at SNOTEL data, snow course data. Or you might be fortunate enough to afford LIDAR airborne measurements provided by the Airborne Snow Observatory that, when flights are done near peak snow accumulation, can provide an extremely accurate estimate of snow water volume. If, however, you want to know the timing and rate of snowmelt, you need to know the snow albedo, which is largely controlled by dust on the snow surface. The mountain snowpack is a natural reservoir. The consequences of earlier and faster snowmelt is water must sometimes be quickly passed through storage reservoirs, lessening water supply during the hottest parts of summer when water is most needed. Water managers need to know timing and rates to maximize storage, power generation, safe operations, and allocation of water.

The CODOS Program provides regular updates that contain near real-time observations and assessments on how dust will effect snowmelt and subsequent streamflows to water managers (i.e. Bureau of Reclamation, other reservoir operators, state engineers, ditch operators, municipalities, state and federal agencies), recreationalists, local community, and forecast centers (i.e. NRCS, Colorado Basin River Forecast Center). This information is an important tool of a suite of tools that the water community incorporates into their water management decision-making process.

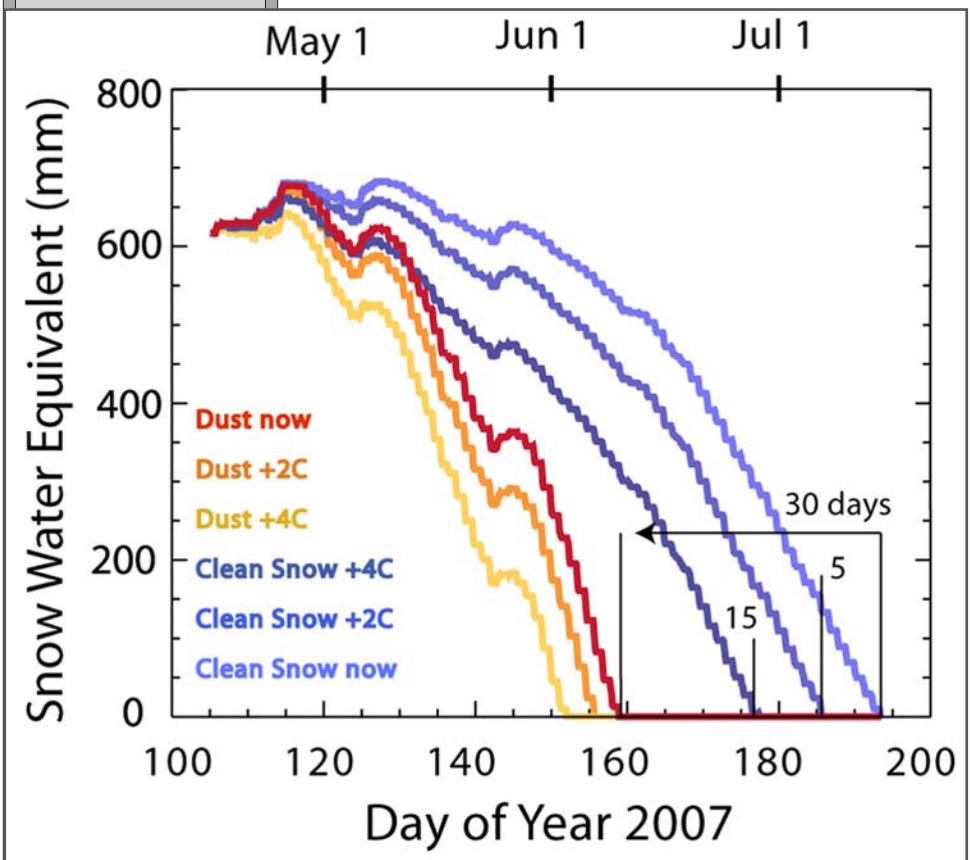


Figure 9: One study modeled snow ablation as it really happened with influence of DOS (red line). Then it tracked snow ablation as if there was no DOS (light blue line). Climate change scenarios (+2C and +4C) were also modeled. This was done for multiple years. The above example shows snow abaleted 30 days earlierr (average for the study). A climate change scenario shows ablation occuring earlier, though not as much as dust forcing alone.

Adapted from: Skiles, et al., (2012), *Dust Radiative Forcing in Snow of the Upper Colorado River Basin*:2. Water Resources Res., 48, W07522. doi:10.1019/2012WR011986.

Dust-on-Snow

Multiple Demands

Managing Flow

Informing Operations

Temperature Variable

Adjustment for DOS

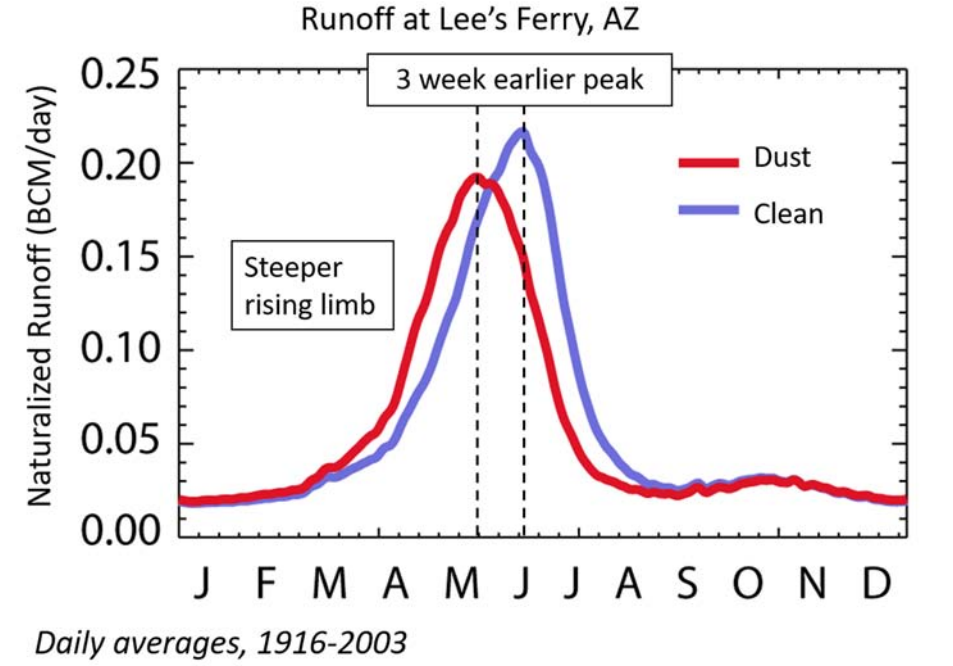
Field Operations

A clear example of the importance of SBB's station data and DOS observations was illustrated in the big snow year of 2019. DOS observations informed multiple operations. There was plenty of water held in the snowpack, but the challenge was to effectively manage flows in the face of multiple demands such as maximizing reservoir storage, maintaining environmental flows at certain thresholds, and sustaining flows for boaters. All of these demands required knowing when and how much water would be coming down the streams. By closely tracking the albedo with our climate stations, dust presence and emergence through our manual snow profiles, and our high elevation stream gauge observations, we were able to contribute to a very successful season. Our daily communications with water managers kept them abreast of what was happening and about to happen in the high country.

As mentioned, radiation and DOS information is one essential tool of many that translates to a successful season. Knowing how much snow, and where that snow exists in the watershed is, of course, another important tool. In the middle of June 2019, well after typical peak streamflow, our observations were still showing a very large snowpack at high elevations, observations not captured by lower elevation SNOTEL data. This allowed us to inform multiple reservoir operations of the large amount of remaining water in the high country that still needed to make its way into the streams and storage facilities. This information helped prevent unwanted reservoir management scenarios such as over-filling, releasing above safe-release capacity, flooding, etc. As an example, for Vallecito Reservoir near Durango, not over-filling the reservoir was attributed to three factors: new radar in the Durango area, a new stream gauge in the watershed, and CODOS observations in the high country.

Dust-on-snow melt forcings and radiation inputs are not typically captured in hydrologic models. With air temperature being a standard variable collected at weather stations it has been commonly used as a proxy for radiation. The temperature index-based SNOW17 snowmelt model the Colorado Basin River Forecast Center (CBRFC) uses is one such model. However CBRFC incorporates special remotely sensed product to calculate departure from average 2000-2015 dust conditions to come up with a dust radiative forcing adjustment to tweak air temperature inputs in the SNOW17 snow model. The more dust on the surface, the higher the air temperature adjustment. This is a big step forward when trying to account for dust on such a large scale as the Upper CRB. Remotely sensed observations, assuming there is no cloud cover blocking a clear view to the ground, only gives an idea of dust conditions at a particular point in time.

It is important to keep in mind the best way to understand dust-on-snow severity and extent is by direct field observations. Direct observations give predictive ability as to the presence of dust, when it may emerge at the surface, and dust layers merging together, further decreasing albedo. Technology is trending toward satellite and airborne data for some good reasons, but the best way to know snow and DOS is getting boots on the ground. There will always be a necessity, now more than ever I would argue, for ground-based networks given the ramifications for water managers, planning, and policy of our changing environment.



Painter, Deems, *et al.*, *PNAS (2010)*

Figure 10: One study found that DOS advances peak discharge at Lee's Ferry by three weeks, forces a steeper rising limb of the hydrograph, and reduces average annual Colorado River flows by 5%.

Solutions to the Dust-on-Snow Problem

River systems originating in the Colorado headwaters are stretched to the breaking point. Demand far exceeds supply. In natural systems there are few options in addressing the supply side of the water supply/demand equation.

Possible Supply Side actions include:

- Weather Modification (aka cloud seeding): possible extra 3-4% of Colorado River water
- Forest Treatments to improve forest health resulting in possible increased runoff
- Soil Stability prevention and remediation measures to prevent dust-on-snow: potential increase of 5% of Colorado River water

Dust-on-Snow

Soil Stability

Reducing Dust

Avoidance

In an attempt to address the water quantity side of the equation, addressing soil stability in the major source regions of the desert Southwest one would think is low hanging fruit. Improving soil stability also would have all the other benefits ranging from a healthier dryland ecosystem to counteracting some effects of climate change by snow sticking around longer thereby contributing to regional cooling.

We can do something about increasing soil stability and decreasing the amount of dust that becomes airborne. Cessation of disturbance generally results in stabilization of soil surfaces within days to years, depending on the type of stabilizers available. Physical soil crusts can reform with intense rains, and thus can stabilize surfaces quickly. Cyanobacterial crusts can reform within a few years after disturbance. Paleoclimate records show multiple examples of regional droughts and megadroughts during AD 900–1300, but lake sediment analysis does not indicate increased dust accumulation during these periods — emphasizing the importance of soil disturbance to dust emission. There are multiple options to reduce dust production. The first is protection of soil stabilizers such as biological and physical soil crusts, rocks, and perennial plants by altering the type, location, and intensity of destructive land use activates. The second is restoration, where treatments can range from drill seeding, physical barriers to control blowing dust, perennial grass restoration, and using lab-grown biological soil crusts for restoring disturbed areas. Whatever treatment is tried, it must recognize soil stability is a prerequisite for revegetation. Avoidance of soil disturbance is likely the most cost effective approach.

One of the big questions is — would this be a piecemeal endeavor or an organized concentrated effort, and if so who would organize and spearhead this effort? Land ownership in the Southwest desert is predominantly federal, including: Bureau of Land Management, Bureau of Indian Affairs, Department of Defense, and the National Park Service, to name the largest. A commitment can only come about by understanding the full causes and repercussions, becoming ever more critical in a warming climate. A sustained research, monitoring, and modeling effort is required to guide best practices for a given landscape, vegetation, and soil characteristics.

Dust & Streamflow Interaction

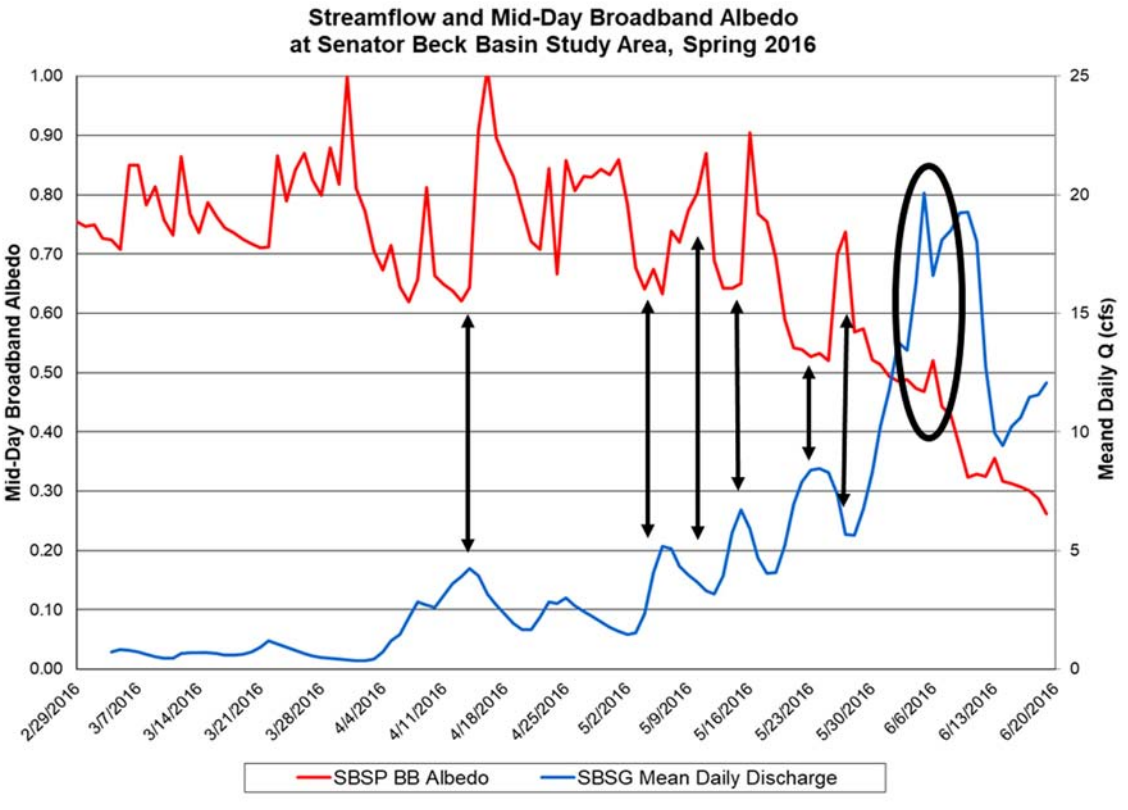


Figure 11: Plot of albedo (red line) and streamflow (blue line) in Senator Beck Study Basin in 2016. This is a good year to illustrate the interplay of dust exposure, albedo resets from new snow accumulation, and stream response. With a change in albedo there is usually a 1-2 day lag time (difficult to see in the above figure) before the repsonse is seen at the stream guage. This is fortunate, as it can give water managers a 1-2 day alert as to what direction streamflow will take.

Dust-on-Snow

Soil Stability

Snowpack Energy Measurement

Funding Uncertainty

Mitigation Priority

Monitoring Necessity

Land Use Impacts

The ill-informed view DOS as unavoidable or a natural process, so why do anything about it? This viewpoint is akin to knowing what causes a disease but not seeking a cure or alleviating its symptoms. The fact is the Southwest deserts are *not* naturally dusty — as long as the occurring crust that anchors the soils is intact. Most with this viewpoint are entities who for a variety of reasons simply do not want to dedicate resources to solving the problem. Though a few government agencies and communities are taking steps to address the problem, it is likely to get worse in the future.

For Colorado as a whole, radiation data within or near a particular watershed may be hard to come by, being non-existent or too spatially distant to be applicable. Analysis of melt forcing under dust, climate warming, or vegetation change scenarios are not possible without the type of measurements collected at the two energy balance towers at SBB and one on Grand Mesa. The predicted worsening of DOS in the future, climate warming, the need to advance the understanding of snow processes for modeling and forecasting requires measurement of the snowpack energy balance *throughout* Colorado's mountains. This is a basic requirement to support long-term climate and snow monitoring. Long-term monitoring is essential to document changes to our natural systems. Many climate stations have a brief existence due to funding challenges. Most funding entities support "projects" — i.e., specific research endeavors that usually last no more than a few years. If climate stations were part of the project, once the project is over so is the funding to support these stations. The nature of the short-sightedness of funding sources makes keeping stations operational a major challenge in the long term. CSAS has been able to keep our highly instrumented stations going nonstop for 15 years, amassing a very valuable dataset. But we are subject to the whims of funding cycles like any other non-profit. The future, beyond two to three years, is uncertain.

The extreme importance and over-allocated condition of water supplies in the CRB and the West in general, not to mention the forecast reductions in water supplies due to climate change, implies that mitigating dust producing lands that contribute to DOS will/should be a top priority in the near future. This emphasizes the crucial necessity of DOS monitoring conducted by the Colorado Dust-on-Snow Program to identify geographic and land-use sources of DOS to help target management and policy changes. And on a seasonal level, to inform water managers, water forecast centers, and researchers of immediate impacts DOS will have on snowmelt timing, rates, and potentially overall yield of the winter's snowpack. All of which is essential in order to efficiently manage and adapt to the DOS phenomena.

Conclusion

In an era of many challenges, unknowns, and pressures on our mountain systems and water resources the Center for Snow & Avalanche Studies was established to conduct high alpine climate and snowpack monitoring and research, as well as operate the applied science Colorado Dust-on-Snow Program. DOS forces the Colorado snowpack to melt earlier and faster presenting additional challenges and complexities to water managers. Dust causes the landscape to become snow free earlier in the season with large effects on alpine ecosystems, including increased evapotranspiration rates that result in a reduction of Colorado River flows by 5% on average.

The movement of dust around the West has increased 300% in the last two decades alone with no signs of abating. The primary dust source region for Colorado is the Southern Colorado Plateau — where land use impacts from off-road vehicles, oil/gas exploration, grazing, increased aridity, and fire to name just a few — has disturbed desert crusts making dust entrainment into the atmosphere during high wind events common. Addressing the problem will require a concerted organized effort that includes avoiding desert crust disturbance and soil restoration. It will also need to include an organization like the Center for Snow & Avalanche Studies to track and monitor dust mineral, microbe, and nutrient composition to identify geographic sources, better understand the impacts of DOS in our mountain ecosystem, and provide assessments of immediate implications to water managers.

For Additional Information:

Jeff Derry, Center for Snow & Avalanche Studies, 907/ 387-5080 or jderry@snowstudies.org

Websites at: https://snowstudies.org/; and www.codos.org/#codos

Jeff Derry is originally from Colorado Springs and has a BA in Geography from University of Colorado at Colorado Springs and a MS in Watershed Science from Colorado State University with an emphasis in snow hydrology. His passion for Polar Regions led him to work in Antarctica and Greenland as a field camp manager and science technician for ten years. As a consultant in Fairbanks, Alaska he conducted applied research in the Arctic for five years. The arc of Jeff's life brought him to the Center for Snow and Avalanche Studies in 2015 where he now draws upon his range of skills and experience to contribute to the future development of CSAS.

Tribal Water Rights

TRIBAL WATER RIGHTS

KLAMATH DECISION: SENIORITY OF RIGHTS V. "TAKINGS"

by David Moon, Editor

"Takings" Claims

On November 15, US Court of Appeals for the Federal Circuit (Court) issued an opinion in a long-running case, rejecting the "takings" claims of fourteen irrigation organizations (plaintiffs). *Baley v. United States*, Cases No. 2018-1323, 2018-1325 (Nov. 14, 2019). The plaintiffs "alleged that the Bureau of Reclamation's action in temporarily halting their water deliveries in 2001 constituted a taking of their water rights without just compensation, in violation of the Fifth Amendment to the United States Constitution. They also alleged that the Bureau's action impaired their water rights under the Klamath River Basin Compact…The plaintiffs further alleged that the Bureau's action breached certain water delivery contracts they had with the Bureau." *Baley Slip Op.* at 6-7. The Court's 55-page opinion contains a lengthy factual history and explanation of the complicated legal history of the case; any party interested in the Klamath Basin, irrigation water rights, or tribal reserved water rights will find it to be fascinating reading.

Klamath Basin

The case arose out of the Klamath River Basin reclamation project that straddles the southern Oregon and northern California borders. "Key features of the Project are Upper Klamath Lake in Oregon, where water is stored for the Project, and the Klamath River. The Klamath River rises at the south end of Upper Klamath Lake and flows from Oregon into California. The river eventually enters the Pacific Ocean near Klamath, California. The Project supplies water to hundreds of farms, comprising approximately 200,000 acres of agricultural land." *Id*. at 5. The Project is managed and operated by the Bureau of Reclamation (Reclamation). "The Bureau of Reclamation also manages the Klamath Project to protect the tribal trust resources of several Native American Tribes." *Id*.

Deliveries Halted

In the drought year of 2001, Reclamation "temporarily halted water deliveries to farmers and irrigation districts served by the Project. It took this action in order to meet the requirements of the Endangered Species Act, 16 U.S.C. § 1531 et seq. (2000)…as outlined in Biological Opinions from the United States Fish and Wildlife Service…and the United States National Marine Fisheries Service…It also took this action in order to meet its tribal trust obligations." *Id*.

Senior Tribal Rights

The Court concluded that the Klamath Basin Tribes — Yurok, Hoopa Valley, and the Klamath Tribes — had senior, federally reserved water rights that predate the water rights of the Klamath Irrigation Project irrigators. The Court also found that the Tribes' non-consumptive water rights require at least enough water left instream to ensure the continued existence of tribal trust species listed under the Endangered Species Act (ESA).

Amount of Water Needed

One of the main issues addressed in the decision dealt with the standard that governs the *amount* of water needed to protect the Tribes' reserved water rights. Plaintiffs-Appellants asserted that the lower court, the Court of Federal Claims, erred when it ruled, "…the Tribes held rights to an amount of water that was at least equal to what was needed to satisfy the Bureau of Reclamation's ESA obligations." *Id*. at 37. Instead, "Appellants contend that the Tribes' water rights only entitled them to a catch [of fish] that was adequate to support a 'reasonable livelihood' or a 'moderate living,' as stated in *Washington v. Washington State Commercial Passenger Fishing Vessel Association*, 443 U.S. at 685, 686." *Id*. The Court, however, rejected that position and ruled that Reclamation was required to halt water deliveries to the extent required to comply with the ESA.

Endangered Species Act

> It is not necessary for us to determine the amount of fish that would constitute a "reasonable livelihood" or a "moderate living" for the Tribes. At the bare minimum, the Tribes' rights entitle them to the government's compliance with the ESA in order to avoid placing the existence of their important tribal resources in jeopardy. We therefore reject appellants' argument that the Court of Federal Claims erred when it held that the Tribes had rights to an amount of water that was at least equal to what was needed to satisfy the Bureau of Reclamation's ESA obligations.

Id. at 46.

Subordinate Rights

In its Conclusion, the Court first pointed to its holding that "….we agree with the Court of Federal Claims that appellants' water rights were subordinate to the Tribes' federal reserved water rights." Then the Court issued its ruling on the dispositive issue in the case: "We therefore see no error in the court's holding that the Bureau of Reclamation's action in temporarily halting deliveries of Klamath Project water in 2001 did not constitute a taking of appellants' property." *Id*. at 55.

Tribal Water Rights

Salmon Survival

The issue of the amount of water necessary for salmon in the Klamath River remains in doubt. According to the Yurok Tribe's press release of November 15, the "…Tribe is currently in other litigation over the amount of water necessary to ensure the salmon's survival. In spring 2019, the Bureau of Reclamation issued a Klamath Irrigation Project operations plan and the National Marine Fisheries Service filed a biological opinion burdened with errors that authorizes insufficient instream flows that threaten the existence of salmon. Yurok and Pacific Coast Federation of Fisherman's Associations are challenging the agencies' 2019 decisions in federal court."

The Water Report is planning to publish a major article on the *Baley* decision in the near future, as it covered many important water rights, ESA, and "takings" issues merely alluded to here.

For Additional Information: Decision available at: www.cafc.uscourts.gov/sites/default/files/opinions-orders/18-1323.Opinion.11-14-2019.pdf; Amy Cordalis, Yurok Tribe, 707/ 482-1350 or acordalis@yuroktribe.nsn.us; Yurok Tribe press release available upon request from *TWR*

WATER BRIEFS

GW MEASUREMENTS AZ

BASIN SWEEP

Beginning the week of December 9, 2019 and continuing for several months, the Arizona Department of Water Resources (ADWR) will be making an extensive effort to measure water levels in wells in the Lower Gila and Gila Bend Basins. This "basin sweep" will cover a large portion of the state southwest of the Phoenix metropolitan area, generally south of I-10 and west of I-85, excluding the Yuma area and along the US – Mexico border.

ADWR staff will attempt to measure water levels at hundreds of wells in the Lower Gila and Gila Bend Basins. This survey of area wells — or basin "sweep" as it is known — will be the first such basin survey of the area since 2008 in Gila Bend Basin and since 1992 in Lower Gila Basin. The data collected will be used for several purposes, including: Analysis of water-level trends; Groundwater modeling; Water-level change maps; Hydrologic reports; and Water resource planning and management.

For info: Shauna Evans, ADWR, 602/ 771-8079, smevans@azwater.gov or https://new.azwater.gov/

IRRIGATED FARMING US

TECHNOLOGY ASSESSMENT

The Government Accountability Office (GAO) has prepared a 122-page report entitled *Irrigated Agriculture: Technologies, Practices, and Implications for Water Scarcity*, GAO-20-128SP (November 2019). This report provides an overview of irrigation technologies and on-farm water conservation practices, factors influencing the adoption of these technologies, and implications of their use for water scarcity.

Demand for freshwater surpasses the amount naturally available in some areas of the US. The agriculture sector competes for this limited resource, and withdraws and consumes the most freshwater of any user in the nation. GAO was asked to conduct a technology assessment around agricultural water use. To conduct this assessment, GAO reviewed scientific literature; convened an expert meeting with the assistance of the National Academies; visited farmers, academics, and industry representatives; interviewed officials from federal agencies; modeled water use in an illustrative watershed; and performed a regression analysis on US Department of Agriculture irrigation, crop, and technology data.

GAO found that in the US, irrigation accounts for more than 40% of freshwater use. Several areas in the nation are both heavily irrigated and considered water stressed. Farmers can select irrigation technologies and water conservation practices to better manage freshwater, an increasingly limited natural resource. Farmers have access to multiple irrigation technologies that could increase efficient use of water. Irrigation technologies include micro irrigation, which applies small amounts of water close to the plants; sprinkler systems, which spray water through nozzles; and gravity systems, where water floods the field or runs down furrows. In addition, practices such as irrigation scheduling may help farmers avoid overirrigation. Farmers can also use precision agriculture technologies, such as soil moisture sensors, computer or smartphone decision support tools, and remote control of irrigation equipment to help optimize irrigation scheduling.

The request for GAO to conduct this study specified a policy goal of reducing the impact of irrigated agriculture in locations facing water scarcity in the United States. With that goal in mind, GAO identified the following options federal policymakers could consider:

• Promote the use of more efficient irrigation technology and practices, such as irrigation scheduling.

• Promote the use of precision agriculture technologies, such as soil moisture sensors and weather stations.

In light of GAO's findings, however, these options may need to be combined with appropriate agreements in order to enable and encourage water savings. Such agreements could include incentives to farmers for conserving water. Both policy options have the potential benefit of reducing the amount of water applied during irrigation. However, challenges include ensuring that water savings on the farm translates to water conservation on the larger watershed level.

For info: Report available at: www.gao.gov/assets/710/702604.pdf; Timothy Persons, 202/ 512-6412 or personst@gao.gov

WATER BRIEFS

PUMPED STORAGE HYDRO OR STORED HYDROELECTRICITY

On April 30, 2019, FERC issued a 50-year construction and operational license to Swan Lake Energy Storage for the Swan Lake Energy Storage Project (Project). To mark the Project's approval, Rye Development released a report on the development and the attitudes toward pumped storage hydroelectric energy in Oregon. The report details the process behind pumped storage hydro and discusses detailed survey results from Oregon residents regarding their renewable energy preferences. Results from the survey indicate that Portland-area residents view stored renewable energy very favorably and the development of pumped hydro storage plants is well-received.

Swan Lake Energy Storage is a proposed 394 megawatt pumped hydro facility, located 11 miles northeast of the city of Klamath Falls. The Swan Lake Energy Storage facility will use a closed-loop system that reuses and recycles the same water over and over, with no impact to rivers or ecosystems. Renewable electricity stored at the facility would be transmitted from the powerhouse along a 32.8-mile-long, 230-kilovolt (kV) aboveground transmission line to interconnect with the Malin Substation.

Pumped hydro facilities are like a huge, infinitely rechargeable battery. In the "charging" phase, they use electricity to pump water uphill through a big pipe to an upper reservoir. In the "discharge" phase, they release the water back through the pipe to the lower reservoir, and in the process, use the water to run turbines and generate new electricity. The advantage of using pumped hydro is that it makes it possible to store excess renewable energy for times when it's needed, a feature that is becoming increasingly important as Oregon moves away from polluting fossil fuels. When wind farms and solar panels produce excess energy, it can be stored in the pumped hydro facility by using the energy to pump water uphill. When demand for electricity increases, if there isn't enough wind and solar power being produced to meet the demand, the water gets released, and new electricity is generated.

The Pacific Northwest's abundant wind and solar resources can amply meet the Project's energy needs according to the developers, but their production naturally fluctuates day-to-day and even hour-to-hour, and may not coincide with the electricity usage patterns of homes and businesses. Pumped hydro facilities provide large-scale energy storage, ensuring that at times when the electricity generated from renewable energy exceeds demand, it can be saved for use later when it's needed. By supplying stored electricity during periods of high demand, pumped hydro can also help stabilize electricity prices.

For info: Report available at Swan Lake Project's website: https://slenergystorage.com/resources.html

WATER DISTRIBUTION MT GUIDE RELEASED BY DNRC

The Montana Department of Natural Resources and Conservation (DNRC) has recently published "A Guide for Water Commissioners, Water Users and District Courts" offering practical steps for water distribution in Montana. The 24-page Guide offers practical steps for water distribution in Montana. It includes best practices for water commissioners, district court clerks, district court judges and water users as well as useful references to Montana law and an excellent section on "Common Challenges/FAQs" (frequently asked questions) for Commissioners.

Montana is unusual among western states because the state's district courts, rather than state or federal water resource agencies, are the primary authority for the distribution of water at the local level. Other states like Wyoming, for example, historically assigned water administration and distribution to the state engineer or similar state office, but Montana deliberately avoided that approach. Authority over water distribution and the resolution of water conflicts remains firmly under the command of Montana's District Courts. Day-to-day decisions regarding water delivery (except for large projects operated by the state or federal governments) are made by local irrigation districts, ditch riders, canal operators, water user associations and a variety of other groups and individuals, including water commissioners.

This guide offers basic information, examples of best practices, and references to the law as it applies to the distribution of water by water commissioners that serve under the direction of Montana's District Courts. The DNRC's role as it pertains to water distribution includes issuing new water right permits; authorizing changes to existing permits, claims and decreed water rights; examining pre-1973 claims; and taking action against illegal water use. DNRC is also responsible for providing training and assistance to water commissioners that distribute water at the local level. DNRC publishes and regularly updates a manual specifically for water commissioners. DNRC also provides annual trainings on the skills and requirements necessary for the effective and legal distribution of water. More importantly, DNRC offers year-round technical expertise from hydrology to planning and conflict resolution.

For info: Guide available at: http://dnrc.mt.gov/WatrDistrGuideLowRes.pdf

COLORADO WATER PLAN CO ANALYSIS/TECHNICAL UPDATE

The Colorado Department of Natural Resources presented the final Technical Update to the Colorado Water Plan to the Colorado Water Conservation Board (CWCB) on September 19, 2019. CWCB recently released the Analysis and Technical Update to the Colorado Water Plan (Technical Update), which includes state of the art approaches to analyzing state water needs and includes impacts from climate change.

In 2016, the CWCB launched an update and upgrade of the state's supply and demand projection data and tools underpinning Colorado's Water Plan.

WATER BRIEFS

The process has come to be known as the Analysis and Technical Update to Colorado's Water Plan (or simply, Technical Update, formerly "SWSI"). This statewide supply study serves two primary purposes to: (1) provide a consistent statewide framework for examining future water supply and demand under different scenarios; and (2) provide tools and data for Basin Roundtables to update their Basin Implementation Plans and develop detailed local solutions to supply and demand gaps.

The July 2019 CWCB Board and IBCC joint meeting marked the preliminary release of the Techincal Update. The final report was presented to the Board in September 2019. The full July presentation was recorded and remains available for viewing on the CWCB YouTube channel.

The 2019 Technical Update replaces the document known as the Statewide Water Supply Initiative 2010 (SWSI). The archived SWSI 2010 can be accessed for reference on the CWCB FTP site during the website transition.

The study and all supporting materials (as modified 9/23/19) are available on the website listed below.
For info: Technical Update available at: www.colorado.gov/pacific/cowaterplan/analysis-and-technical-update

WATER PROJECT LOANS CO

LOW INTEREST LOANS

Colorado Water Conservation Board (CWCB) recently touted its Water Project Loan Program, noting that interest rates have dropped to the lowest rates in the history of the Program. A CWCB publication noted, "[I]f you have a water supply project that's been planned for years, but thought you couldn't afford it, maybe now is the time to act. With interest rates for the program starting as low as 1.45%, this is the best time to finance new construction or rehabilitation of your raw water infrastructure."

CWCB went on to state that "Current interest rates can also bring big projects within reach. For agriculture projects, the annual payment on a $1 million, 30-year loan at current rates is less than $42,000 a year. For municipal projects of the same size, the annual payment could be as low as $45,000 a year. And if that isn't good enough, there are rate reductions for 10 or 20-year loans that could reduce the interest rate by as much as 0.65%!" Although that may sound like a come on to an Internet scam, the loan possibilities are tempting.

Approximately $50 million is available annually for the CWCB Water Project Loan Program, which provides low-interest loans to agricultural, municipal, and commercial borrowers for the design and construction of raw water projects in Colorado. A minimum loan request of $100,000 is recommended. Projects financed by the Water Project Loan Program must align with the goals identified in Colorado's Water Plan and its measurable objectives. The standard loan term is 30 years. Rates are reduced by 0.25% for 20-year loans, and by 0.65% for 10-year loans. Rates are increased by 0.25% for 40-year loans; 1.0% will be charged on the loan amount as a loan service fee.

Any private or public entity can apply for a loan that can contract with the state, and that can establish and document the need for the project. The project sponsor must show that the project is technically, economically, institutionally, and financially feasible. Eligible projects for financing include new construction or rehabilitation of existing raw water storage and delivery facilities, such as: Reservoirs; Ditches and canals; Pipelines; River diversion structures; Groundwater wells; Water rights purchases; Flood control projects; and Hydropower.
For info: Matt Stearns, CWCB, 303/866-3441 x3257 or CWCB's website at: http://cwcb.state.co.us/LoansGrants/water-project-loan-program/Pages/main.aspx

FULLY APPROPRIATED CA

INTERACTIVE GIS WEB MAP

The California State Water Resources Control Board, Division of Water Rights (Division) has released an interactive GIS web map for representing Fully Appropriated Stream Systems (FASS) in California. The web map provides access to FASS and related information, including seasonal limitations, court references, and Board decisions all in one place and within a geospatial context. The web map can be found at the following web address: https://gispublic.waterboards.ca.gov/portal/apps/MapJournal/index.html?appid=b2188e89dfea4e44b156600370f1edf7

The Division is planning to host a webinar on the new tool in mid-December, and will follow up with additional information on the time and date of that webinar in the near future. More information can be found on the Division's Fully Appropriated Stream Systems (FASS) webpage.
For info: FASS webpage: FASS@waterboards.ca.gov

SUBSIDENCE IMPACT CA

CANAL REPAIR

The Bureau of Reclamation (Reclamation) announced on December 3 that it is seeking public input about its plan to restore a subsidence-impacted, 33-mile stretch of the Friant-Kern Canal (FKC) that has lost over half of its original designed and built capacity to subsidence — a sinking of the earth from groundwater extraction. The canal, located in California's eastern San Joaquin Valley, delivers water to over 1 million acres of highly productive farmland and over 250,000 residents. The reduced channel capacity has resulted in up to 300,000 acre-feet of reduced water deliveries in certain water years with effects most dramatic in the FKC middle reach (milepost 88 to milepost 121).

The Friant-Kern Canal Subsidence and Capacity Correction Project (Project) would restore capacity from the current estimated 1,900 cubic-feet-per-second (cfs) to the original 4,000 cfs in the most critical area near the Dear

WATER BRIEFS

Creek Check Structure (milepost 103). The Friant Water Authority, the non-federal operating entity for the canal, is supporting the design and feasibility assessment of the proposed project and is working with Reclamation to meet state and federal environmental law requirements.

A Notice of Intent to prepare an environmental impact statement, in accordance with the National Environmental Policy Act, for the "Friant-Kern Canal Middle Reach Capacity Correction Project," was published in the Federal Register on December 3, 2019. Reclamation is seeking comments for the next 30 days. A public scoping meeting is planned for December 18, 2019 to solicit input from 5:30 p.m. to 7:30 p.m. at US Forest Service office, 1839 S. Newcomb Street, Porterville, California. As part of the scoping process, Reclamation will release an Environmental Assessment/ Initial Study (EA/IS).

A copy of the NOI and the EA/IS may be found online at: www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=41341. Contact Rain Emerson at 559/ 262-0335 or remerson@usbr.gov for a CD document copy. Scoping comments may be submitted to Ms. Emerson within the next 30 days.

For info: Adam Nickels, Reclamation, 916/ 978-4415 or anickels@usbr.gov

SUPERFUND SITE RISKS US

CLIMATE CHANGE IMPACTS

A study by the US Government Accountability Office, "GAO-20-73," found that available federal data — from the Environmental Protection Agency (EPA), Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, and US Forest Service — on flooding, storm surge, wildfires, and sea level rise suggest that about 60% of all nonfederal National Priorities List (NPL) sites are located in areas that may be impacted by these potential climate change effects. GAO analyzed 1,571 active and deleted nonfederal NPL sites for its study.

Administered by EPA, Superfund is the principal federal program for addressing sites containing hazardous substances. EPA lists some of the most seriously contaminated sites — most of which are nonfederal — on the NPL and has recorded over 500 contaminants, including arsenic and lead, at those sites. Climate change may make some natural disasters more frequent or more intense, which may damage NPL sites and potentially release contaminants, according to the Fourth National Climate Assessment.

GAO was asked to review issues related to the impact of climate change on nonfederal NPL sites. This report examines, among other objectives: (1) what available federal data suggest about the number of nonfederal NPL sites that are located in areas that may be impacted by selected climate change effects; and (2) the extent to which EPA has managed risks to human health and the environment from the potential impacts of climate change effects at such sites. GAO analyzed available federal data; reviewed laws, regulations, and documents; interviewed federal officials and stakeholders; visited three nonfederal NPL sites that experienced natural disasters; and compared EPA actions to manage risk to GAO's six essential elements of enterprise risk management.

GAO made four recommendations to EPA, including that it clarify how its actions to manage risks at nonfederal NPL sites from potential impacts of climate change align with current goals and objectives. EPA agreed with one recommendation and disagreed with the other three. GAO continues to believe that all four are warranted.

Additional information on some of these sites can be viewed in an interactive map and downloadable data file, available on the GAO website listed below.

For info: GAO website: www.gao.gov/products/GAO-20-73

PFAS ACTION PLAN US

SAFE DRINKING WATER

On December 3, the US Environmental Protection Agency (EPA) sent the proposed regulatory determination for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water to the Office of Management and Budget for interagency review. This step is part of EPA's extensive efforts under the PFAS Action Plan to help communities address per- and polyfluoroalkyl substances (PFAS) nationwide. PFAS are a large group of man-made chemicals used in consumer products and industrial processes. In use since the 1940s, PFAS are resistant to heat, oils, stains, grease, and water — properties which contribute to their persistence in the environment.

The Safe Drinking Water Act establishes robust scientific and public participation processes that guide EPA's development of regulations for unregulated contaminants that may present a risk to public health. Every five years, EPA must publish a list of contaminants, known as the Contaminant Candidate List or CCL, that are known or anticipated to occur in public water systems and are not currently subject to EPA drinking water regulations. EPA publishes draft CCLs for public comment and considers those prior to issuing final lists.

After issuing the final CCL, EPA determines whether or not to regulate five or more contaminants on the CCL through a process known as a Regulatory Determination. EPA publishes preliminary regulatory determinations for public comment and considers those comments prior to making final regulatory determinations. If EPA makes a positive regulatory determination for any contaminant, it will begin the process to establish a national primary drinking water regulation for that contaminant (*see* www.epa.gov/ccl).

A full summary of EPA's action to address PFAS can be found in the PFAS Action Plan, available on the website listed below.

For info: EPA's PFAS website: www.epa.gov/pfas

WATER BRIEFS

AG WATER RATE CA

NEW PROGRAM STRUCTURE

In late November, the San Diego County Water Authority's Board of Directors approved a new and permanent Special Agricultural Water Rate structure that offers lower water rates to farmers in exchange for lower water supply reliability. Unlike the current temporary program, the new program will let new participants join as a way to strengthen the region's multi-billion-dollar agriculture industry.

Farmers and growers who participate in the new program will continue to receive a lower level of water service during water shortages or emergencies, allowing the Water Authority to reallocate those supplies to commercial and industrial customers, who pay for full reliability benefits. In exchange, participating farmers are exempt from fixed water storage and supply reliability charges. Under the current temporary program in 2020, participants will pay $1,231 per acre-foot for treated water, while municipal and industrial users will pay $1,686 per acre-foot.

New ag water program rates will be determined in the spring of 2020 as part of the Water Authority's annual rate-setting process. The program will take effect January 1, 2021, replacing the current program that sunsets at the end of 2020. Additional program details, such as the signup process and qualifying criteria, also will be developed early next year.

San Diego County is unusual among major metropolitan areas in the US because it includes one of the nation's most valuable and productive farm sectors adjacent to one of the nation's largest cities. The region sustains 3.3 million people and a $231 billion economy, thanks to decades of regional investments in water supply reliability projects, including the nation's largest seawater desalination plant and the biggest conservation-and-transfer agreement in US history.

For info: Authority's website: www.sdcwa.org/

SALINITY REDUCTION CO

PUBLIC COMMENT SOUGHT

The Bureau of Reclamation is seeking public input on alternatives to reduce salinity in the Colorado River from sources in the Paradox Valley in western Colorado. Currently, the Paradox Valley Unit (PVU) in Montrose County, Colorado, is intercepting naturally occurring brine and injecting it 16,000 feet underground via a deep injection well. The PVU began operating in 1996 and is nearing the end of its useful life. The United States has a water quality obligation to control salt in the Colorado River, in compliance with the Colorado River Basin Salinity Control Act, the Clean Water Act, and a 1944 treaty with Mexico.

"The Paradox Valley Unit is a cost-effective salinity control project in the Colorado River Basin as it prevents 95,000 tons of salt annually from reaching the Dolores River and eventually the Colorado River — that's approximately 7% of total salinity control occurring in the basin," said Area Manager for Reclamation's Western Colorado Area Office Ed Warner. "Reducing salt in the rivers improves water quality, crop production and wildlife habitat in the basin."

Reclamation is preparing an Environmental Impact Statement and has released a draft for public review and comment. Alternatives analyzed in the draft EIS include a new injection well; evaporation ponds; zero liquid discharge technology; and no action, which would result in no salinity control in the Paradox Valley.

The public is invited to attend public meetings to learn more, ask questions, and provide comments. Two public meetings will be held on:

- Tuesday, Jan. 14, 2020 in Paradox, Colorado
- Wednesday, Jan. 15, 2020 in Montrose

The draft Environmental Impact Statement is available online at www.usbr.gov/uc/progact/paradox/index.

Reclamation will consider all comments received by February 4, 2020.

For info: Lesley McWhirter, Reclamation, 970/ 248-0608 or lmcwhirter@usbr.gov

DEMAND MANAGEMENT WY

FEASIBILITY INVESTIGATION

In November, the Wyoming State Engineer's Office, with the assistance of the University of Wyoming Extension, kicked off a public stakeholder process in the Green and Little Snake River Basins to investigate the feasibility of an Upper Basin Demand Management (DM) Program in Wyoming. The DM Program is one element of the Drought Contingency Plans (DCP) that were approved this past spring by the seven Colorado River Basin States and the US Department of Interior (Interior).

The Colorado River Basin has been experiencing persistently dry hydrology since the turn of the 21st Century. Given these conditions, the Upper Division States of Colorado, New Mexico, Utah and Wyoming have coordinated with Interior and stakeholders throughout the Basin to evaluate proactive options for protecting critical elevations at Lake Powell. Lake Powell is the Upper Basin's primary storage facility to help assure continued compliance with the Colorado River and Upper Colorado River Basin Compacts, and the reservoir assists the continued use and development of Colorado River water by the Upper Division States.

The purpose of an Upper Basin DM program would be to support the voluntary, compensated, and temporary reduction of consumptive uses in the Upper Basin or augment supplies with imported water, if needed in times of drought, to help assure continued compliance with the 1922 Compact and without impairing existing water rights. Like mandatory curtailment, any DM program would be a state-based effort implemented under state law.

No DM program can be created and implemented unless and until the four Upper Division States and the Upper Colorado River Commission determine it to be feasible and consistent with the terms of the DCP.

For info: Steve Wolff, Wyoming State Engineer's Office, 307/ 777-1942 or steve.wolff@wyo.gov; website: www.uwyo.edu/uwe/wy-dm-ucrb/.

CALENDAR

December 16 WA
Fifth Annual Tribal Natural Resource Damage Assessments Seminar, Seattle. Crowne Plaza Hotel - Seattle Downtown. For info: Law Seminars International, 206/ 567-4490 or www.lawseminars.com/

December 17 DC
Navigating NEPA 50 Years Later: The Past, Present, and Future Event, Washington. Dentons US LLP, 1900 K Street, NW. Registration/Payment Required by 12/12/19; Presented by Environmental Law Institute. For info: www.eli.org/events/navigating-nepa-50-years-later-past-present-and-future

December 18 CA
Friant-Kern Canal Middle Reach Capacity Correction Project - Public Scoping Meeting, Porterville. US Forest Service Office, 1839 S. Newcomb Street, 5:30 pm - 7:30 pm. Bureau of Reclamation Meeting. For info: Adam Nickels, 916/ 978-4415, anickels@usbr.gov or https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=41341

January 10 WA
SEPA - NEPA Conference, Seattle. 1111 3rd Avenue Bldg. For info: Law Seminars International, 206/ 567-4490 or www.lawseminars.com/

January 14 WY
Colorado River Demand Management - Water Forum, Cheyenne. Water Development Office, 6920 Yellowtail Road, 10 am - Noon. Presented by Wyoming State Engineer's Office. For info: Jeff Cowley, WSEO, 307/ 777-7641, jeff.cowley@wyo.gov or https://sites.google.com/a/wyo.gov/seo/interstate-streams/water-forum

January 22-23 TX
11th TCEQ State of the Bay Symposium (Galveston Bay), Galveston. Moody Gardens Convention Center. Presented byTexas Commission on Environmental Quality. For info: www.tceq.texas.gov/p2/events/state-of-the-bay-symposium

January 23 TX
6th Annual TAWC Water College, Lubbock. Lubbock Memorial Civic Center. Presented by Texas Alliance for Water Conservation. For info: www.depts.ttu.edu/tawc/

January 23-24 WA
Electric Power in the West Conference, Seattle. John Davis Conference Center, 920 Fifth Avenue, Ste. 3300. For info: Law Seminars International, 206/ 567-4490 or www.lawseminars.com/

January 23-24 WA
Endangered Species Act Seminar, Seattle. Washington Athletic Club, 1325 6th Avenue. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

January 23-24 CO
Project Management for Water and Wastewater Utilities, Greenwood Village. Plaza One Tower Conference Center. For info: www.euci.com/event

January 26-29 IL
80th Midwest Fish & Wildlife Conference - "Bringing Science Back to the Forefront of Resource Management", Springfield. BOS Center. Presented by American Fisheries Society. For info: www.midwestfw.org/

January 29 OR
Sediment Remediation Conference: Design & Cleanup Technologies - What's Effective?, Portland. World Trade Center, 121 SW Salmon Street. For info: Environmental Law Education Center: www.elecenter.com

February 10-11 GA
International Symposium on Potable Reuse - Latest Innovations in Treatment & Technology, Atlanta. W Atlanta Downtown. Presented by American Water Works Assoc. For info: www.awwa.org/Events-Education/Events-Calendar

February 11 WY
Crow Creek Restoration - Water Forum, Cheyenne. Water Development Office, 6920 Yellowtail Road, 10 am - Noon. Presented by Wyoming State Engineer's Office. For info: Jeff Cowley, WSEO, 307/ 777-7641, jeff.cowley@wyo.gov or https://sites.google.com/a/wyo.gov/seo/interstate-streams/water-forum

February 16-21 CA
Ocean Sciences Meeting 2020, San Diego. San Diego Convention Center. Presented by American Geophysical Union, Assoc. for the Sciences of Limnology and Oceanography and The Oceanography Society. For info: www2.agu.org/ocean-sciences-meeting

February 20-21 NV
Family Farm Alliance 2020 Annual Meeting & Conference, Reno. Eldorado Resort & Casino. For info: www.familyfarmalliance.org

February 25-28 CA
WEF/AWWA Water Utility Management Conference - Latest Approaches, Practices, Processes, Garden Grove. Hyatt Regency. Presented by World Environment Federation / American Water Works Assoc. For info: www.awwa.org/Events-Education/Events-Calendar

February 26 CA
Water & Environmental Law Program Speaker Series: Mark Arax, Water Journalist & Author, Sacramento. McGeorge School of Law. Presented by Water & Environmental Program. For info: Jennifer Harder at jharder@pacific.edu

February 27-28 TX
Texas Wetlands Conference, Houston. JW Marriott by the Galleria. For info: CLE Int'l, 800/ 873-7130, live@cle.com or www.cle.com

February 27-28 CA
Environmental & Land Use Issues in Cannabis & Industrial Hemp Conference, Oakland. Oakland Marriott City Center. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

March 2-3 CO
Special Institute for Young Natural Resources Lawyers & Landmen, Denver. The Oxford Hotel. Presented by Rocky Mountain Mineral Law Foundation. For info: www.rmmlf.org/conferences

March 2-3 TX
North American Shale Water Management 2020: Reducing the Cost of Water Recycling & Use (Exhibition & Conference), Houston. Aloft Houston Katy. For info: www.shale-water-management.com/?join=VR

March 3-4 MT
Montana Water Summit: At the Confluence of Land & Water, Helena. Presented by the Montana Department of Natural Resources & Conservation. For info: http://dnrc.mt.gov/divisions/water

March 5 OR
Immerse 2020 - A Benefit for The Freshwater Trust, Portland. Redd on Salmon Street, 831 SE Salmon Street; 5:30 - 9 pm. For info: www.thefreshwatertrust.org

March 5-6 MT
Real Estate & Land Use Law Seminar, Missoula. DoubleTree by Hilton Missoula Edgewater. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

The Water Report
Water Rights, Water Quality & Water Solutions in the West
260 N. Polk Street • Eugene, OR 97402

CALENDAR

(continued from previous page)

March 10 WY

Update on GIS Data Model Implementation Study & Water Supply Index - Water Forum, Cheyenne. Water Development Office, 6920 Yellowtail Road, 10 am - Noon. Presented by Wyoming State Engineer's Office. For info: Jeff Cowley, WSEO, 307/ 777-7641, jeff.cowley@wyo.gov or https://sites.google.com/a/wyo.gov/seo/interstate-streams/water-forum

March 11 OR

2020 Superfund Conference: Getting to Cleanup, Portland. TBA. For info: Environmental Law Education Center: www.elecenter.com

March 12-13 AZ

Law of the Colorado River Conference, Scottsdale. Hilton Hotel. For info: CLE Int'l, 800/ 873-7130, live@cle.com or www.cle.com

March 19-20 OR

Shoreline Regulation, Permitting & Development Seminar, Seaside. Seaside Civic & Convention Center. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

March 24-26 CA

Water Innovation Week 2020: The Next Decade, San Francisco. Presented by Imagine H2O. For info: www.imagineh2o.org/wiw2020

March 27-29 TX

Cattle Raisers Convention & Expo, Fort Worth. Fort Worth Convention Center. Presented by the Texas & Southwestern Cattle Raisers Assoc. For info: http://cattleraisersconvention.com/

March 30-April 3 VA

WSWC/ICWP/NWSA Washington, DC Roundtable * WSWC Spring (192nd) Meeting * WSWC/WestFAST Forum, Arlington. DoubleTree Hotel Crystal City. Presented by the Westernn States Water Council, Interstate Council on Water Policy & the National Water Supply Alliance. For info: www.westernstateswater.org/upcoming-meetings/ or www.icwp.org

March 31-April 3 TX

Texas Water 2020: Exhibition & Conference, Fort Worth. Fort Worth Convention Center. For info: www.txwater.org

April 14 WY

"2020 Water Supply Outlook" (USBR) & National Weather Service Update on Spring Runoff - Water Forum, Cheyenne. Water Development Office, 6920 Yellowtail Road, 9 am - Noon. Presented by Wyoming State Engineer's Office. For info: Jeff Cowley, WSEO, 307/ 777-7641, jeff.cowley@wyo.gov or https://sites.google.com/a/wyo.gov/seo/interstate-streams/water-forum

April 16 CA

CLEE Environmental Awards Banquet, Berkeley. University of California. Presented by the Center for Law, Energy + the Environment. For info: www.law.berkeley.edu/research/clee/