

# COMPREHENSIVE WATERSHED MANAGEMENT FOR THE VALLEY OF THE SUN AND THE CENTRAL ARIZONA BASINS

## Watershed Monitoring Report, July 2005.

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### Wildfire Effects on Reservoirs

We initiated this project just prior to the Rodeo-Chedeski Fire during the summer of 2002. At that time, we attended a meeting at ADEQ with several state and federal agencies discussing potential impacts of this fire on the Salt River chain of reservoirs. Besides the initial impact, we were the ones to mention the long-term impacts to the reservoirs. Almost all of these long-term impacts have proven true and the reservoirs still chronically suffer because of them. We can examine, and quantify, these impacts because we have consistently and comprehensively sampled from this watershed before, during, and after the fire. One of the lessons learned from this event was that the short-term impacts to water quality were relatively minor compared to the long-term chronic effects. We continue to monitor the effects of the Rodeo-Chedeski Fire on the Salt River reservoirs in collaboration with ADEQ and AzG&F.

This season, the Cave Creek Complex (CCC) fire has burned over 240,000 acres in the Verde River watershed to the north and east of Bartlett and Horseshoe reservoirs. Will the effects of this fire have similar results on these reservoirs as they had on the Salt River? As of today, no one knows but it's important to remember that there are major differences between the Rodeo-Chedeski and Cave Creek Complex fires and that all wildfires are different.

The largest difference between the Rodeo-Chedeski and CCC fires is the type and amount of fuel consumed. The Rodeo-Chedeski fire consumed vast amounts of relatively large diameter Ponderosa pine whereas the majority of the CCC fire consumed oak, chaparral, brush and grasses. Especially damning during the Rodeo-Chedeski fire was the huge amount of fuel that had built up on the forest floor over the past 100 years or so due to various reasons. This resulted in not only crown fires, but also an intense ground fire which removed vegetation and organic matter down to bare mineral earth. The heat and intensity of the Rodeo-Chedeski fire destroyed roots, tubers, and rhizomes beneath the soil surface. This may be one reason why post-fire re-vegetative efforts, while necessary, have not been as successful as hoped. In contrast, the CCC fires ground fuels were nowhere near as heavy as Rodeo-Chedeski. The lower portions of the CCC fire occurred in areas that, historically, have never seen wildfire (more on this later), however, chaparral and wildfire have co-evolved to the point where the former requires the latter in order to spawn re-generation. Loading of ash and material to the Verde River, tributaries, and downstream reservoirs, while still able to overwhelm the system for brief periods, may not be as heavy as what occurred in the Salt River following the Rodeo-Chedeski fire because of the different types and amount of fuels consumed in each fire. While pine forests may take hundreds of years to recover from major wildfires, chaparral and oak typically take considerably less time (decades). The upper Sonoran desert ecosystems that have burned in the CCC fire (approximately 10% of the burn area) have virtually no resistance to wildfire

and may never fully recover to post-fire status.



*The CCC fire rolling over desert hills. This is in stark contrast to the type and amount of vegetation ("fuel") burned during the Rodeo-Chedeski fire. (AP Photo/Matt York)*

There are no man-made structures that could feasibly contain material from the CCC fire in the watershed. This option was discussed by state and federal agencies involved in the Rodeo-Chedeski fire and were determined to be largely infeasible. Runoff following wildfires often takes on the form of debris flows and trying to contain these in the watersheds, besides being ineffectual, merely delays the inevitable. Debris flows would easily take out any structures made to contain them in the watershed. It would be a good idea, however, to use as much water from the Verde River reservoirs as possible prior to any large-scale runoff event(s) to allow for increased storage capacity switching over to the Salt River side only after these events take place. This would contain the majority of the runoff in Bartlett and Horseshoe. Bartlett typically has soluble Fe and Mn in its hypolimnion every summer; all of the reservoirs do and we can quantify this because we've sampled for both dissolved and total metals quarterly for over 3 years. While we were the only ones to predict and quantify hypolimnetic increases in metals and nutrients in the Salt River reservoirs following the Rodeo-Chedeski fire, the so-called "slug" of metals or other pollutants did not manifest itself as much as predicted in reservoirs downstream of Roosevelt. Hypolimnetic anoxia and reduced forms of metals may, or may not be, exacerbated in

Bartlett due to loading of organic material from the watershed. What we have learned from our extensive monitoring of the Salt River reservoirs following the Rodeo-Chedeski fire is that subtle, chronic stressors have a far greater effect on water quality than any immediate post-fire impact. At any rate, panic may be the biggest concern following major events such as wildfire and inevitably do more harm than good.

Just like following the Rodeo-Chedeski fire, we have partnered with ADEQ to closely monitor and sample from the Verde River, Bartlett, and Horseshoe reservoirs, following the CCC fire. An "event-type" of monitoring strategy is already in place in addition to ongoing ambient monitoring. Our collaboration and inter-service agency agreement with ADEQ has and continues to be, close, allowing the best possible understanding of all stressors as they affect watersheds surrounding the Valley and throughout the state.

## **Wildfire and Invasive, Non-Native Plant Species**

While the abundant precipitation this winter has provided some protection of pine forests from wildfire, lower to mid elevations have been hit especially hard this summer. Some vegetative types, such as upper and lower Sonoran Desert ecosystems, have never co-evolved with wildfire and have little or no protection against them. The following article from the Arizona Daily Star/Tom Beal does an excellent job of explaining why we are seeing so many fires at lower elevations this year compared to previous years.

*"The Sonoran Desert is burning. It's not supposed to happen, and it could signal the transformation of our saguaro-dominated landscape into something that more closely resembles an African savannah as native plants that have developed no defense to fire die off.*

*You can blame an invasion of nonnative plants for many of this year's low-elevation blazes.*

*The 55,000-acre Goldwater Fire between Ajo and Gila Bend burned through a landscape that hadn't known fire in 10,000 years, said plant researcher Julio Betancourt. He blames waist-high fields of a Mediterranean weed known as Sahara mustard that moved in to dwarf the creosote bushes.*

*The Cave Creek Fire is burning now through higher elevation grasslands where fire is common. But the two fires that combined to give it a roaring start began lower, in the northernmost range of the Sonoran Desert, where the desert plants were linked to each other by fields of another Mediterranean invader called red brome.*

*The Sonoran Desert never saw fire below 3,000 feet until the 1970s, when the invading weeds began filling in between native plants that had kept their distance for centuries and competed for sparse rainfall, said Mark Dimmitt, director of natural history at the Arizona Sonora Desert Museum.*

*Over centuries, desert plants learned to weather heat and drought, but fire was not frequent or wide-ranging enough to force adaptation. Unlike plants that evolved with fire, they did not develop thick bark or cork layers to protect delicate tissue, and are easily killed.*

*The foothills palo verde, whose chlorophyll-filled bark is thinner than a succulent leaf, is particularly vulnerable. If fire girdles its thin bark, it's a goner. Its mortality rate in a good burn is 100 percent.*

*The saguaro, whose conductive tissue lies just beneath its waxy cuticle and whose dried needles easily flame up to scorch its tender green flesh, is also quite vulnerable, Dimmitt said.*

*Scientists have kept an inventory of native and nonnative species since the Desert Laboratory's establishment in 1903. The first count, in 1906, listed three nonnatives. In 2005, the number was 44.*

*The trick is identifying the ones that have the most potential for harm, said Betancourt, a senior scientist with the U.S. Geological Survey who works at the Desert Laboratory on Tumamoc Hill in Tucson.*

*In the Tucson area, the threat comes from buffelgrass, a North African species brought to the region as forage and now a principal fuel in roadside brush fires.*

*About 30 percent of Tumamoc Hill's 860 acres are thick with buffelgrass, said Travis Bean, senior research specialist at the Desert Laboratory. Nearby Sentinel Peak is infested to an equal or greater extent, he said.*

*And it is climbing the slopes of the Tucson Mountains and the Santa Catalinas.*

*Buffelgrass has 10 times the mass needed to carry fire in the desert, Bean said. He documented it as the fuel in five major brush fires in the Tucson area since May 5, including a May 30 fire that burned along two miles of Interstate 10 near the Houghton Road exit, he said.*

*Dimmitt bristles when fires are identified simply as burning through brush or grass because it leads people to believe they are a natural occurrence after a wet winter produces abundant wildflowers and other native vegetation.*

*Native plants, even when a wet year brings them out in profusion, lack the mass of the invaders and rarely burn, he said. "They disintegrate when they dry out."*

*Red brome, inadvertently introduced to the United States as a seed contaminant, was the most prolific of several invasive species that caused the Cave Creek Fire's rapid development, said Norm Ambos, forest soil scientist for the Tonto National Forest. It was also the main fuel in two other fires that*

*burned near Roosevelt Lake this year. It has been carrying fires in the Tonto since the early '90s, he said.*

*Only 10 percent of the Cave Creek fire burned through the Sonoran Desert zone of giant saguaros and palo verdes, but much of that landscape may not recover, he said.*

*"I've seen areas where it's going to end up killing 90 percent of the saguaros," Ambos said.*

*The fire also burned through areas that had fire in them just last year, Ambos said. The red brome had come back thick enough to burn again.*

*Successive fires are the scary part of the scenario, said the Desert Museum's Dimmitt. Fire kills mature native plants and successive ones keep juveniles from returning. The non-natives quickly fill in. "These fires in the desert really convert it to a monocultural wasteland," Dimmitt said.*

*Betancourt, who joined with other scientists recently to have buffelgrass listed by the state as a "noxious weed," said it's not too late to do something about the invasion. Programs at the Desert Laboratory and in nearby Saguaro National Park are studying effective eradication methods.*

*But Betancourt says the battle against buffelgrass and other nonnatives needs a full-fledged push - a "state Department of Invasive Species Control."*

*People need to be made aware of the threat posed by non-native species and scientists need to identify the biggest threats sooner, said John Hall, Sonoran Desert program director for the Nature Conservancy, which has its own programs for invasive-species control.*

*This year could be an educational one as fires burn where they're not supposed to burn, he said. It's important to not dismiss them as an*

*obvious consequence of a wet winter.*

*"The solution is not blaming the rain," Hall said.*

*Needless to say, the type and amount of vegetation in all watersheds, including those surrounding the Valley, have direct and indirect impacts on water quality delivered to the reservoirs and, ultimately, to treatment plants in the Valley. Vegetation type also determines post-fire impacts to receiving water bodies. Invasive plant species have the potential to increase fire frequency as well as add fuel to areas where, typically, wildfires have never occurred. I whole-heartedly agree, it's time for a state Department of Invasive Species Control to deal with issues such as invasive plants, both terrestrial and aquatic including potentially toxic species of algae.*



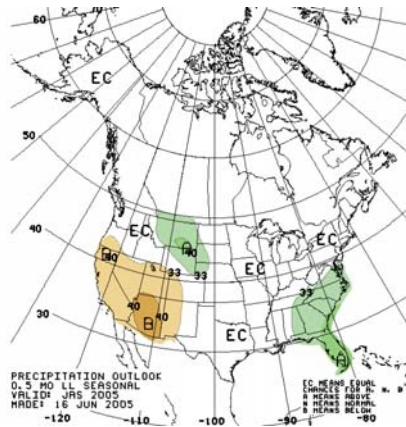
*Tonto NF Fire Prevention Officer Courtney Baughman inspects a saguaro partially burned in the CCC fire. Saguaros, like most Sonoran desert plants, have no adaptation(s) to protect themselves from wildfire. (AP Photo/National Interagency Fire Center, Tom Story)*

## Drought and Short-Term Climate Forecasts

While reservoirs surrounding the Valley and elsewhere in the southwest show marked improvement in water storage than at this time last year and yes, the relatively wet winter is responsible for this, does this mean we are no longer in a long-term drought? Absolutely not and becoming complacent or apathetic about long-term drought, while common following a wet season, should be avoided. The relatively heavy precipitation experienced this winter and spring are more than likely due to a relatively weak El Niño event. This event, however, is possibly embedded within a Pacific decadal oscillation which has longer term impacts and may be one of the leading factors why we experience drought in the southwest. In other words, the precipitation experienced this winter and spring is possibly a wet “blip” in a long-term drought. In terms of planning for drought, we need to start thinking in longer term time scales than season-to-season.

The “good news, bad news” regarding short-term forecasts is that the region is predicted to be drier-than-average through September while temperatures are predicted to be above average through December. Predicting that it’s going to be hot and dry is certainly nothing new for us in the desert but it’s possible that monsoon precipitation may be largely absent or delayed this year. This is, potentially, “good news” regarding post-fire runoff from the CCC and Three and Four complex fires as monsoon precipitation is far more erosive than winter rains. While the exact cause of reduced or at least delayed, monsoon activity is not clear, studies have shown that above average snowpack in the Southern Rockies combined with spring rains in Arizona, which is exactly what

happened this year, can have a negative impact on monsoon precipitation ([www.ispe.arizona.edu/climas](http://www.ispe.arizona.edu/climas)).



Precipitation forecast for July-September 2005 from NOAA-CPC indicate a weak monsoon. ([www.cpc.ncep.noaa.gov/products/predictions/long\\_range/lead01/off01\\_prctp.gif](http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead01/off01_prctp.gif))

While the predicted weak monsoon may be good news regarding post-fire runoff, it’s bad news regarding the probability of more wildfires throughout the summer. This becomes especially problematic if we have an increased chance of “dry lightning” sparked fires followed by little or no moisture.

To summarize this section, Arizona is predicted to have higher-than-normal temperatures and less-than-average precipitation through September. This may mean less post-fire runoff delivered to rivers and reservoirs, but an increased likelihood of a prolonged wildfire season.

## Algal Toxins and *Prymnesium parvum* in Salt River Reservoirs

Since 2001, we have been collecting information on algal toxins in all rivers and reservoirs surrounding the Valley. This includes analyzing for toxins themselves (anatoxin-a, microcystin, saxitoxin, and cylindrospermopsin) and also identifying and quantifying phytoplankton on a quarterly basis for over 3 years. This represents a

substantial undertaking and is the most comprehensive and complete database specifically as it applies to algal toxins in watersheds surrounding the Valley. We were the first in the state to identify several invasive, and potentially toxic, species following the Rodeo-Chedeski fire and this includes the cyanobacterium *Cylindrospermopsis raciborskii*. Our finding of *C. raciborskii* in Roosevelt in 2001 (prior to the Rodeo-Chedeski fire) was the first reported observation of the species in the state. Since that time, we have collaborated and worked with several state and federal agencies on algal toxin issues including ADEQ, AzG&F, and USDA.

It is extremely important to remember that species capable of producing toxins can readily be found in most water samples. The fact is, the vast majority of the time, they do not produce toxin(s). For example, species of *Microcystis* are ubiquitous found in waters world-wide and, most of the time, produce little or no toxin. *The only way to determine toxicity in a water body is to analyze for toxin(s) themselves.* Merely the presence or absence of an algal species tells us little to nothing about what the root cause of toxicity to humans or wildlife actually is. This is especially true in the case of *C. raciborskii* which has been implicated in toxicity to wildlife in various parts of the world including the U.S. After careful analyses of *C. raciborskii* grown in unialgal culture, the strain found in the Salt River reservoirs produces little, and in most cases, no cylindrospermopsin (a toxin produced by *C. raciborskii*) or other toxin. This is in complete agreement with what we found in Saguaro following last years large fish kill on June 11<sup>th</sup> in that numbers of *C. raciborskii* greatly increased *after* the toxic events stopped. This alone should indicate that *C. raciborskii* not be considered a suspect species or implicated in any toxicity to fish but we also have the added knowledge of *having all measures of cylindrospermopsin taken from Saguaro before, during, and after the fish kill as being below detectable limits.* At this point, based on all of our previous findings, we can probably rule out *C. raciborskii* as a potential culprit of

toxin production in the Salt River reservoirs.

Algal toxin production is not only species, but also strain-specific. Knowing about the life history, environmental requirements for growth, or genetic make-up of a non-toxic species, tells us little or nothing about species which may be producing toxin(s). All cyanobacteria, or prymnesiophytes, are not created equal and future research should focus on those species proven to produce toxin(s) either through direct analyses or bio-assays.

This spring, Kevin Bright from AzG&F made the initial identification of *Prymnesium parvum* from the Salt River reservoirs. This is the first confirmed finding of *P. parvum* in the state and Kevin is to be congratulated for identifying an extremely small, difficult to identify, alga. *P. parvum* produces an ichthyotoxin that is known to be highly toxic to gilled organisms (e.g., fish, mollusks, etc.) but poses no known risk to human health. Since this finding, we have worked very closely with AzG&F in doing subsequent identification and enumeration. While it is likely that threadfin shad found dead or dying in Saguaro earlier this year succumbed to *P. parvum* other toxins could have played a role later in the summer. For example, relatively large, multiple species, fish kills in early June may be more indicative of cyano-toxins but fish may have already been stressed from *P. parvum*. Synergism of different toxins or stressors in general, is poorly understood. Water movement between reservoirs, especially Canyon and Saguaro, may play a role but this is yet to be quantified or substantiated. It's amazing how similar the pattern of toxicity this year was to last year.

As previously mentioned, *P. parvum* poses no risk to human health; however, its potential impact on a precious state resource should not be under

estimated and this is true for threatened and endangered as well as sport species of fish. Since the finding of *P. parvum* in the Salt River reservoirs, it has been found and implicated in other fish kills, in the San Pedro River and several urban lakes in the Phoenix Metropolitan area (Rick Amalfi of Aquatic Consulting and Testing and Eric Swanson from AzG&F are diligently working on the urban lakes aspect). Even though washing and disinfecting of fishing gear, boats, sampling gear etc. is *always* recommended, algal species like *P. parvum* can also be spread by non-human means such as on the legs of waterfowl or simply, on the wind. *P. parvum* is a major threat to aquatic species in Texas and has been implicated in several huge fish kills there.



*Prymnesium parvum*



Two *P. parvum* cells preying on and ingesting one dinoflagellate cell (*Heterocapsa rotunda*, the green in the center of the picture).  
<http://www.alf.homepage.dk/Framesets/FramesetPhotos/Photoshome.html>.

On June 30<sup>th</sup> 2005, we attended a meeting with AzG&F and ADEQ to discuss our current state of knowledge regarding algal toxins in general, which direction future

research might take, and potential remediation of affected water bodies. We have also collaborated with colleagues at Texas Parks and Wildlife Department, USGS, and Univ. of Texas who have been dealing with this issue for awhile.

Some environmental factors known to either cause growth or toxicity of *P. parvum* are:

Water bodies with levels of specific conductance higher than 1000  $\mu\text{s}/\text{cm}^2$  are preferred.

*P. parvum* always shows some degree of heterotrophy regardless of nutrient levels in the water.

*P. parvum* proliferates under high nutrient levels; however, it is generally believed to produce more toxin under low nutrient levels.

At one time, *P. parvum* was believed to prefer cooler water, it has been shown to survive and produce toxins at water temperatures in excess of 27° C.

Thinking about how some of the above findings fit into plausible scenarios within the Salt River reservoirs:

Roosevelt, while having higher nutrient levels than downstream reservoirs also contains *P. parvum*, however, there have been no fish kills, and perhaps no toxin production, in Roosevelt possibly due to these elevated nutrient levels.

Water released from the hypolimnion of reservoirs early in the spring and summer is, generally depleted of nutrients.

Earlier this year, threadfin shad were noticed dead or dying throughout Saguaro. The large kill that occurred in early June, however, was in the riverine area which is heavily influenced by releases from Canyon where pump-back storage occurs. Pump-back storage in Canyon results in de-stratification in the lacustrine area by the dam. This de-stratification causes an overall suppression of dissolved oxygen throughout the water column

but, compared to other reservoirs during similar times of the year, an overall increase in dissolved oxygen at depth within Canyon. Increased dissolved oxygen at depth in Canyon means little in the way of bio-available nutrients making their way from Canyon into Saguaro and this released is, in a sense, "nutrient-depleted". Could this relative nutrient depletion of water released from Canyon actually increase toxicity of *P. parvum* in the riverine portion of Saguaro? Additionally, fish kills in Apache have occurred primarily below Roosevelt Dam and earlier in the spring before anoxia and hypolimnetic nutrient release from Roosevelt occurs. Just as in Saguaro, fish kills in Apache subside later in the summer possibly due to hypolimnetic nutrient release from Roosevelt. This is just one of several possibilities and while this scenario makes some sense in the Salt River reservoirs, it makes less sense when applied to urban lakes. Also, it does nothing to address the possible synergistic effects of toxins.

We will be receiving funding from ADEQ, with substantial in-kind support from AZG&F, to maintain and grow uni-algal cultures of all suspect species of algae from the Salt River reservoirs. This information will hopefully enable us to determine what species actually produce toxins and where research efforts should focus. After these cultures have been grown in the lab, we will perform bio-assays to determine toxicity. Those cultures proven to be toxic through bio-assays will be analyzed for suites of algal toxins including bio-active peptides which have been proven to increase toxicity of algal toxins primarily microcystin. Once the species that actually produce toxin(s) have been identified, we will try and determine conserved genes within these species that code for toxin production. With this information, DNA probes can be developed that will tell us when toxicity may be occurring, not merely the presence or absence of

an individual species. We will also determine the synergistic effect of other potentially toxic species of algae and their possible role in causing fish kills and/or any human health implications in these reservoirs.

## Upcoming Watershed Meeting at ADEQ

We will be having another watershed meeting at ADEQ sometime in late August. We will be discussing current knowledge and data examining all watersheds surrounding the Valley as well as discussing future direction of this project. This project has always been geared toward agencies and cities providing as much feedback as possible so everyone's input is welcomed. We will be sending out invitations later this month with exact dates, times, and agenda items.

## Lake Pleasant Operations and Water Quality in the CAP Canal

We continue to consult with the Central Arizona Project to refine release strategies from Lake Pleasant to maximize water quality throughout the release season in the CAP canal. The current strategy is the result of years of data collection, analyses, and limnological expertise specifically as it applies to conditions in Lake Pleasant and the resulting effect on parameters such as mib and geosmin production in the CAP canal. The Central Arizona Project is to be commended for implementing this strategy and has always been pro-active when it comes to delivering the best water possible to municipalities downstream of Lake Pleasant.

We have been working with the Central Arizona Project since 1996 on taste and odor issues in Lake Pleasant and the CAP canal. It's easy to forget that Lake Pleasant and the canal did not always enjoy the relatively low levels of taste and odors currently found. The reason relatively low levels of mib and

geosmin are produced in the CAP canal are the direct result of release strategies in place since 1997. The proposed new strategy of stopping releases from Lake Pleasant in September can only further improve water quality, especially any taste and odor issues. Dissolved oxygen levels as of June 15, 2005 at the release towers did not show any levels below 4.0 mg/L. These are considered very favorable conditions especially when compared with previous years.

## Other News and Projects

We have recently completed a project for ADEQ examining effluent dependent waters in the state. This project is titled "An Exploration of Nutrient and Community Variables in Effluent Dependent Streams in Arizona" and the final report can be viewed online at <http://ag.arizona.edu/limnology/EDW.pdf>

Other projects we are currently working on include the following:

*Endocrine Disruption in Bonytail Chub (Gila elegans) Exposed to Secondarily Treated Effluent*

*Investigation of the Backwaters of the Lower Colorado River as Potential Habitat for Native Fish Species – Phase I.*

*Aquatic Macroinvertebrates as Indicator Species to Quantify Permanence of Water and Instream Flow Rights in Middle Rincon Creek, AZ.*

If anyone has any questions about these projects, or anything in this newsletter, please feel free to contact me at [dwalker@ag.arizona.edu](mailto:dwalker@ag.arizona.edu)