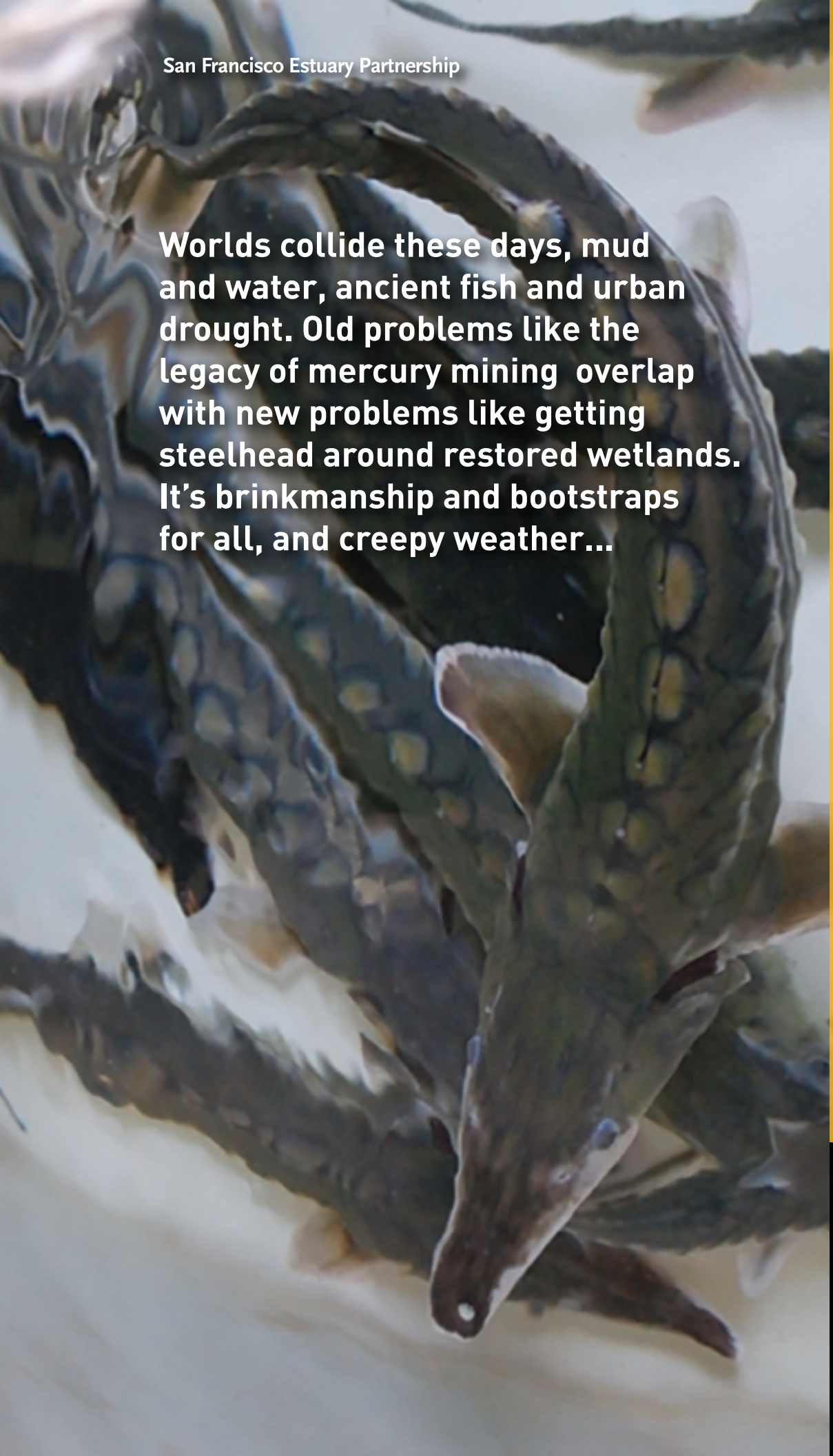

San Francisco Estuary Partnership

Worlds collide these days, mud and water, ancient fish and urban drought. Old problems like the legacy of mercury mining overlap with new problems like getting steelhead around restored wetlands. It's brinkmanship and bootstraps for all, and creepy weather...

ESTUARY NEWS

SCIENCE • RESTORATION • WATERSHED • POLITICS • SPECIES • BAY

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Shifts in Selenium Spike

USGS scientists headed up river this June to see whether two Asian clams had also headed upstream with the drought. When there's less fresh water flowing out to sea, salty ocean water intrudes inland, and changes the distribution of these pesky invertebrates.

Collecting clams on the USGS Polaris.

Potamocorbula like it saltier than *Corbicula*, and usually hang out in the Suisun Bay region. But scientists suspect drought conditions may have changed all that, and with it, how and when the contaminant selenium gets cycled through the estuarine food web via the clams.

"If there's a broader distribution of *Potamocorbula*, then we could potentially see an increased risk of exposure in predators because these clams are smaller and easier to eat, and accumulate more selenium, than *Corbicula*," says the U.S. Geological Survey's Robin Stewart.

When diving ducks, sturgeon, and splittail eat the clams, the selenium can cause reproductive problems and deformities. Stewart hasn't found any deformed splittail this year, but in prior drought years they've turned up at the pumps — although no one knows if the cause was selenium exposure or something else. Based on 17 years of monitoring — the results of which Stewart and her colleagues published last October in the *Marine Ecology Progress Series* — she sees a correlation between low flows and higher selenium in clams. What's interesting though is when over the course of the year you see these spikes.

"It's not just the amount of dryness, but the timing of the dry period that is important when it comes to selenium," says Stewart. "Typically there's a mantra that selenium concentrations are higher in the fall than in the spring. But dur-

continued on back page

CONTAMINANTS

Freeing Fish While Locking Up Mercury

The restoration of the South Bay salt ponds to tidal wetland has, from the very beginning, been an exercise in adaptive management: take an action; monitor the results; make any indicated fixes; repeat. There's no better example than Pond A8, where the Guadalupe River enters San Francisco Bay via Alviso Slough. Restoration planners were worried that connecting the former salt evaporation pond with the Bay could introduce long-dormant mercury to the wider ecosystem, and initial studies of levels in waterbird eggs and fish reinforced that concern. A set of adjustable gates between the pond and the river allows seasonal closure of the pond and the ability to control the flow. But that raised a new question: would the river's steelhead run get sidetracked into potentially dangerous waters as they move past the gate and out to the Bay? A high-tech approach to tracking the movement of outbound juvenile steelhead has provided preliminary answers, along with better understanding of a little-studied fish population. Meanwhile, continued monitoring of mercury levels suggests opening A8 may not be worsening contamination.

Tagging steelhead. Photo: James Hobbs

Mercury is one of the Bay's legacy contaminants. As the US Geological Survey's Laura Valoppi, lead scientist for the restoration project, explains, it's been washing down from the New Almaden district in the Santa Clara foothills since mining began in 1845: "The more rainfall, the more mercury it mobilizes." Up to 90 percent of the Guadalupe's mercury load is mining-derived – its watershed once contained one of the largest mercury mines in the Northern Hemisphere. Lester McKee of the San Francisco Estuary Institute's Clean Water Program calls the river "the number one mercury-pollution hot spot in the Bay Area." He's measured higher concentrations of mercury particles in water and sediment, and higher total concentrations in water, in the Guadalupe than any other Bay tributary.

Moveable gates in the A8 "Notch." Photo: James Hobbs.

When it reaches the sediments of the former marshland that is now Pond A8, mercury can undergo a sinister alchemy called methylation. "Especially in the spring, water temperatures get warm and create good conditions for methylation," says restoration project manager John Bourgeois. Algae proliferate, then die off, creating a feast for bacteria. The bacteria create methylmercury, a more toxic form of the element that is much more easily absorbed into aquatic food webs, as a byproduct of their metabolism. "If the pond was open to the Bay all year round, flow conditions would cool temperatures down, increase circulation, and minimize the production of algae," Valoppi continues. But that could expose the Bay to a methylmercury backlog. "We want to restore full tidal action, but not put the Estuary at risk by increasing the input of mercury," Bourgeois says.

That's why they built the Notch: a 40-foot concrete structure with eight movable gates to let managers govern the movement of water in and out of A8. The gates are kept closed from December 1 through May 31 every year, out of concern that out-migrating juvenile steelhead might swim into the pond and be unable to navigate back out to the Bay. Managers are also concerned the steelhead might be unable to find refuge from predators in the shallow pond or suffer from adverse water quality.

The seasonal closure also seemed prudent in view of the elevated mercury levels that had been recorded in fish from Guadalupe and Alviso sloughs and in the eggs of fish-eating Forster's terns that nested locally. Concerns that this could be an ongoing problem were allayed by new data: tern eggs analyzed last year showed a 60 percent decrease in mercury levels from 2011. (Monitoring was interrupted in 2012 for lack of funding.) "Also, in 2013 there was

continued on page 4

Risk Factors for Green Sturgeon around Intakes

UC Davis researchers continue to look for ways to protect green sturgeon from getting trapped in water diversion intakes along the Sacramento River (see "Goofy Sturgeon Behavior," June 2012). Fish ecologist Nann Fangue, conservation biologist Dennis Cocherell, graduate student Jamilynn Poletto, and colleagues recently published an update to their findings in PLoS ONE.

The Sacramento is the last refuge of the federally threatened southern population segment. Previous genetic studies suggest there may be as few as 10 to 28 spawning adults in that watershed, although unpublished results of ongoing monitoring programs indicate a more optimistic number. Most lay their eggs in the mainstem Sacramento; a few may still use the Yuba and Feather. After hatching, juveniles hang out for up to 18 months before migrating to the sea:

Photo: Myfanwy Rowlands

ample time to encounter one of the river's estimated 320 unscreened diversions, not to mention those in the Delta.

Putting lab-reared sturgeon through their paces in Davis' experimental flume, the scientists quantified the risk factors. They concluded juveniles were "highly vulnerable" to entrainment in unscreened diversion pipes, which may be a significant source of mortality. "It's the combination of the rate of the water pulled through the diversion and how fast the river's flowing," explains Fangue. Although river flow speeds vary with rainfall, snowmelt, and summer reservoir releases, diversions peak in summer when young sturgeon move south. Since sturgeon stay low in the water column, placing pipes near the river bottom may exacerbate the danger.

Screening thousands of intakes, some not currently documented, would be pricey. "We're trying to develop cost-effective methods to prevent the fish from being entrained," Cocherell says: behavioral deterrents like lights, sounds, or vibrations to warn the sturgeon away from danger points.

Scientists find sturgeon behave differently around intakes than the other species studied, like Chinook salmon. Their sensory wiring is different, with fewer neuromasts, skin cells that detect underwater vibrations. "Chinook rely on neuromasts more to interact with water velocity," Poletto says. Even white sturgeon, a more abundant species, don't respond like green sturgeon. "There may not be a one-size-fits-all solution for sensitive fish," adds Cocherell. **JE**

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Unscreened Diversions & Sturgeon Paper, 1/2014: PLoS ONE, www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0086321

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Netting juvenile steelheard in the upper Guadalupe River watershed. Photo: James Hobbs

no increase in mercury in fish in the sloughs that we could attribute to A8," says Valoppi.

Scientists now wonder if the previous increase was a one-off event due to mercury-loaded sediment stirred up by construction activity. "That's our hope," says Valoppi. "Even though it was shut six months of the year, there were enough flows that the mercury source decreased. Mercury levels in the terns are still really high, and that's a concern." But the pattern suggests this piece of the restoration project is on the right track: "We're trying to create habitat, not make things worse."

Mercury researchers encouraged the project to open the Notch earlier or keep it open year round. But what about the steelhead? "We turned it into an experiment," Bourgeois recalls, underlining the ongoing adaptive management approach of his project. The National Marine Fisheries Service approved a test of alternatives, conditional on a study of steelhead movement. That brought in UC Davis fish biologist Jim Hobbs, who was already monitoring how fish responded to the restoration process. This year, the Notch was opened in March while the steelhead were moving out.

In an urban stream like the Guadalupe, mercury is not the only challenge for steelhead. Fed by creeks in the Santa Cruz Mountains, it flows through downtown San Jose, not far from the Sharks' arena. A historic coho salmon run is long gone. Steelhead persist, but encounter urban challenges: homeless people turn shopping carts into improvised weirs, trapping adults as they move upstream to spawn. The last thing these anadromous trout need is a death trap at the mouth of the Bay.

Hobbs surveyed the river and its tributaries, selecting five monitoring stations on feeder creeks, along the Guadalupe mainstem, and at the Notch. Steelhead smolts were captured upstream, equipped with passive integrated transponder (PIT) tags — "the same technology used in microchipping pets," he explains — and released at the capture site. Of 71 tagged fish, only seven were detected by the monitors. "One of the seven went into A8 and right back out again," he adds. Not a huge data set, but Valoppi and Hobbs hope funding will allow a repeat next year — and an extension of mercury monitoring. "As a bonus, we're getting really good data on a population that's not well studied," Bourgeois says. **JE**

USGS mercury monitoring in the South Bay Salt Pond Restoration project.

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PRESERVATION

UC's Vernal Backyard

In the baking heat of a San Joaquin Valley summer, the rolling grasslands surrounding the University of California, Merced look dusty, brown, and dead. But once the rains of winter arrive, this treeless landscape will burst with life. Subtle depressions in the hard claypan soils will fill with water, forming vernal pools. The pools will draw breeding salamanders and trigger a mass hatching of translucent fairy shrimp, each one racing to mate and lay eggs before these ephemeral wetlands evaporate.

In May, this 6,561-acre expanse was dedicated as the Merced Vernal Pools and Grassland Reserve. Part of the University of California Natural Reserve System, the reserve is the 39th in a network of sites managed for activities such as university-level teaching and long term field research. The 756,500 acres of the NRS includes examples of most major state ecosystems, from deserts to mountains to coastal shorelines.

The reserve is home to a variety of distinctive San Joaquin Valley species. Two types of endangered fairy shrimp and the endangered California tiger salamander are found on reserve lands, as well as two dozen species of rare, protected, or endemic plants. The reserve also includes the hummocky mima mound formations characteristic of vernal pool landscapes, as well as soils 2 to 4 million years of age considered some of North America's oldest.

The reserve was born of controversy over the construction of UC Merced. In 1995, the University decided to locate its tenth campus on the largest vernal pool complex in the state. Environmentalists cried foul because more than 90 percent of California's vernal pools have been destroyed by development.

UC Merced agreed to set aside extensive vernal pool acreage for conservation and sought to make the seasonal wetlands adjacent to campus part of the reserve system. The establishment of the Merced Vernal Pools and Grassland Reserve makes good on the campus's promise and quells the controversy that has long dogged construction of UC Merced.

"Visiting here is not like taking a field trip to the African savanna," says reserve director Christopher Swarth. "It reveals its secrets slowly and subtly. The first one or two times you visit you might find it a little desert-like, harsh, with the sun beating down. But if you walk here many times you may get rewarded by hearing a coyote and seeing its scat or seeing an eagle dive to the ground. Sometimes you encounter flocks of horned larks that stream toward you, hundreds of them, in an unending group. But it usually won't hit you over the head with its ecological drama."

The power of observation and the value of patience have been just a few of the lessons learned by the more than 1,200 UC Merced undergraduates who have visited the "reserve next door" so far. Some have conducted field research into the grassland food web, while others have visited as part of writing or ecology classes.

"Every time I go out I learn something," says Cammy Vega, a UC Merced student and the reserve's first intern. "There's so much more to this terrain than just grass." **KW**

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CLIMATE CHANGE

Surrender Not the Only Option

For conservation practitioners, climate is a massive game-changer. Do terms like "natural," "restoration," and "preservation" still mean anything? Is "adaptation" a code word for fatalistic surrender? *Climate-Smart Conservation: Putting Adaptation Principles into Practice*, a new report from the National Wildlife Federation, addresses these questions in an attempt to provide guidance for climate adaptation in the context of resource management.

Some of the examples and case studies in the 272-page report will be familiar to Bay Area audiences: the South Bay Salt Pond restoration project as a paradigm of adaptive management, Pacific Coast Chinook salmon as a species-level management target. Others, from elsewhere in North America, have clear relevance: coastal shorebird habitat in Delaware Bay, oyster reefs on the Gulf Coast, multi-use water management for Florida's Lake Okeechobee. Chapters cover coping with uncertainty; selecting targets and adaptive strategies; managing for change, not just persistence; and communicating the right balance of urgency and hope to confused, disengaged, and/or hostile publics.

The document and a curriculum developed to accompany it are finding receptive audiences at training sessions—Sacramento in March, Tucson in May, more to come. Federation climate change adaptation director Bruce Stein, who chaired the workgroup that produced the report, says federal, state, local, and tribal resource managers in Tucson were finding a lot to take home. "It's not prescriptive, but offers concepts and principles to inform and improve how an agency carries out decisions and does its planning."

Stein recognizes the challenges: "Rethinking your underlying assumptions and conservation goals can be an uncomfortable thing to grapple with." California Landscape Conservation Collaborative coordinator Debra Schlafmann, also in the workgroup, observed "relief and appreciation" in Sacramento participants who may have been overwhelmed by the complexities of climate change: "After taking the course, folks feel that it's something they can take on and accomplish. There's a sense of realization that they can actually do this." **JE**

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RAW MATERIAL

Hamilton Done but More to Do

Breaching the outboard levee near Marin County's Hamilton community this May is cause for both a whoop of celebration and a sigh of relief. Celebration because it was an ambitious wetland restoration project with a complicated design and multiple partners that wasn't easy to pull off, yet in just a few months it's become a beautiful landscape filled with blue water, green shoots, yellow flowers, quacking ducks, and happy neighbors. Relief because at times the costs and challenges of moving so much mud to the site, in order to the raise the elevation of subsided wetlands, seemed overwhelming to those in charge. But they did it. And now they need to do it again; only this time they hope it won't be such a bear.

"If we don't get creative about how to import sediment more efficiently and finish the expansion into Bel Marin and the antenna field, we could lose the opportunity forever," says State Coastal Conservancy project manager Tom Gandesbery.

Importing mud from an Army Corps deepening project in the Port of Oakland to the Hamilton site cost a pretty penny – about $95 million all told. A recent federal-state review suggests using the same approach to raise the land level for planned restoration of 314 acres remaining on Hamilton's air and antenna fields, and an additional 1,600 acres of adjacent Bel Marin Keys hayfields, would cost $340 million. Unless they try another tact.

For Hamilton, project partners built a five-mile-long pipeline from out in the middle of San Pablo Bay — where the water was deep enough for barges to offload — across vast mudflats to the onshore restoration site. Next, they stationed an "offloader" at the end of the pipeline. The offloader sucked the dredged material out of the barges, mixed it with water to make a slurry, and pumped the resulting soupy mix onshore.

"With the offloader, you have a crew and large, expensive equipment just sitting and waiting for material to come, and you can only serve one barge at a time, all of which can drive up the cost," says Gandesbery.

For the Bel Marin expansion, project partners are now thinking about a simpler approach, both in the design of the restoration site and the method of mud delivery. The new plan is to just raise a part of the Bel Marin site and leave the rest in farmland or managed wetlands. And on the sediment side, planners are exploring everything from stationing a smaller offloader at the mouth of the Petaluma River — that could work more continuously at more reasonable cost — to creating an ATF.

Photo: Marc Holmes

While the acronym may call to mind drug busts and gun running, it actually stands for "aquatic transfer facility." An ATF is a depression dug in the bottom of the Bay, where dredgers can dump, and the sediment stays put, until it can be retrieved later for restoration work. As proposed in a 2008 EIR, this ATF would have a footprint of 58 acres in San Pablo Bay, where the water is 27 feet deep (MLW) and the lack of currents make conditions depositional – in other words, things settle to the bottom and stay there. Once dug, the ATF would be about 18-33 feet deeper than the current bottom.

"The idea is to strategically locate the basin in a hydraulically appropriate area and create a basin deep enough to keep the sediment all together until it can be economically dredged in large volumes all at once," explains the SF Bay Conservation and Development Commission's sediment program manager Brenda Goeden.

"The ATF lets us decouple the restoration projects from the dredging projects. They don't have to work out logistics and contractual issues and navigation issues. It's basically a sediment recycling center," says Gandesbery.

The proposed location is next to the existing approved dredged material disposal site in San Pablo Bay. So dredgers can take material to the new ATF instead of one of the four in-Bay disposal sites, or the far off ocean site. This has the added benefit of reducing net emissions from ocean-going tugs; replacing the big offloader with an ATF cuts $C0_2$ emissions 33 percent for the proposed project.

Penciling out the dollar costs for the Bel Marin and remaining Hamilton restorations, the ATF approach costs 50 percent less than the offloader – about

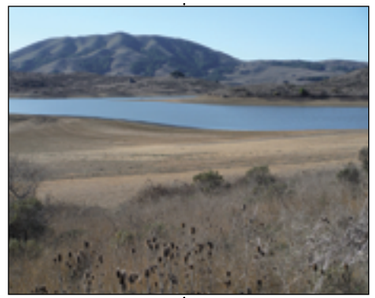
continued to page 16

CONSERVATION

Great Gifts, Great Responsibility

Governor Brown has asked all Californians to reduce their water use by 20 percent in response to some of the most severe drought conditions in recorded history. Not all watersheds are created equal, however, and some communities are feeling the pressure more than others.

In early 2014 the Marin Municipal Water District (MMWD) implemented a water shortage contingency plan that included a voluntary 25 percent reduction in water use. In comparison, the East Bay Municipal Utilities District (EBMUD) called for a 10 percent reduction. Such a marked difference between communities in such close proximity merits a closer look as to why, exactly.



As it turns out, Marin is unique in that the vast majority of its water comes from local reservoirs. Dan Carney, director of Marin's conservation program, says "75-80 percent of all water used in Marin county comes directly from our own watershed, with the remaining water piped in from the Russian River." Marin County's watershed comprises seven reservoirs, but they are small lakes, combining for a maximum storage capacity of 79,566 acre-feet. An acre-foot (ac-ft) is enough to cover an acre in a foot of water, or to supply three households for a year.

For a comparison, the East Bay supply comes from a similar number of reservoirs, but possesses a maximum storage of over 766,000 ac-ft (including both reservoirs in the East Bay and the Mokelumne River watershed in the Sierra Nevada). Pardee reservoir alone can store twice the amount of the entire Marin watershed.

If one compares total water stored per capita, EBMUD and MMWD actually come out fairly equal. However, the matter is further complicated by strict operational regulations imposed in Marin. Many of the Marin headwaters are vital habitat for spawning Coho salmon, and, according to Carney, 16 percent of all water held by Marin reservoirs must be released to maintain stream flows for the fish each year. This leaves the local watershed with an operational yield of only 20,000 ac-ft.

The Marin water picture is one of rich, but limited resources. Beautiful lakes and ecologically diverse headwaters create an idyllic picture, but with that idealism comes more stringent conservation standards. So, MMWD asks its residents to cut back 25 percent.

Fortunately, the community came close, achieving a 20 percent reduction. "We're very pleased that customers responded with such enthusiasm," says Carney, "especially to voluntary measures. The list of [conservation] methods people report to have used is long."

What does a 20 percent reduction in water use look like? According to MMWD, residential water use per person has risen in recent years, up to 88 gallons per day in January 2014. Even without installing water efficient faucets and showerheads, reducing use by 18 gallons can be as simple as taking shorter showers (five minutes can save 12 gallons) or only washing full loads of clothes (anywhere from 15-45 gallons of water per load).

MMWD, and the Marin community at large, take pride in approximating a natural cycle of water use. The rain that fell in March and April offered a temporary reprieve, but reservoirs are still well below average storage and the near future can be expected to be fairly dry. Marin residents have so far proven they can rise to conservation challenges, but will have to continue their creativity and dedication as temperatures rise during the summer months. Anyone for the beach? **MHA**

PUBLIC ACCESS

Wildlife First, People at Bay

Just when crews were doing the final grading at Hamilton this spring, they discovered a couple of snowy plover nests. This tiny endangered bird likes disturbed habitat and beaches for nesting, and this was only one of many instances over the 18-year construction period when the interests of sensitive wildlife trumped human and heavy equipment schedules. "Just one nest too close to our activities could have shut construction down entirely," says the Coastal Conservancy's Tom Gandesbery. "But luckily they were at enough of a distance, all we had to do was monitor."

In designing trails and public access, the Conservancy, the Bay Trail and Army Corps partners took some very specific steps to separate sensitive species from people walking dogs, riding bikes, and making noise. "We tried to foresee human impacts on wildlife and design trail around it. In some places we have roads, in some wire fencing, in one place we located the trail on the back side of the levee to protect wetlands. There is a lot of debate about the effectiveness of such mitigation measures, but not much scientific study of trail use impacts on wildlife. So it's a challenge to even define the problem," says Gandesbery.

Part of the effort involves a monitoring plan to see how preventive measures like fencing, elevation changes, and the like are working out, and how intense the use of the trails actually is. Another measure has been signage and education. As a result, project staff hope the locals enjoying the view and their new trail will respect the wildlife enjoying their new habitats. **ARO**

SEASONS OF BAY LIFE

San Francisco Bay, Pacific Coast

Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

MIGRATING SALMON
Four different runs, or populations, of Chinook salmon spawn in the San Francisco Bay watershed, each named for the season when the majority of adults return from the ocean to freshwater streams to breed.

WINTERING WATERBIRDS
More than 700,000 ducks, swans, geese, and other waterfowl have been counted overwintering in San Francisco Bay and Delta. Most travel here for the season along the Pacific Flyway, a transcontinental avian thoroughfare stretching from Alaska's North Slope to Patagonia.

BROWN PELICANS
These majestic birds can be seen swooping around the Bay one behind another in undulating lines. In late fall, they head south for breeding rookeries in Baja, southern California, and Florida.

TRAVELLING PEEPS
Diminutive Western sandpipers depart breeding grounds in Alaska and make the 1,800-mile flight to San Francisco Bay each fall in pursuit of a snow-free winter. They forage for food along mudflats and salt ponds (males use a bristle-shaped tongue to lap up diatom goo).

LEOPARD SHARKS GIVE BIRTH
Females that have hatched their eggs safely within their own bodies swim into eelgrass beds to give birth to two dozen or so wriggly pups. Births coincide with the most luxuriant growth of eelgrass, making this tidal nursery a safer place for young sharks to hide.

WATERBIRDS NEST ON ALCATRAZ
The Rock — inaccessible to predators and close to seafood-rich waters — is considered a choice residence by ground-nesting Western gulls, three species of cormorants (double-crested, Brandt's, and pelagic), and pigeon guillemots.

HARBOR SEALS PUP
Mothers give birth to spotted, nickel-gray pups at haul out sites along mudflats, rocky intertidal zones, islands, and sandy pocket beaches.

HERRING SPAWN
Pacific herring stream through the Golden Gate by the millions and deposit their tiny orange eggs on every available surface, from eelgrass strands to pier pilings — a seafood smorgasbord for gulls, ducks, and sturgeon who slurp up more than 95 percent of each egg batch laid.

AMERICAN AVOCET CHICKS HATCH
These speckled balls of fluff are able to run within a few hours of hatching, and pick through the mud, snapping at food on comically stilt-like legs behind their elegant, rose-tinged parents.

CALIFORNIA LEAST TERNS BREED IN ROOKERIES
Endangered California least terns settle down to raise their chicks on open shoreline such as the abandoned runways of Alameda Naval Air Station. Parents stuff their young with anchovies and smelt.

CLAPPER RAIL BREEDING SEASON
These endangered birds build nests amid the cordgrass of the low marsh, taking advantage of its spring and summer growth spurt to hide their young from predators. Birds race to avoid the ultra-high king tides during the same period, which can swamp eggs.

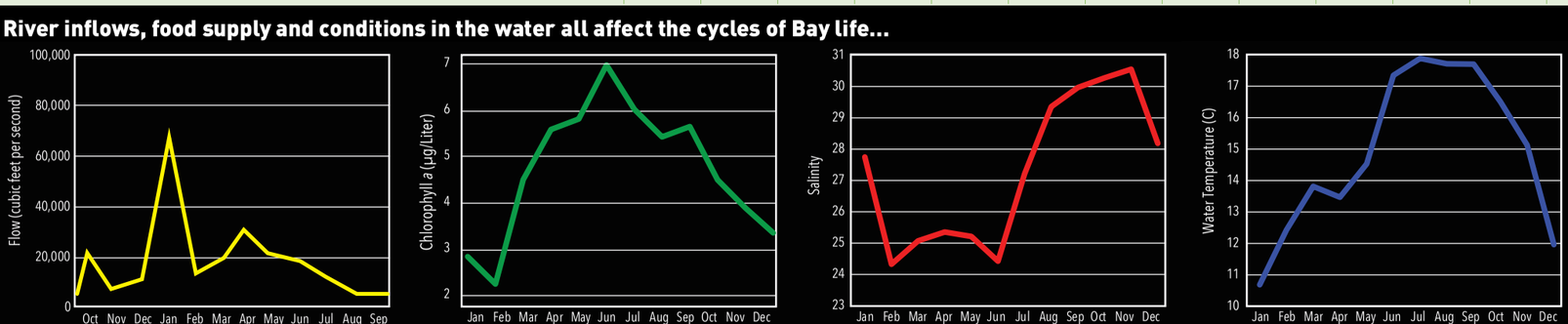
PHYTOPLANKTON BLOOMS
An influx of nutrients from the ocean, combined with clearer surface waters and more sunlight, causes phytoplankton to multiply in blooms that may cover many square miles. The largest blooms once regularly occurred in spring; recent years have seen blooms nearly year round.

SUMMER PETALS IN THE MARSH
Longer days trigger gumplants to unfurl bright yellow flowers along many tidal marshes. The flower heads produce a sticky white resin that often varnishes the entire plant.

EELGRASS FLOWERS
Warming water temperatures are among several cues that trigger eelgrass to produce flowers within sheaths called spathes. The resulting ripe fruits, which resemble grains of wheat, are most available in July and August.

Photos: Verne Nelson, chicks, fishing pelicans, flying peeps, avocet chick; Bob Lewis, pelican head; Peep nest, gull chicks, commercials, tern, rail, crabs; DFW & FWS, salmon; Aquarium of the Bay, herring, sharks; Gary Bares, eagles, plankton; Kathleen Wenig, gum plant; Stephanie Kirakopoulos, herring eggs & eelgrass; Design: Darren Gamptos

River inflows, food supply and conditions in the water all affect the cycles of Bay life...



Actual freshwater flow for water year 2010, DWR; Monthly mean values in 2010 for other drivers from USGS stations in San Pablo, Central and South Bays. Data from http://sfbay.wr.usgs.gov/access/wqdata/index.html

Produced by the San Francisco Estuary Partnership, 2014. Larger prints available for $25. To order or submit potential photos, estuaryeditor@gmail.com

OVERDRAFT

Running Our Groundwater Dry

California often leads the nation in environmental protection, but we're way behind when it comes to groundwater. Like mineral rights, aquifer rights have been viewed as coming with the land. So while surface water is allocated to the last drop, groundwater isn't even regulated comprehensively. This makes us the exception in the western U.S. from Texas to the Pacific coast. And now that we're in our third straight year of drought—with the Sierra snowpack down to 18 percent of normal in the final 2014 survey—we're pumping more groundwater than ever, and levels statewide are the lowest ever recorded.

Aquifers recharge when rain, snowmelt or irrigation water seeps into the ground, percolating down into tiny pores in the underlying rock. Most of our groundwater is in the vast interior valleys but there are also many smaller coastal aquifers, and these are often the primary water source for local communities and farms. "The total Central Valley storage capacity is huge," says Jay Lund, Director of the UC Davis Center for Watershed Sciences, adding that "roughly 150 million acre-feet is accessible by pumps statewide." An acre-foot of water is what it takes to cover one acre to a depth of one foot, or about 326,000 gallons, and for planning purposes the California Department of Water Resources (DWR) equates this with how much water a suburban family uses in a year.

But while we have a lot of groundwater, we also use it at a prodigious rate. Groundwater supplies nearly 40 percent of our water during average years and about 60 percent during drought years, and three-quarters of Californians get at least some of their drinking water from subterranean sources, says DWR. "The biggest areas of overdraft are in the San Joaquin and Tulare basins in the southern Central Valley, and in lots of coastal basins," Lund says. "The overdraft is 1.5 to 2 million acre-feet per year, and this drought year could deplete groundwater by 6 to 10 million acre-feet." Today, groundwater levels in many parts of the San Joaquin Valley are more than 100 feet below previous historical lows.

The biggest downside of groundwater depletion is that eventually there won't enough stored water to tide us through dry years. In addition, taking too much water out of aquifers can deplete rivers and streams. That's because groundwater and surface water are very tightly linked, flowing into and out of each other depending on relative water levels. This makes the distinction between the two somewhat artificial. As Lund says, "There's no such thing as groundwater in California, it's mostly stolen surface water."

Other downsides of groundwater depletion include salt intrusion into aquifers along the coast, and salt accumulation as well as subsidence (sinking land) in the San Joaquin Valley, which has sunk as much as 28 feet in some places. Most of this subsidence is historical. "Subsidence is the result of compaction when you first draw an aquifer down," Lund explains. But new wells have caused recent subsidence by nearly a foot a year in the center of a 1,200 square mile bowl near Merced, says the U.S. Geological Survey's California Water Science Center.

Ironically, this sunken land could disrupt the flow of water from north to south because it's traversed by the Delta-Mendota Canal, an aqueduct in the Central Valley Project. Moreover, the drought is likely to increase subsidence further even in the absence of new wells. "We're drawing water down to a new level," Lund points out.

Done right, tapping groundwater when surface waters are scarce is a sound practice. "We're fortunate to have groundwater in California," says Heather Cooley, Director of the Pacific Institute's Water Program. "It's OK to draw heavily during drought years—if you allow recharge during wet years."

While we've been doing it wrong for ages, that may finally be about to change. Proposed legislation, Senate Bill 1168, would let local agencies manage their own groundwater but would also let the state step in if they don't. "This is a creative way to deal with the impasse over regulation," Cooley says, adding, "either we solve this issue or it's going to solve itself." For example, pumping uses energy, and at some point groundwater will be so deep that the cost of bringing it to the surface will be too high.

Comprehensive groundwater management is just a good first step, however, partly because we have been using way too much for way too long. "It will still take a long time to recover," Cooley says. In addition to banking more groundwater during wet years, we can speed the recharge rate by replenishing aquifers with purified wastewater, as Orange County has done for decades, as well as by capturing stormwater, which slows it down enough to infiltrate the ground. "There are a lot of great opportunities out there," she says.

Using groundwater sustainably "won't solve our water woes," Cooley says. Citing work by graduate student Heidi Chou, Lund says that ending the Central Valley overdraft would just shift the problem: "It would put more pressure on the Delta because we have all these thirsty farmers." At current rates of water use, taking less groundwater would mean taking more surface water. And this in turn would shrink flows through the Sacramento-San Joaquin Delta, into the San Francisco Estuary, and out to sea.

What else can we do? We can use water more efficiently and we can use less altogether. Says Lund, "California is a dry state with a big population and a big economy, and we care about the environment—we're not going to have enough water for everything unless we conserve." **RM**

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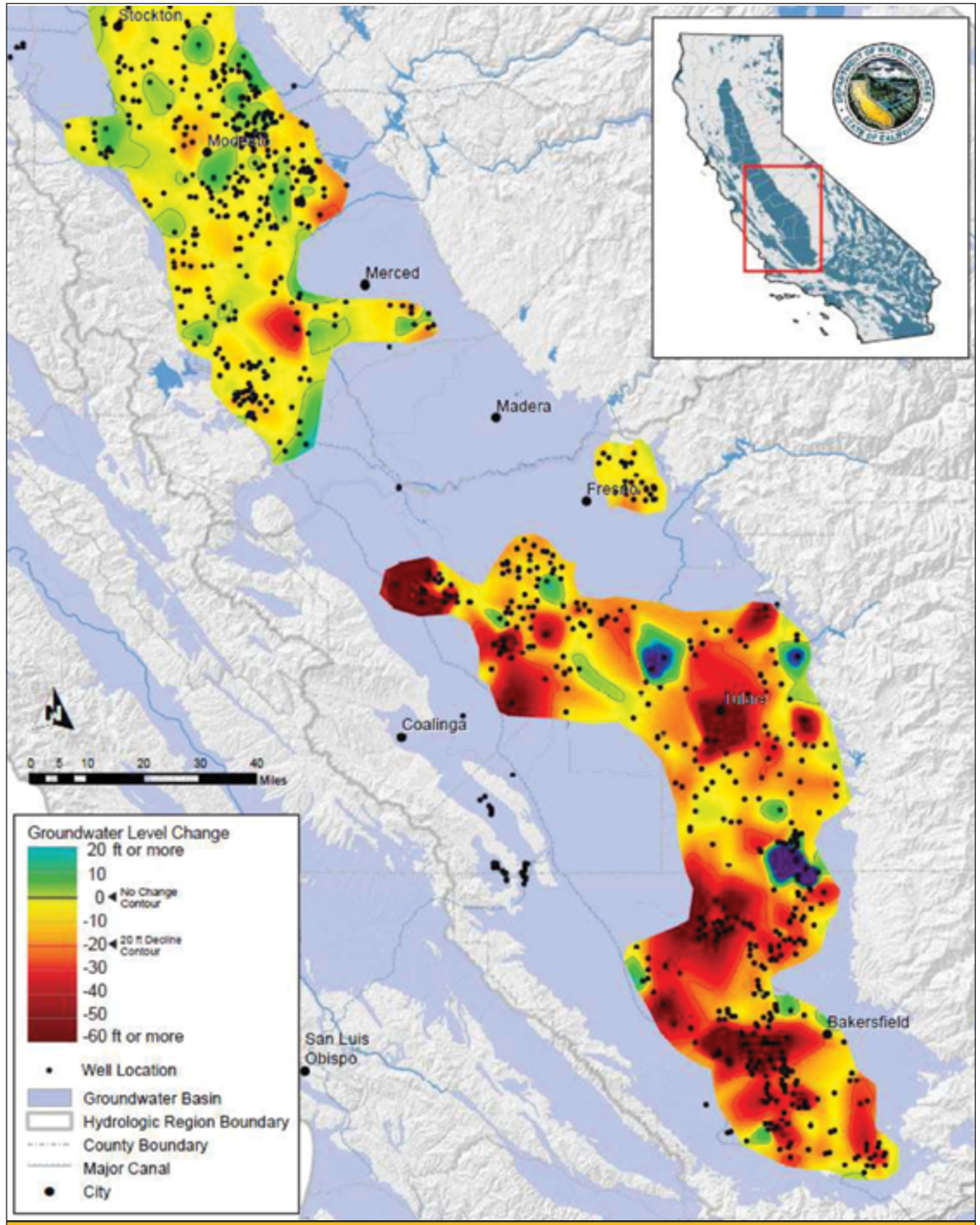


Groundwater level change in Southern Central Valley between Spring 2013 and Spring 2014. Source: Public Update for Drought Response: Groundwater Basins with Potential Water Shortages & Gaps in Groundwater Monitoring, California Department of Water Resources, April 2014.

RECYCLING

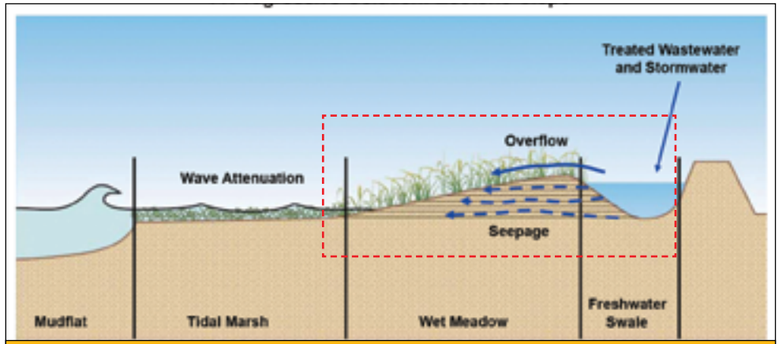
Wastewater on a Wedge of Meadow

The most resilient infrastructure — the kind that will protect the Bay Area against rising sea levels, while at the same time bolstering the region's sanitation capabilities—does not involve building with more steel, concrete, or advanced materials, as it turns out. "Nobody can afford to build giant levees, or re-plumb the South Bay to deal with excessive pollutant or nutrient discharges," says coastal habitat expert Peter Baye.

Instead, in order to adapt to future uncertainties caused by climate change, tomorrow's shoreline infrastructure might need to look a lot like in the 19th century, when broad wet meadows and floodplains connected the hills to tidal marshes.

That's the idea, at least, of the Oro Loma ecotone pilot project, which is seeking approval to build an engineered, gradually sloping marsh along 800 feet of bay frontage. If all goes to plan, the surface of the marsh will host a variety of native plant species, running on a gradient from brackish to sunny upland, that are best adapted to absorb or process into gas the nutrients from the treated wastewater piped in from the nearby plant.

The marsh itself, built wedge-like, with the high end resting against a levee, will contain substrates that can be manipulated to achieve optimal hydrology for treatment, and to act as a buffer during flooding and stormwater events. "We are trying to create subterranean flow," says Oro Loma Sanitary District general manager, Jason Warner. "Having this broad slope helps us deal with a variety of scenarios and recreates what used to be here."



Experimental solution, an ecotone slope wetted with wastewater. Red line approximates Ora Loma demonstration project scope. Graphic courtesy ESA-PWA.

PIPE LINE

Sonoma Water Trumps Cash

The Bay Area's growing marshes need both salt and fresh water supplies to thrive, but the latter is harder to come by during this worst drought in recorded California history. With so much less water to go around, borrowing from existing streams, marshes, and sloughs through pipelines or breached levees can be an environmental challenge.

But the Sonoma County Water Agency, which manages the local sanitation district, recently demonstrated an attractive solution by building a $10 million pipeline to send recycled water — treated wastewater — from the District's sewage treatment plant in the town of Sonoma to the Napa-Sonoma Salt Marsh, seven miles away.

When fully restored, the marsh will add 10,000 acres of healthy wetlands to the regional total. But to get there, state and national agencies leading the restoration must dilute and discharge salt residue known as "bittern" from a 300-acre former salt pond, a process that will take a lot of time — up to a decade — and a lot of water.

Recycled water does the trick (in this case, treated to be safe enough for most agricultural irrigation) without any impact on aquifers, wetlands, or other users. Wastewater from sewage plants that is purified to different degrees is also used on golf courses, schools, business parks, and municipal properties, but most is simply discharged to the Bay.

Piecing the pipeline project together wasn't easy, says the water agency's principal engineer Kevin Booker, and required coordination with a long list of agencies, funders, and landowners over a period of more than 15 years. Most recently, negotiating easements and rights of way proved harder than expected. The pipeline was routed through eight different private properties: seven vineyards and a parcel owned by the Sonoma-Marin Area Rail Transit authority (SMART). The drought only complicated the discussions, as all seven vineyard owners requested water, not cash, as compensation for allowing access. "The water was more valuable to them than the money," Booker says. "It gives you a sense of what's going on in that area as far as groundwater."

In the end, the agency ended up offering traditional payments paired with hookups for paid access to a portion of the water. Finally, the agency had to negotiate with SMART, as the pipeline travels under the proposed tracks.

Obtaining permits provided its own set of challenges, although environmental resources coordinator Jessica Martini-Lamb says that regulatory agencies are getting more comfortable with using treated wastewater for restoration. "Recycled water is a ready supply of fresh water that doesn't have the same environmental impacts," she says. **NS**

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Located on a 10-acre parcel adjacent to the Hayward Regional Shoreline, the project is in the permitting phase and slated to cost $2 million, which is funded by four year Integrated Regional Water Management grant. The project site is a vacant lot that is owned by the Oro Loma Sanitary District. In connection, the sanitary district is spending an additional $4 million on a wetland-based treatment system which will be used for "polishing" treated water and for stormwater runoff storage.

"Since this is a prototype, and an experiment, it is a closed system," says Jeremy Lowe a coastal geomorphologist with ESA PWA. By modifying some of the existing discharge infrastructure, some of the treated fresh water will be allowed to seep through the marsh and recreate the wet meadow type of habitat feature that is largely missing from the present day Bay Area.

"With wastewater treatment plants, all of the water is already down by the shoreline in pipes, so why not put it into the back of marshes?" Lowe says. Once it has traveled through the marsh, the water will be collected, analyzed, and returned to the treatment plant for discharge through the current system of pipelines.

"Our property is an ideal laboratory," Warner says, "We can put this behind a levee and if things go wrong, we can still run all of the water through the treatment plant." Twenty one other wastewater treatment plants rimming the Bay could potentially benefit from some of the lessons learned from this experiment. Researchers from UC Berkeley and Stanford will also use the project as a research test bed.

While wetland and salt marsh restoration projects have been happening with frequency for the last 40 years, little is known about building a transitional ecotone, or a broad terrace instead of a steep levee wall, between two types of systems. Baye, who championed the idea of reintroducing more upland-style, groundwater-fed marshes to the Bay Area, most recently during the commenting period for the South Bay salt pond restoration planning, draws inspiration from restoration work in the Chesapeake Bay. Facing up to similar development and human population stresses has helped that community realize that the kidneys of the Chesapeake are not oysters or saltmarsh, but giant disappeared floodplains, which soaked up sediments and nutrients before they even arrived at the bay's edge.

"We are trying to emulate the historic landscape and modify it to benefit the future," Lowe says. **DM**

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PUBLIC SPIRIT

Winning his Father's Fight

Slung low along the bayshore between the Chevron Richmond Refinery and Point Pinole Regional Park, and peppered with remnants from decades of unregulated use, Breuner Marsh is often overlooked. It is found off the Richmond Parkway at the end of Goodrick Avenue near the gun club. "You can see the beauty of the place if you hike out a little ways," says East Bay Regional Park District board member, Whitney Dotson.

This summer the marsh will become more accessible. In July the park district begins the construction phase of Breuner Marsh's restoration. The $8.5 million effort includes removing old structures and hazardous materials; restoring 65-acres of wetlands and 85-acres of coastal prairie; and closing a mile-and-a-half Bay Trail gap. The long-running effort to preserve the marsh was most recently punctuated by a three-year eminent domain legal battle ultimately decided by the state Supreme Court. The court's ruling resulted in the park district purchasing the 218-acre site for $6.8 million in 2011.

The current restoration work is funded by a number of local, state, and federal agencies "It took years of very active work," says Dotson, about the effort to save the marsh, "but now it will be preserved forever."

Dotson lives nearby in the house where he grew up. The house is part of Parchester Village, a planned community built on the heels of World War II when, Dotson says, "Mr. Parr had the idea to develop housing for black ship workers." (The name Parchester combines Parr's last name and the name of his son Chester.) Houses were sold with the understanding that the open swath of land — now known as Breuner Marsh — between the houses and the Bay would remain undeveloped.

By the 1970s, the undeveloped land surrounding Parchester was sold to Gerald Breuner, a businessman who intended to build a small airfield on the marsh. "My father started organizing against that," Dotson says. The airfield remained on the drawing board, but throughout the years other developers have bought and sold the site. In 2000, a plan to build a light industrial complex on the marsh again inspired the community to organize.

Dotson moved to Parchester when he was five. He is 69 now, but he remembers what his father had taught him. "He inspired me to jump into the fray. He told me the whole story." **DM**

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Breuner Marsh. Photo: Julia Stalker

COMMUNITY

Here There Be Dragons

Winning a 500 meter dragon boat race, like Berkeley's DragonMax team did at Lake Merced on May 3rd, takes more than the brute strength required for 2.5 minutes of full-tilt paddling. These long, narrow canoes are crewed by up to 26 people, all of whom must work in impressive unison to propel the boat forward. This coordination is painstakingly developed by a relentless six-days-a-week, year-round practice schedule, and fueled by an abiding desire to see the sport flourish. To get a glimpse of how it works, I decided to attend a recent Wednesday evening practice.

At the practice, we crew two dragon boats (one for seasoned team members, another for a mix of both experienced and novice paddlers) and take them out into the Bay off the Berkeley Marina at the direction of team coach Rodger Garfinkle. He demonstrates how to properly drive the paddle through the water to create thrust, as well as the necessary movements to maximize strength from the engaged muscle groups.

Sitting to my left on the dragon boat "Max" is Paul Kamen, a kind of antithesis to Roger. While they both possess a wealth of knowledge and infectious passion for the sport, Paul trades Roger's explanations of technique and physiology for lessons on fluid dynamics and history.

Kamen helped found the Berkeley Racing Canoe Center in 2004, which hosts DragonMax and is dedicated to involving the local Berkeley community. At the 2014 Berkeley Bay Festival on April 12th, the racing center offered free paddling lessons to over 300 people, and expects anywhere from 500-900 for the upcoming July 4th celebration.

While we paddle "Max" around the marina, Kamen fills me in on the sport's origins. The first evidence of dragon boat racing appears in the 3rd century B.C. but early designs focused on river transport — "the 747 of the ancient world," says Kamen – rather than racing. The sport began gaining traction in the west around 1995, in advance of the Chinese reaquisition of Hong Kong. British residents of Hong-Kong immigrated to Canada, and brought their dragon boats with them.

Locally, dragon boating appeals to youth. Paul cites the democratic nature and forgiving learning curve of the vessel: "Every kid with a paddle in their hand is a full participant. This is especially important for underprivileged youth who are not likely to have any boating background... It's not just a more accessible introduction to boating. It also offers practical opportunities for follow-up participation at essentially zero cost."

The racing center also supports the youth Rough Riders Dragon Boat Team, composed primarily of students from El Cerrito High School. While currently only 24 members strong, the team is growing rapidly and recently competed against 24 other teams in the California Dragon Boat Association Youth Race. Their coach, Lawrence Pang, says they "performed well for a team of novice paddlers, beating a couple of more experienced teams."

With a recent grant from the Coastal Conservancy, the racing center commissioned some custom paddles for smaller children. According to Kamen, "They were built by local youth learning boat building and repair skills, and the purchase price helped with their program."

DragonMax's success does not hinge on towering behemoths who single-handedly power the boat to the finish. Neither, I think Kamen would argue, does a successful community. It's a group of equals, working in unison to drive toward a commonly shared goal. **MHA**

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INVASIVE SPECIES

Chamomile Wars

Until recently, mayweed chamomile *(Anthemis cotula*), a rank-smelling weedy cousin of the popular herbal tea ingredient, was barely on the radar of the invasive plant community. But it was bad news for the endangered California least terns that nest on artificial sand-and-shell islands at the Hayward Regional Shoreline until the East Bay Regional Park District resorted to chemical warfare.

Five years ago, the plant overgrew Island Five, crowding the terns into a remnant sliver of open ground. Ducks, which, unlike terns, prefer vegetated nest sites, moved in. District biologist Dave Riensche says they were "an attractive nuisance" – drawing raccoons and red foxes that preyed on duck and tern nests alike. The upshot? A two-year decline in the terns' reproductive success.

In 2012 the District struck back with a cocktail of herbicides contributed by Dow AgroSciences and applied by Caltrans workers before the nesting season. That knocked back vegetation cover from 90 to 10 percent. The terns rebounded. Last year the Hayward Shoreline hosted the second-largest tern colony north of Ventura County, with 85 nests, and had a 95 percent hatching rate.

After this year's herbicide treatment, mayweed's foothold was reduced to two percent of Island Five. Hand-pulling, Riensche explains, would not have eliminated the seeds that can lurk in the soil for a couple of decades. In addition, the plant's waxy resin can cause a contact rash.

Riensche says 2014 looks like a banner year for the terns, with courtship activity starting early. "I'm sure we'll get close to a hundred nests," he predicts. The Alameda Point colony, with more room for nests, is still the region's largest—but Island Five, with one of the highest nesting densities on the Pacific Coast, continues to provide insurance. **JE**

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ENGINEERING

A Landslide Victory

In January 1982 a three-day storm descended on the San Francisco Bay Area and dumped a record-breaking amount of rain on already-saturated hills. Thousands of debris flows occurred, including a landslide that permanently closed the eastern end of Carquinez Scenic Drive. Since then a 1.7-mile section of the road that connects Martinez to Crockett in Contra Costa County has been officially closed to vehicles, but unofficially the cracked and crumbling road has become a popular spot for dog walkers, cyclists, and local artists who use the blacktop as a canvas.

For the last year, the closed section has been truly closed while the East Bay Regional Park District converts the damaged county road into an eight-foot-wide, multi-use trail. The district acquired an easement in 2012 and a year later began a two-year, $5.5 million project to repair landslides, stabilize slopes, and repave the road. The section being repaired is part of the San Francisco Bay Trail, and will reopen to pedestrians and bicycles in fall 2014.

The original road was cut into steep slopes 170 feet above the southern shore of the Carquinez Strait. The newly refurbished road will have 31 new retaining walls to combat the erosion and slides common to the cuts in the slopes. The posts of the retaining walls are steel H-piles that have been driven into the loamy, grassland soil up to forty-feet deep. Above ground the piles support stacked square cement logs. This type of landslide stabilization is called soldier piles (named for the rows of piles lined up like soldiers) and lagging (the cement logs). The district's senior construction inspector, Eric Bowman, explains that the pilings—not just the walls—help to prevent landslides. By drilling (not digging) the piles deep into the ground, the soil around them is displaced and compressed, which causes friction and increases the load-bearing capacity.

The 1982 landslide left a slump of dirt and rock that covered the road. Last year engineers reestablished that section of road and installed a long and winding retaining wall on the upslope side. This year they are driving 35-foot-deep piles into the outside curve of the road to further stabilize the soil. Once the down-slope piles have been installed, workers will raise the level of the road with stacked polystyrene blocks. These four-by-eight-by-two-foot geofoam bricks will reduce the load on the retaining walls.

H-pilings on Carquinez Strait trail. Photo: Aleta George

Photo: Aleta George

The last step in the project will be to grind the existing blacktop in place and to resurface it with a thin layer of road base. Soon after, the ribbon will be cut and happy users will populate the trail once again. Even the newts can use the road. Each of the six drainages that flow to the Carquinez Strait will have signs to warn people where they cross.

Bowman is as excited as anyone for the trail to be finished. He lives in Martinez where he hops on his bike for a spin several days a week. Before the trail was closed his favorite after-work ride was the two-bridge Carquinez Strait Scenic Loop Trail. When the trail opens he will once again ride in a counter-clockwise direction throught Benicia, Vallejo, and Crockett, and with the sun at his back pedal for home on the Carquinez Scenic Drive with it's spectacular views. For the last 1.7 miles he will ride on the reengineered road ready for the welcome rains. **AG**

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HAMILTON, *continued from page 6*

$164 million. But it's the environmental costs that are holding up approval. While the magnitude of the impacts is difficult to determine, no one has the money to do pilot experimentation and monitoring. "The biggest worry is entrainment of endangered fish by the hydraulic dredge at the ATF," says Goeden.

Like all in-bay disposal of dredged material, moving mud from one place to another in the Bay can smother or bury bottom-dwelling animals, while hydraulic dredges can suck up longfin smelt, salmon or sturgeon, not to mention other native fish. Such concerns were detailed in a 2008 EIR, and also explored in technical workshops hosted by the Army Corps in 2012.

Mitigation measures could work, like screening suction heads or requiring dredgers not to switch on the pumps till the head is in the mud, not the water. Or they might not. "No one really knows if fish like green surgeon get sucked in, or if they get curious about the muddy water or potential prey, so are more at risk," says Gandesbery. In the meantime, where fish are concerned, the offloader approach is still preferred because it doesn't create local turbidity or disturb the bottom.

Of course, environmental impact reports tend to look only at the site and project in question, not at the regional benefits of a diminishing sediment supply put to work to save marshes – and the cities behind them – from the accelerating creep of sea level rise.

And there are other regulatory and policy hurdles. "We can easily permit offloading activities, but an ATF might require a *San Francisco Bay Plan* amendment," says Goeden.

For the moment there seems to be a stalemate among the various responsible agencies due to the loss of funding to move forward and unresolved environmental concerns. "There's no current ongoing coordination at this point," says Goeden.

Gandesbery sees no other path but to try to get the Bel Marin project shovel ready and to keep actively exploring each and every mud-moving option. "The amount of sediment we need to do these large scale restorations around the Bay is staggering," he says, noting it would take 8-10 years of maintenance dredging to dump enough material in any ATF to restore Bel Marin and the antenna field alone. Meanwhile, Skagg's Island and Sears Point wait in the wings for their share of the mudlift that might save them and their respective endangered species — salt marsh harvest mice and California clapper rails — from climate change impacts in future. "We need new, less costly ways, to move sediment. The alternative is for these areas to go underwater forever," says Gandesbery. **ARO**

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SELENIUM, *continued from page 2*

ing prolonged periods of low flow we've seen high concentrations of selenium continuing through spring. This means fish and birds ready to spawn or nest are exposed during the most sensitive time.

Stewart offers some rough baselines for managers: when spring freshwater flows are below 200 cubic meters per second, selenium concentrations may range between 10-16 micrograms per gram – a range that is at the risky level. The good news is selenium doesn't hang around. "It's leaky, lost quickly from the tissues of organisms. It only gets high when animals are eating a high selenium food source like the clams," says Stewart **ARO**

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