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ESTUARY

North Delta Weighs Way of Life and Wildlife

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Board Requires More from Cities and Counties on Green Infrastructure

Grand Experiment with an Eastshore Supershore: Giant Marsh Project

Pushing the Blue-Green Infrastructure Envelope

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WATER
ENVIRONMENT
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EDITOR'S DESK

Infrastructure is always a mouthful. Tack on modifiers like 'green,' 'blue' or 'nature-based' and it rarely rolls off the tongue. But the term does at least resonate with a wide spectrum of real people and special interests. Everyone needs roads and bridges.

As our climate changes, however, we also need much more from our infrastructure of the future: power lines that don't spark fires; rail lines that get us out of our gas guzzlers and emitters; pipelines that can not only deliver but also recycle water; levees planted with endangered species habitats; wastewater that never goes to waste; renewables in every sense of the word — solar and wind, forest and snowpack, salmon and lettuce.

This issue looks at leafing out our cities and buffering our shorelines with green and blue infrastructure.

If Americans are builders, just think how much more we could be building: oyster reefs, rain gardens, sustainable streets, wind farms, bike corridors, castles for climate refugees.... The economy awaits a mind-blowing reset focused on functional ecosystems thriving within the human footprint.

Whatever we call it — sustainable, renewable, green, or new deal — isn't what's important. It's the choosing of life over death. It's acknowledging we made a mess — not pretending we aren't drowning in it — and getting down to the business of fixing it.

So whatever the spirit is that moves you, let it. We need to get going or we're toast.

ARIEL RUBISSOW OKAMOTO
EDITOR

Photo: Verne Nelson

LANDSCAPE

Wildlife and Way of Life in the North Delta

REPORTER ROBIN MEADOWS

Californians ask a lot of the Sacramento-San Joaquin River Delta, where the state's longest rivers meet and deliver snowmelt from the mountains. Water suppliers want to reconfigure the Delta's plumbing via the ever-contentious Water Fix project, which Governor Gavin Newsom just sent back to the drawing board. State wildlife officials want to boost restoration in the region, and the 2019 Delta Conservation Framework outlines their latest plan. And people in the Delta want to live and farm there as they have for generations.

There may not be a way to give everyone what they want from the Delta. But there are ways to restore ecosystems while preserving local communities. This is true even along State Route 160, which traverses the most populated and most intensively farmed part of the region. The highway follows the Sacramento River into the Delta, twisting and turning around leveed islands between Freeport and Rio Vista.

This is the North Delta and it's a spectacular drive. The river beckons as farms — vineyards, pear orchards, corn fields — and charming towns roll by. Take a side road, however, and you'll find there's even more here to appreciate. The North Delta is vital for birds migrating up and down the Pacific Flyway as well as for Central Valley salmon migrating to and from the ocean.

While most North Delta land is privately owned, some is protected. The Stone Lakes National Wildlife Refuge, nestled on the eastern edge of the region, has grown to about 6,500 acres since its creation 25 years ago. Now the focus is on restoration.

"Historically, the forests that grew along our waterways were up to a mile wide," says Beatrix Treiterer, the refuge's assistant manager. "They're hugely important for migrating songbirds." Riparian woodlands provide nest sites and food for ash-throated flycatchers, blue grosbeaks, and other songbirds that summer here and winter south of the U.S.

Before restoration, the land was farmed for field crops like alfalfa and tomatoes. "They used as much of the land as possible," Treiterer recalls. "They didn't leave much edge habitat." In partnership with the Sacramento Tree Foundation, the refuge has reforested more than 80 acres along waterways in the last decade. Volunteers planted nearly 10,000 trees including Valley oaks, Fremont cottonwoods, and box elder maples, as well as understory plants.

The benefits to birds were swift. "Even when the trees were small, we immediately saw birds," Treiterer says. "Before there were hardly

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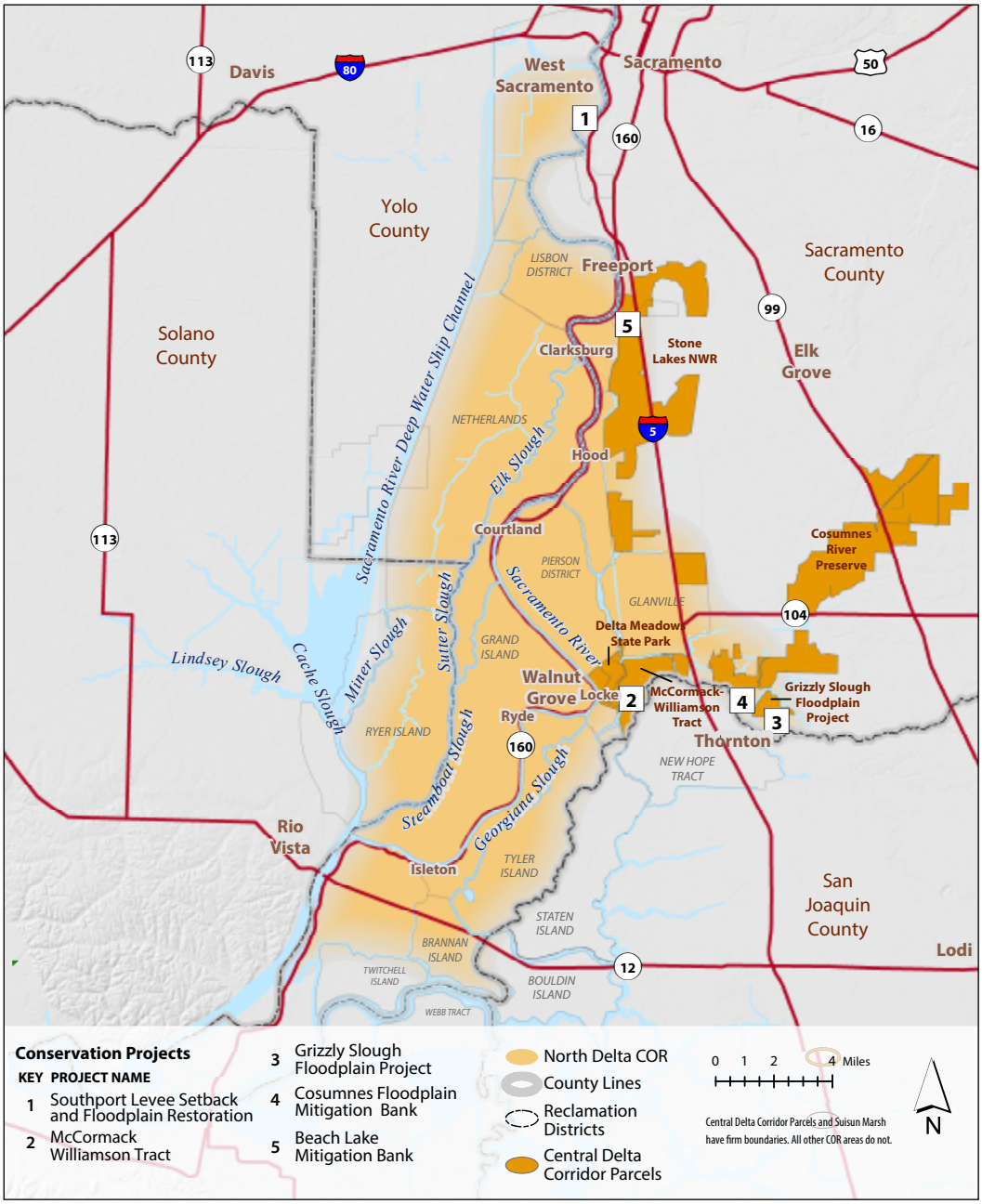

Map of conservation opportunity region in the North Delta from the 2019 Delta Conservation Framework. Map courtesy CDFW

any." Some of the first trees that were planted are now 30 feet high, forming a leafy canopy over a dense understory of native grasses and shrubs like wild rose and elderberry. Today more than 120 bird species use the refuge, which is part of a wildlife corridor system that links riparian habitats in the Central Valley.

Yellow-rumped warbler, a riparian regular. Photo: Rick Lewis

Wildlife-friendly farms near the refuge also play a key role in conserving sandhill cranes, which winter in the Central Valley. "Farmers are hugely important to cranes," Treiterer says. "We can't supply all their energy needs." The refuge provides roosting habitat while farmers provide foraging habitat, explains Russell van Loben Sels, whose family has farmed the Delta since 1876 and who has farmed the land himself for half a century.

He grows minimum-till corn on about 70 acres right by the refuge, a practice that leaves about five percent of the kernels after harvest. "The kernels are all on top, sandhill cranes love it," he says. "All they have to do is hop across the levee and into the field." Before the refuge was established, he only saw a few cranes in his field; now he sees around 100.

Much as van Loben Sels enjoys the cranes, he points out that farming practices must make economic sense. "Farmers are governed by one hard rule of thumb," he says. "You've got to produce or you won't be farming long." Many North Delta farmers have converted from corn and other row crops where sandhill cranes forage to high-value crops like wine grapes.

Even so, van Loben Sels believes "there will always be some row crops" due to the Delta's terrain. Permanent crops do best on the island edges, where the elevation is relatively high. In contrast, row crops are suited to the island middles, where the elevation is lower and the groundwater is higher.

The interests of North Delta residents and conservationists can also align in other ways. Elk Slough, a winding nine-mile waterway between Clarksburg and Courtland, was once connected to the Sacramento River at both ends. This gave salmon and green sturgeon an alternate migration route through the Delta. Today the slough is leveed at the top, blocking fish that go up it, and open at the bottom, potentially causing floods during big storms.

Partners in a plan to remove the levee at the top and put gates at both ends include affected reclamation districts, which are responsible for flood control. The gates would be open most of the time to allow fish passage, and closed as needed to control floods.

Unlike most waterways in the Delta, Elk Slough has a remnant of mature riparian forest. Tall trees shade the water, keeping it cool enough for salmon. In addition, woody debris from the forest helps fish in several ways: it slows water down so they can rest; offers places where they can hide from predators; and decomposes into organic material, ultimately boosting their food supply. "It's great habitat," says Doug Brown, an environmental consultant on the project. "You don't need to do much for fish except provide access."

Town of Walnut Grove in the North Delta: Photo: Amber Manfree

The potential for outside conservation planning to disrupt flood control is a major concern for local farmers and landowners. "The system has adapted and developed over generations in a way that works," says Erik Vink, director of the Delta Protection Commission. "Anything that changes that could have an adverse impact."

He favors focusing restoration efforts on public land, and following the Good Neighbor Checklist developed by the California Department of Water Resource's Agricultural Land Stewardship Workgroup. Checklist guidelines include involving all neighboring landowners in project planning, and protecting landowners from endangered species-related liability.

Outside planning efforts can also overwhelm Delta residents. "You could go to meetings about plans all day long," says Anna Swenson, a graduate of the Delta Protection Commission's Delta Leadership Program and co-leader of North Delta Cares. "It's like a full-time job."

Swenson would like to see official local representation in conservation planning for the Delta. "Each island has an elected governing board for the reclamation district," she says. "I think they should have more of a voice on restoration projects."

"Everybody has a different idea of what they want us to be," Swenson continues. "I want us to be what we already are."

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www.sfestuary.org/estuary-news-north-delta-conservation-as-way-of-life/

ENDANGERED

Brinksmanship for Frail Smelt

REPORTER JOE EATON

At some point, if it hasn't already happened, the number of Delta smelt in hatcheries, currently about 25,000, will exceed the number in the wild. Whatever the latter number may be, it's already dangerously small. The species had a bad year in 2017, despite flow conditions similar to 2011 when there was a modest rebound in smelt abundance.

Although scientists are still analyzing 2017 data, so far the message seems to be that strong freshwater flows alone are not sufficient to provide conditions to allow the smelt population to increase. Last year, for the first time ever, the California Department of Fish and Wildlife (CDFW) found no smelt during its annual Fall Midwater Trawl survey. They're still out there, but the 2019 Spring Kodiak Trawl index of relative abundance was the lowest on record.

Meanwhile, although the stewards of the cultured smelt population have been maintaining its genetic diversity, the dwindling number of wild smelt available to replenish it has ominous implications. The resulting sense of urgency has led fish biologists to consider how cultured smelt could be used to supplement wild populations, and to experimentally deploy captive-bred fish under controlled conditions in natural environments.

"We've considered the cultured smelt as a lifeboat, not to be used unless it's really, really necessary," says California Department of Water Resources (DWR) biologist Ted Sommer. "Now we're taking the first steps to figure out how to launch the lifeboat."

Larry Brown of the US Geological Survey heads the Flow Alteration – Management, Analysis, and Synthesis Team (FLOAT-MAST), whose public-agency, academic, and water-district representatives have been trying to determine what happened in 2017. It was a wet year, and precedents like 2011 suggested that should have been good for the smelt, even in a Delta reshaped by exotic predators, competitors, and prey; algal toxins; and human contaminants.

Cultured smelt cages test survival in wild conditions. Photo: DWR

Spring survey results were encouraging. Then came summer, and higher water temperatures in smelt habitat: over 22 C (71.6 F). "The big thing we noticed was that 2017 was much warmer than 2011," Brown reports. "In 2011 it was cool through summer and into fall, but in mid-July of 2017, water temperatures got quite warm. Whether this caused direct mortality of juvenile smelt is unclear, but it wasn't a good year for survival through summer and fall."

Even if higher temperatures didn't kill the fish outright, heat stress might have impacted their transition from juvenile to adult stages. Fall survey numbers for 2017 hit an all-time low.

Smelt life history is complicated, and teasing apart all the potential influences is difficult. Brown notes that the 2017 data set isn't complete yet, with otolith (ear bone) and pathology work still in progress. However, he says none of the other variables predicted to affect reproductive success were significantly different in 2017.

"Toxic algal blooms weren't an issue, although the algae were still there. The year 2017 seemed pretty good for the smelt's zooplankton prey base. The years 2011 and 2017 weren't terribly different for turbidity or salinity," Brown says. "Temperature is the major message. We're not ruling out other things, but temperature seems to be the obvious thing."

We're almost halfway through another wet year, and fingers are crossed. But the spring results aren't encouraging, and summer is a wild card. "There are so few fish out there now that it might take more than one good year to bump up their population," Brown cautions. Ted Sommer concurs: "Even with a good summer, it's going to be challenging."

Even before 2017, biologists raised the issue of releasing cultured smelt in the Delta: supplementation, if wild fish were still out there, or reintroduction, if the species became extinct in the wild. In a 2016 article, UC Davis fish biologist Peter Moyle and several co-authors suggested placing cultured fish "in protected enclosures in food-rich environments, such as the flooded Yolo Bypass, or ponds such as those on Twitchell Island."

The authors foresaw a limited time window for such actions: "The loss of wild fish to interbreed with cultured fish to maintain genetic diversity will eventually result in domesticated smelt, best suited for survival inside the hatchery rather than outside of it. Reintroductions will have to be done within a few years of loss of wild fish, into an environment with better capacity to sustain them."

The staff of the UC Davis Fish Conservation and Culture Laboratory near Byron, which houses most of the cultured smelt, controls the mating of the fish as closely as

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Photo: DWR

the siring of thoroughbred horses. Permits allow the collection of up to 100 wild smelt every year as supplemental broodstock. This spring, only 28 could be found.

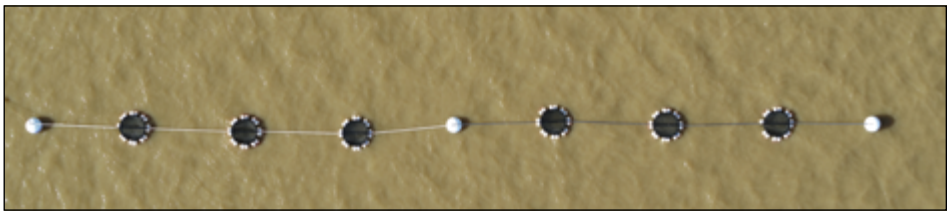
Without that infusion, the risk of inbreeding and domestication would increase. Cultured fish live in stable environments and eat pelletized food; it's not much like the Delta. As the smelt adapt to these conditions, domestication can be inadvertent, as with the Russian project in which breeding foxes for docility led to progeny with piebald coats, floppy ears, and curly tails.

"There's a body of work with salmon and trout showing that domestication can generate substantial changes in fish," says Sommer. "You select for a different shape of fish. There are changes in the brain, feeding, and response to predators. They don't do as well in the wild." Exposing the fish to more natural conditions can help counteract these problems.

A workshop in 2017 involving the major players in smelt science and management reinforced the need to learn how to use cultured smelt more effectively. "There was hesitation on pulling the trigger, but a consensus that, yeah, it's time," Sommer recalls. "First, we needed to learn more about how the fish grow and behave if they're taken from the hatchery and put out in the wild."

The first step was a proof-of-concept experiment to see if cultured fish would survive in more natural conditions. DWR and UC Davis collaborated with the US Fish and Wildlife Service (USFWS) to develop smelt cages that could safely hold fish in the wild. The team came up with three prototypes of hundred-pound perforated steel cylinders, three feet across and four feet high, that would contain the fish while allowing water to flow through and their zooplankton prey to enter.

This January, at a time of cool water and strong flows, six cages, each with 60 smelt, were deployed in the Sacramento River off Rio Vista. After four weeks, the researchers retrieved the fish and found that almost all had survived. A second trial in the Sacramento Deep Water Ship Channel, with warmer water and cargo-ship traffic, was also successful, with 98-percent survival rates. The bodies of smelt from both sites are being analyzed to determine their growth and diet and detect any effects of water temperatures, contaminants, and pathogens.


Cultured smelt live in wild conditions within cages. Photo: DWR

"The team is working hard right now to wrap this project up," says Sommer. "We want to write this up quickly so others can make use of the tool. Then we want to push the envelope a bit by using the cages in other seasons and locations to see how broadly they can be used."

Potential test sites include the North Delta, the lower Yolo Bypass, and, within the brackish zone, Suisun Marsh. "We'll be using the fish as lab rats, seeing how they fare when conditions change," Sommer says. "The locations and timing will be helpful because of flow and management actions planned for those times."

If the cage experiments help identify where smelt might thrive in the wild, reintroduction is still a long way down the road, with permitting and other issues to navigate. "We're not a fisheries agency," Sommer explains. "It's up to USFWS and CDFW to figure out a management strategy. Habitat-restoration projects are reasonable candidates for using cultured smelt, and I'm guessing these sort of projects would be the first place where smelt were released besides those put in cages. How many years from now we don't know."

Reintroduction of wildlife from captive-bred populations is always a tricky process. "Exploring the suitability of techniques for deploying and perhaps eventually releasing Delta smelt into the wild is prudent," says Interagency Ecological Program lead scientist Steven Culbertson. "But having those techniques at hand won't relieve policymakers of having to make hard decisions about the choices of resource management and exploitation of populations for nonrenewable purposes."

Alternatives may be limited, though. "It's hard to see the recovery of Delta smelt without help from the hatchery population," Sommer concludes.

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YOUTH

A Tricky Ballet

REPORTER MICHAEL HUNTER ADAMSON

Malea G., a fourth grader at Bayview's Malcolm X Academy Elementary School, shows me her Tower of Power. It's a wooden, trapezoidal structure roughly two feet high and decorated with stickers naming personal qualities she's proud of. I ask her which of these she might turn to when dealing with climate change. "Leadership," Malea answers after a brief pause. "If there was a flood, someone would need to take charge."

The class teacher, Christopher Moore, is exercising leadership talents of his own, balancing a buzz in the room that goes beyond the typical enthusiasm of a grade school class. Unfamiliar adults are there and fifth graders are outside, hoping to see how their work last year compares. In the middle of the room, bordered on three sides by a row of desks, is an extensive diorama where Moore's students, in partnership with Y-PLAN, have laid out an extensive vision of a more resilient Bayview and Islais Creek. The diorama is the class' combined effort to address a question: How can we educate our families and community about the impacts of sea level rise on Bayview and San Francisco?

Y-PLAN, an education initiative developed by UC Berkeley, aims to use project-based, community-focused learning experiences to encourage youth to consider real-world problems. Twelve years ago, while still new to teaching, Moore eagerly volunteered to help pilot the project at Malcolm X Academy. His enthusiasm for the project was multi-faceted, from the chance to incorporate hands-on creative activities into his fourth grade curriculum to the opportunity for his students to "tackle a real-world problem using their ideas and voices to solve it."

At the culmination of the unit, the students present their project surrounded by evidence of their voices. Some, like the diorama, express a collaborative voice. Others, like posters hung above cubbies holding backpacks and sweatshirts, express a personal vision. One, written by Antahj P., an effervescent girl eager to share her work, reads: "When the climate changes I want to protect my cousin...she lives down by the water. We have to stay together as a community."

As Antahj's poster suggests, Moore shares Y-PLAN's emphasis on community-focused learning and extends it to subjects beyond sea level rise. "Even when I'm starting a math lesson, [I ask myself] is there any way I can pull in what students are interested in, or something that's going on in the community," he says. "If you can do that, you can usually ignite something in them."

The range of budding personalities and contrasting learning styles in the classroom are revealed in the students' projects. Take the Towers of Power, for instance. While each tower had to fit entirely upon a small wooden rectangular block and measure no more than twenty-four inches high, there was no visible common design thread. Some were sturdy, angular designs reminiscent of modern commercial high-rises. Others were whimsical, like ornate spires of Agrabah. When students came to collect their Y-PLAN diplomas and were encouraged to say a few words about themselves into the microphone, some relished the chance to speak up, while one took his diploma in silence and walked resolutely back to his desk.

"It's kind of a tricky ballet," Moore says. One of his keenest dance moves may be his willingness to draw upon personal experience to enforce a lesson. As a former chef, he has used reading recipes and baking bread as vehicles to teach lessons on heat, energy, and the needs of living things. "I want to always get to that point with my students where they trust me enough so I can push them academically." Moore talks about how teachers often say "know your students' lives." But for him, the knowledge needs to flow both ways: "My students need to know my life."

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Photos: Michael Hunter Adamson

GREEN INFRASTRUCTURE

Clock Ticking for Cities to Commit to Greening

REPORTER DANIEL MCGLYNN

Managing stormwater is a physics problem, and not a very glamorous one. In decades past, the main objective of managing stormwater was figuring out how fast it could be directed through the Bay Area's built landscape via storm drains, culverts, and channels, and into the Bay. In decades future, however, the object will be to slow down the runoff, and sink it into greener, spongier surfaces sprinkled throughout our cities and counties, or to run it through more meandering, natural channels and drainages. Such measures fall under the classification of green stormwater infrastructure. And building more green infrastructure isn't just some kind of concept or vision. Instead, the region's water quality regulators want to see more of it from local municipalities — enough to make it a requirement of another five-year federally-mandated permit to discharge stormwater.

"The goal is to figure out how we can interrupt the conveyor belt of pollution caused by the grey-infrastructure storm drain system, in which pollutants in urban runoff are discharged to creeks and the Bay without treatment," says Keith Lichten, Watershed Management Division chief of the San Francisco Bay Regional Water Quality Control Board. This September starts a new planning cycle for the board's municipal regional permit (see History Lesson p.10). During the upcoming cycle, local municipalities will have to show they are compliant with the stormwater permit by incorporating green infrastructure into their future plans.

Of course green infrastructure has been around for eons, it just hasn't been on the front burner for many urban planners. "This is an opportunity for cities to look at their new and redevelopment plans for the next 25-plus years and figure out ways to implement stormwater treatment controls by replacing grey infrastructure with green infrastructure," says Lichten.

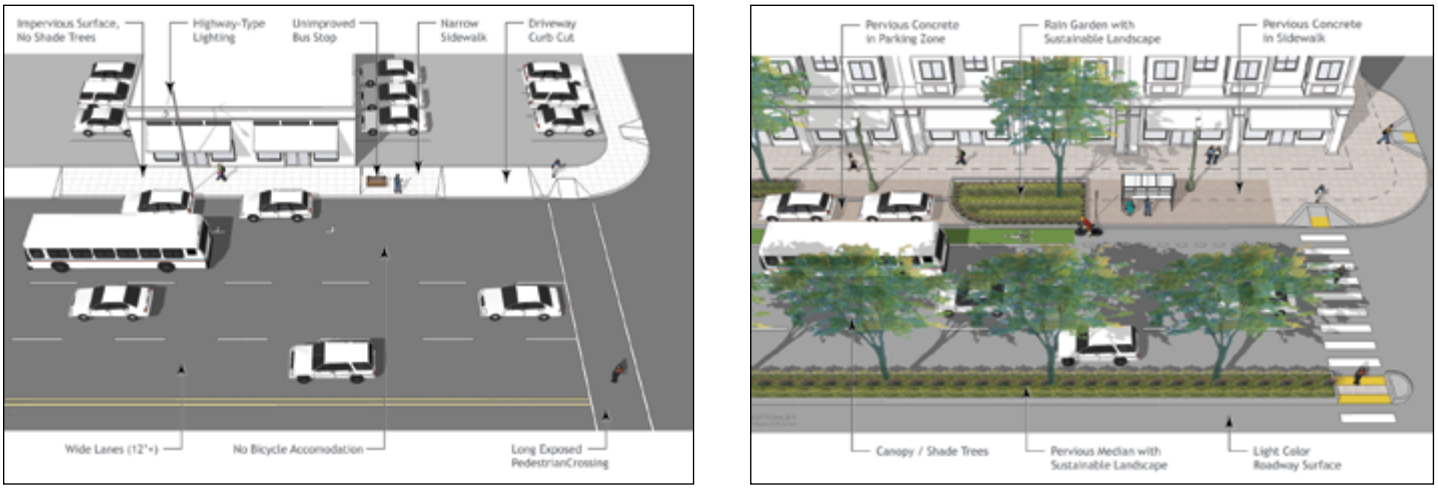
Scaling Up

Green infrastructure is a loosey-goosey kind of term: Part of the reason is that green infrastructure is more like a set of design principles — or design outcomes, really, than it is a strict discipline. Part of the utility of green infrastructure, particularly with regard to stormwater management — where the goal is to slow, spread, and sometimes even store runoff — is that the same principles are scalable across different size projects.

Matt Fabry manages the San Mateo County-wide Water Pollution Prevention Program and he explains the three different scales at which green infrastructure is being developed in the Bay Area, or what he calls an "evolving state of practice for managing stormwater."

The first is at the parcel or individual property level, particularly during any redevelopment. "The Water Board recognized that it is going to take time to change the urban fabric," Fabry says. Beginning in 2005, the board required that new development or redevelopment that added or replaced 10,000 square feet or more of impervious surfaces had to have some way of locally managing runoff. The requirements started with on-site mechanical filtration but have since moved to a more landscape-based approach. While the parcel level is the smallest scale, the funding is also the simplest because the construction costs become part of the project budget. "Cities are looking at more ways they can get this done with private dollars," Fabry says.

The second scale of green stormwater infrastructure development is happening at the street or neighborhood level. The definition of a comprehensive urban street continues to get more sophisticated. It began with a model called complete streets, which is more pedestrian and bike friendly. Then came the idea of green streets, which replaced hard impervious curbs and gutters with pockets of vegetation and deep wells around street trees that allow water to collect, and cuts in curbs to slow the flow of water. Those two concepts are now being married together into something called sustainable streets, which combines the goals of making streets more pedestrian and bike-friendly while layering the green infrastructure elements of slowing and spreading stormwater runoff. The sustainable streets model is currently being implemented in numerous cities around the Bay Area (see graphic below).



Complete streets design. Art: Bottomley Design Partners

The third level of scale according to Fabry is happening at the city or watershed level. He points to a project in the design phase in South San Francisco, where city officials are working with San Mateo County Flood Control District to re-engineer part of Colma Creek. The creek, with its headwaters on the flanks of the San Bruno Mountains, currently drains about 6,500 acres, and while running through the busy blocks between the 280 and 380 freeways is confined to a hardened concrete channel. On its way to an outlet in the Bay near the San Francisco International Airport, the creek passes by the popular Orange Memorial park. The wide-open baseball and softball fields there provide the perfect testing ground for a massive green stormwater infrastructure project, but maybe not in the way you might think. After years of planning and public input, the city and its partners are scheduled to break ground by early next spring on a project that will put a massive reservoir underneath one of the ball fields. Before the water hits the subsurface cistern it will be filtered to remove trash and pollutants, like the heavy metals targeted by the Regional Water Board. Roughly half of the water will be used to irrigate landscaping around the park and along the adjacent stretch of Centennial Trail, and the remainder will be allowed to slowly feed back into the region's aquifers. Any of the filtered overflow will be diverted back to the concrete creek where it will eventually meet the Bay (see map p.10).

"In addition to the usual challenges encountered by public infrastructure construction, this particular project has unique elements requiring several rounds of public outreach and feedback" says Bianca Liu, Associate Engineer for the City of South San Francisco and project manager for the Orange Memorial Park stormwater capture project. "The idea of a giant underground storage tank in the neighborhood is a new concept, and the project will require the temporary closure of a portion of a popular park."

If this mesh of projects all sounds a little ad-hoc, that's because so far, green infrastructure development largely occurs on a case-by-case basis. Until now the nature of trying to build infrastructure has been inherently opportunistic, and the new Regional Water Board permitting process aims to change that by requiring long-term municipal plans. In reality, building any green infrastructure that crosses the boundaries of a single parcel often requires the coordination of multiple public agencies, and several layers of permitting requirements.

There's the additional wrinkle that green infrastructure can be complicated to fund, although both project planners and funding agencies are becoming more creative. "It's amazingly expensive to retrofit the existing built environment especially when you are doing it as a standalone project," says Josh Bradt, a watershed program manager for the San Francisco Estuary Partnership. "It only really pencils out when it is part of a bigger project."

South San Francisco's regional scale green infrastructure project is actually being funded by $9.5 million from Caltrans. Caltrans has their own water quality guidelines to meet, and if they can't do enough on a specific project then they can find ways to offset impacts by funding a project elsewhere that will reduce runoff or pollution. "We need to be talking to the transportation community and natural resources community to see where these projects can be synced up. Right now, it's a real jigsaw puzzle to figure out the funding sources," Bradt says.

But relying on a connect-the-dots funding approach is changing. "As far as the funding goes, there are more bonds and grants out there for green infrastructure projects today than five to ten years ago, but maybe it's time green infrastructure becomes a budget line item," says Mitch Avalon, who formerly oversaw Contra Costa County's clean water program. Avalon has been advocating for new state legislation that would formally integrate stormwater management into any future regional transportation projects and funding opportunities, and also working with regional agencies such as the Bay Area's Metropolitan Transportation Commission on other avenues to achieve the same goals. He says the first step in that process is actually defining what integrating stormwater into transportation planning actually means on the ground. "If you are familiar with the Americans with Disabilities Act, you might remember that it was a big policy decision that required people to change the way things were built. At first, people thought that was crazy, but eventually compliance just became another line item in a construction budget," Avalon says. "As a policy and as a society, we decided it was important." The same thing is happening with green infrastructure funding.

Aiming for Multiple Benefits

Realistically, however, municipalities won't suddenly be rolling out green infrastructure projects on every street corner or along every urban creek come September, when the Regional Water Board's new planning requirements solidify. Right now, cities fall along a spectrum of readiness. Some report still being in the planning phase and others are much farther along. "Oakland is prepared to meet the current regulations, says Kirstin Hathaway, acting Watershed and Stormwater Division Program manager for the City of Oakland. "We see green infrastructure as important for the city beyond the regulatory requirements."

But progress over the last decade has been much slower than some would have hoped. "It is frustrating to see conventional right of way projects continue to be undertaken without GI elements when the impacts of landscape hardening to watershed health are well known," says Bradt. "I am hopeful that the Water Board's requirement for watershed-based GI master plans will be a game-changer. At the very least it should encourage much better coordination."

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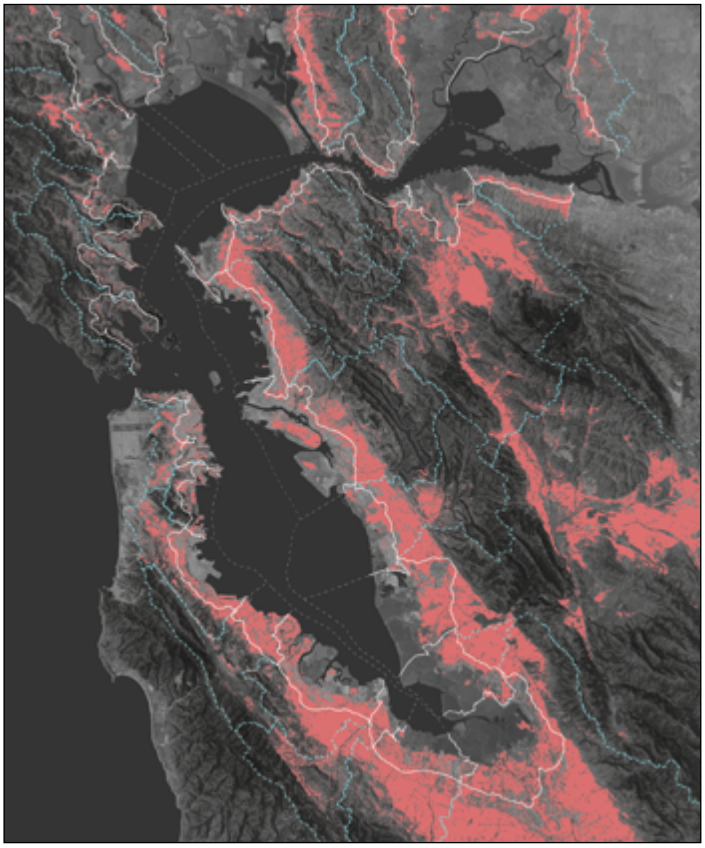

Area suitable for green infrastructure: Source: Kass et al (2011) & SFEI

One factor that helps build enthusiasm among planners is that while the board's permit requirements are focused on reducing urban runoff pollutants including PCBs, mercury, and trash from entering the Bay (see RMP story p. 15), there are many other compelling reasons for increasing the acreage of green infrastructure around the region.

Sustainable streets could not only reduce pollution but also add buffers that might be useful in a changing climate, such as more vegetation to help with heat island effects or a place to capture surge events that will likely happen secondary to sea level rise. And the larger, regional projects like the one underway at Orange Memorial Park can be used to capture and store stormwater that today might be used to irrigate a ball field, but in the future could be used for other purposes. Not to mention that green infrastructure just generally makes the built environment more comfortable and livable — a factor not always accounted for or built into project cost analysis.

"It takes a little bit of time to get these things baked together," says Michael Germeraad, a resilience planner with the Metropolitan Transportation Commission and Association of Bay Area Governments, referring to how people are starting to talk about the advantages of green infrastructure as a means to accomplish multiple objectives. "As municipalities adopt plans in the next two years, I think we will see increased pressure to start including green infrastructure and planning so that one plus one equals three."

And for some communities thinking about how to insulate against the impacts of climate change and sea level rise isn't really about planning for the future — because the forecasted scenario of increased flooding has already arrived.

"We've actually had people kayaking in our streets," says Elizabeth Patterson, the Mayor of Benicia where a citizen group called Sustainable Solano is leading the charge and training residents about resilience. "This is not just a reaction to regulations, not just because the state was saying you have to do this, a lot of municipalities are asking for help for this."

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www.sfestuary.org/estuary-news-green-infrastructure-planning-mrp/

HISTORYLESSON

Ruling Over Runoff

During wet weather events, stormwater comes pouring down from Bay Area hillsides and collects in the lowlands. This makes sense because historically the fringes of the Bay were perfect catch basins for heavy flows. But starting more than a century ago those low-lying basin-like areas have been filled in with homes and buildings and with roads and parking lots. As the Bay Area became built and developed hard surfaces, greater quantities of runoff raced over the landscape.

Then, following the passage of the Clean Water Act of 1972, came the awakening that stormwater was more than just a flooding issue. The flows, it was acknowledged, could be laced with concentrations of toxins rivaling that of the end-of-pipe sources that the Clean Water Act was written to control. By the late 1980s, and after the passage of more federal water quality legislation, states were put in charge of making sure that municipalities were meeting stormwater requirements outlined by the National Pollutant Discharge Elimination System (NPDES), the regulatory teeth of the Clean Water Act.

In California, the State Water Resources Control Board and Regional Water Quality Control Boards are tasked with making sure that local agencies are operating in compliance with NPDES. Beginning in the 1990s, the San Francisco Bay board began issuing NPDES permits for municipal stormwater discharges, which eventually grew into the Municipal Regional Permit, also known as the MRP, as of 2009. The MRP requires Bay Area municipalities to clean up urban runoff pollution and, over time, to improve the way the urban environment is built to reduce the amounts of pollutants it discharges. And because the Bay Area has legacy contaminants from previous industrial and urban activities — particularly mercury and PCBs (both of which accumulate in food chains, especially fish, and pose health risk to the people that eat eventually eat the fish) — that get stirred up and carried to the Bay during storm events, the MRP targets those pollutants specifically, along with reducing the amount of trash that enters creeks and the Bay during storms.

Needed Now: A Big Blue-Green Push

Guest Editor: Lisa Owens Viani

The UC Davis Green Infrastructure Club celebrated completion of its third rain garden this spring. It absorbs runoff from a large lecture hall. Photos: UC Davis

With climate change making rainfall and storm intensity less predictable in California — and with new regulations requiring green infrastructure in most new developments that create 10,000 square feet or more of new hardscape — designers and developers are stepping up their efforts.

Green infrastructure, with its multiple benefits—improving water quality, providing urban greening, cooling urban heat islands, increasing tree canopy and sequestering carbon — can play a key role in helping cities tackle climate change. "Blue" infrastructure is another piece of the green infrastructure puzzle that can help at the large scale: softening eroding shorelines using setback levees, pebble dunes and gravel beaches, or oyster reefs that offer habitat while helping tackle sea level rise, or expanding the natural sponges and carbon sinks of wetlands.

Check out the innovations these projects demonstrate and the challenges they face as we try to expand our blue-green envelope.

New Generation Takes a New Tack

Students in the Green Infrastructure Club at UC Davis are not only learning how to design stormwater treatment systems but also demonstrating that these systems don't have to be complicated and costly. Using the UC Davis campus as their laboratory, they've built three nimble rain gardens in the past three years and have been asked by the cities of Woodland and Rancho Cordova to help design similar projects. Each of the projects cost less than $5,000 to install, even taking into account the value of volunteer labor, says landscape architect Kevin Robert Perry of Urban Rain Design, who teaches at the university and heads up the club.

Perry, who's coined the term "tactical green infrastructure," teaches his students to look for areas that are fairly simple to retrofit without having to manipulate existing stormwater infrastructure a lot, and where a project can be built in a short amount of time. That means avoiding "green infrastructure on steroids," he says—over-engineered projects that use lots of concrete. "Do the most you can do with the resources you have and the soils you have," he advises. He says many project designers are spending lots of money on soil prep and underground water storage systems with large rock galleries, creating overcomplicated systems. "Keep water flowing on the surface as much as possible," he advises.

Senior Kaylin Hui says her work with the club has shown her how to identify strategic locations for treating stormwater as well as how to work with different materials that are less costly than concrete (the students' most recent rain garden uses a runnel made of wood). "The runnel is just something simple but very effective," she says. LOV

Pebble Dunes Buffer Rise

Last year's Resilient by Design challenge spawned new ideas for shoreline adaptation that may take years to mature. But some solutions from the year-long brainstorm are already making their way toward the landscape.

Take the gravel beach and berm envisioned by team Public Sediment for the mouth of Alameda Creek. It doesn't merely resist erosion but actually encourages accretion with storm surges and rising tides while providing new shorebird habitat. The State Coastal Conservancy picked up the idea almost immediately in hopes of integrating it into existing plans for the site within the Eden Landing Ecological Reserve in Hayward, as part of the ongoing South Bay Salt Pond Restoration Project.

In August 2018, three months after Resilient by Design teams unveiled their final presentations, the Conservancy applied for a grant through the National Fish and Wildlife Foundation's new National Coastal Resilience Fund to support engineering and design of the two-mile beach and berm at Eden Landing. Just three months later, the agency learned it had won $237,000, to complement $238,000 of its own matching funds.

Today, a year from the conclusion of the Resilient by Design challenge, using the new grant money, the Conservancy is gathering site-specific info to feed into engineering plans for a 300-foot pilot feature that will appear on permit applications next year; work could begin in 2021.

"The levee on the site is subject to a lot of wave action and has failed in the past, and so the Public Sediment team proposed that to improve the resilience of the levee and protect the marsh, a gravel beach and berm could be installed," says Laura Cholodenko, a project manager with the State Coastal Conservancy.

Also dubbed a "pebble dune," the idea is that as waves come in, heavier pebbles and cobbles restack vertically rather than shifting along the shore, protecting the levee from erosion while simultaneously adding height and protective capacity. On the backside, an expanded upland transition zone slopes gradually toward the marsh.

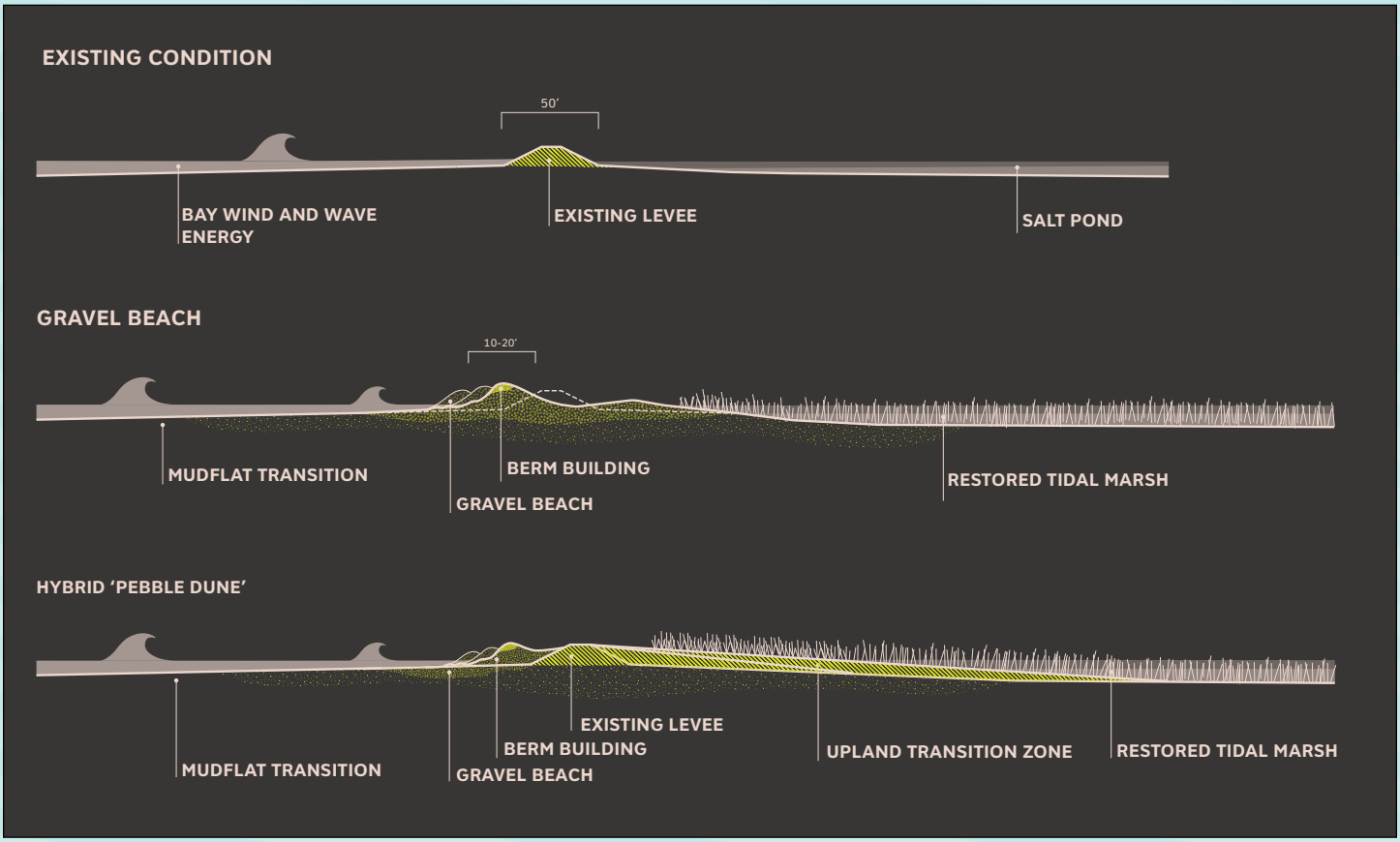
"It would work with the waves to rebuild (itself) and dissipate wave energy while also providing habitat, especially for shorebirds and terns, and potentially for aquatic wildlife as well," Cholodenko says.

The concept holds promise not only at Eden Landing but also across the Central and South Bay where gravel beaches could support resilience, Cholodenko says. "There's a lot of interest in this, so we're really interested in piloting it and seeing how it works." NS

Lots of Permeability

Most parking lots have a single purpose. The one at 951 Turner Court in Hayward has three: public education, water filtration, and the aforementioned parking. Surrounding — and in some cases sitting beneath — its 160 spaces are demonstrations of 14 different flavors of green infrastructure.

The $2.5 million installation is intended not only to inform and instruct (and ideally inspire) the use of green infrastructure, but also to tackle the parking lot's pollutants. It has been in place since last fall and handled runoff all winter, says Sharon Gosselin,



Gravel beach and berm conceptual cross section. The gravel beach and berm, or pebble dune, is a hybrid solution that incorporates the flood risk reduction functions of erosion control with the habitat function of a gravel beach. Image: SCAPE Landscape Architecture DPC

a stormwater program manager with the Alameda County Public Works Agency (ACPWA), on whose property the project was installed.

"We thought this would be a good opportunity to showcase some different features and options for green infrastructure," says Gosselin. "It's kind of a win-win. We also get a parking lot that's treated."

Among the lot's stealthier stormwater-slowing features are pervious concrete, porous asphalt, and permeable pavers, all hard at work beneath the well-used parking spaces. More eye-catching is the 820-gallon metal rain barrel collecting runoff from a 3,000-square-foot roof; the captured runoff is used for landscape irrigation and other non-potable needs. A tenth of an inch of rain is sufficient to fill the tank almost three times over.

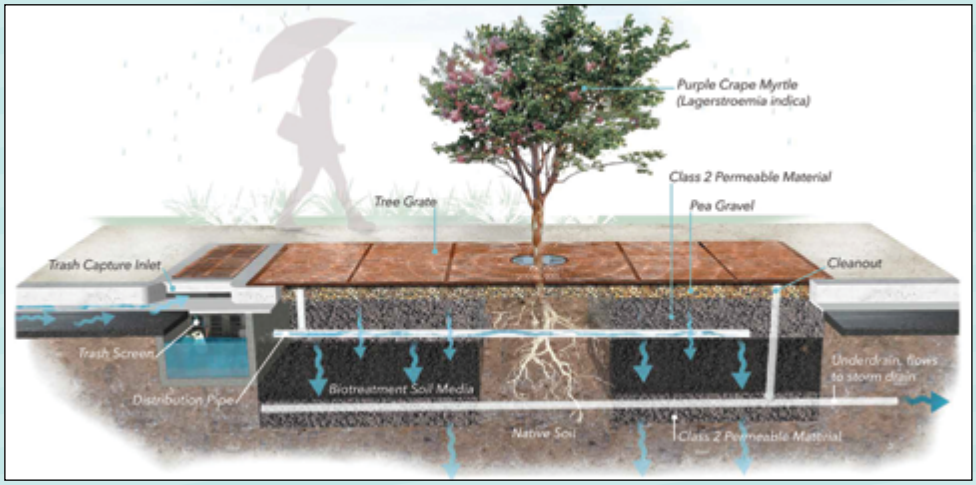
This busy lot also includes working examples of small tree wells designed for high flows in locations with limited space, and of large tree wells with walkable grate surfaces that conceal both a trash-capture device and a large bioretention area where specialized soils filter out pollutants. NS

Valley Rain Garden Inspires More

A weedy vacant lot in Elk Grove became one of the first large-scale rain gardens in the Sacramento Valley — and the state — in 2012, and inspired the city to build five more rain gardens. The one-acre Rain Garden Plaza includes a dry well that recharges groundwater, a plaza with different types of permeable pavement, plants to attract birds, butterflies, and bees, rain barrels and rain chains, community gathering spaces, and a work-out area. The garden was designed to be a micro-watershed that demonstrates how runoff moves through different types of terrain, says Paul Mewton, Chief of Planning, Design & Construction, Cosumnes CSD Parks & Recreation.

The garden, which retains all runoff of one inch or less in 24 hours, is popular on school tours as well as with developers wanting to learn how to capture stormwater on their sites. Mewton says the garden includes no costly underground plumbing.

"Elk Grove is a very fast growing suburb of Sacramento," says Mewton. "We wanted the rain garden to double as an outdoor education center that could inform the public about stormwater pollution and what they can do to help." The garden uses river-friendly landscaping principles, he says, which means no pesticides. LOV



Tree well with trash capture device, designed by the city of Fremont. After trash is captured by a screen, stormwater enters the bioretention area where pollutants are filtered out. Credit: ACPWA

Scaled-Back Spine

What is the best way to push green infrastructure innovations forward? Retrofitting cities is tough, with many devilish details — and no one knows better than Josh Bradt, Watershed Specialist and Project Manager with the Estuary Partnership. He's been working since 2012 on an ambitious stormwater "spine" along San Pablo Avenue. Originally planned to include curbside stormwater treatment in seven cities, the spine will now feature four cities — Emeryville, Oakland, Berkeley, and El Cerrito — treating six acres at a cost of $2.5 million. As the overall project manager, Bradt has run into conflicts with unexpected underground infrastructure requiring last minute design changes, lengthy and complicated permitting processes and requirements, changes in city staffs, arson fires on adjacent properties, and jurisdictional challenges. Another challenge is the high cost of working in the public right-of-way. When Portland built one of the first large-scale green streets projects

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A multi-purpose rain garden in Elk Grove was designed to function as a micro-watershed. Credit: Cosumnes CSD Parks & Recreation

The flourishing plants and tailored soils of the Chynoweth Avenue rain gardens filter out oil and grease and other traffic-related pollutants. Inset: The curb extension rain gardens under construction. Photos: City of San Jose

15 years ago, total cost was only $20,000. But the city did all design and construction in house. Not only do most public works projects have to go out to bid, says landscape architect Kevin Robert Perry with Urban Rain Design, but current regulatory requirements often mean building over-sized treatment facilities, adding to the cost.

Despite the challenges he's faced with the spine project, Bradt is excited about its highly visible locations, which he hopes will inspire more. He says one way to encourage more of these projects would be for cities to dedicate a certain percent of their budget for any public right-of-way project to green infrastructure as a component. LOV

San Jose's Newest Green Street Soaks Up Pollutants

The western stretch of Chynoweth Avenue, which runs alongside Martial Cottle Park in the heart of San Jose, used to be a site for illegal drag racing and a source of erosion and other runoff-related water pollution. But now, after 2017 renovations, that has all changed. Cork oak trees are flourishing, along with sedges, rushes, and yellow-flowered yarrow. The street-narrowing project, which aligns with the principles of the city's just-released Green Stormwater Infrastructure Draft Plan, created seven bioretention rain gardens, added a porous asphalt sidewalk, and replaced an eroding bare dirt median with a landscaped, raised curb median that can help reduce traffic speeds. It also provided bike lanes, parking, and pedestrian crosswalks.

"Most cities were built with what we call 'gray' infrastructure, where stormwater goes straight into traditional drains," said Jeff Sinclair, Supervising Environmental Services Specialist with the city, who oversaw grant deliverables for this project. "On the way it picks up pesticides, trash, litter, and sediment, which all get routed into creeks, rivers, and ultimately into San Francisco Bay."

But not the runoff from the retrofitted Chynoweth Avenue. Recent monitoring showed that the rain gardens have reduced stormwater pollutant loads by over 80 percent, according to Tiffany Ngo with the city's Watershed Protection Division. Sediment runoff dropped by 99 percent; most common stormwater metals were reduced by 90 to 96 percent (the exception being copper, which dropped by 77 percent). The rain gardens have also reduced diesel and gasoline levels by over 80 percent each, Ngo said.

The project worked around a variety of constraints, Sinclair said: underground utilities precluded bioretention basins on the south side of the street, so the plan was revised, and the cork trees were planted in the median to help reduce stormwater runoff. "We put in broadleaved evergreen trees, and ensured that the bioretention basins were unlined to promote infiltration into the native soils and reduce overall runoff into the creeks," Sinclair said. Funding was obtained through Proposition 84, the 2006 Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act.

The city is now looking to move beyond a project-by-project approach. "What we have been doing is looking for these opportunities as they come up, and incorporating green stormwater infrastructure where funding allows and where it makes sense technically," Sinclair said. "Now, with the development of our first plan for Green Stormwater Infrastructure, we hope to move forward with a more strategic approach, so we can have a combination of projects throughout our city."

The plan is still pending approval from the City Council, but it aims to implement both smaller, multi-benefit projects such as Chynoweth Avenue, and also larger undertakings that could treat stormwater draining from over 100 urban acres. JC

MONITORING

Next Day Delivery: PCBs, Plastics and Mercury All in One Package

REPORTER ALASTAIR BLAND

The health benefits of eating seafood go beyond protein. Fish and marine invertebrates contain high levels of omega-3 fatty acids, considered "heart-healthy" and important for brain function and development. These important oils, some have speculated, may even have played a role in driving the more recent evolutionary stages, especially pertaining to cognitive powers, of modern Homo sapiens.

But in San Francisco Bay, humans' long and healthy relationship with seafood has turned toxic. Polychlorinated Biphenyls — commonly called PCBs — and mercury, until recently used in various industrial practices, have accumulated in sediments of the seafloor and the flesh of the food chain, making it unsafe to eat certain local fish species.

Mercury, especially in its more biologically available methylmercury form, can disrupt brain development in fetal humans and children. PCBs also cause developmental harm and are carcinogenic.

And because they still linger in the soils of contaminated sites and in many buildings, these compounds are still entering watersheds and, eventually, the marine environment — a prime example of what scientists refer to as legacy contaminants.

This slow downstream chemical migration is one that Lester McKee and colleagues at the San Francisco Estuary Institute hope to cut short, with the help of Bay Area cities and counties. Using funding provided by the Regional Monitoring Program, they've been sampling creeks that enter the central and southern San Francisco Bay for years, identifying the most contaminated waterways.

The team recently released an RMP report summarizing their findings from the 2015, 2016, and 2017 water years, when they sampled a total of 55 sites in urbanized watersheds around the Bay.

The goal of the research, explains McKee, a senior scientist at the Institute, is to help city and county stormwater managers and regulators at the San Francisco Bay Regional Water Quality Control Board pinpoint significant upstream contaminant sources and then direct efforts to treat or excavate and dispose of tainted soils before they leach their legacy into moving water.

"We want to short-circuit that conveyor belt that delivers the pollutants we're concerned about into the food web that people depend on," McKee says. Identifying the largest inputs of pollution, he adds, helps agencies — including city and county governments, the Regional Board, and the California Environmental Protection Agency — find the most cost-effective solutions.

Alicia Gilbreath, an environmental scientist with the Estuary Institute and the lead author of last July's report, has carried out much of the data collection. To properly sample a waterway, she says, the scientists must be ready as the rain begins to fall — and preferably just before — since precipitation immediately mobilizes contaminants from urban land surfaces.

In some cases, they get negative readings — very low concentrations of pollutants in the water. This could be a false reading, which repeat testing can determine. If a sampling site consistently registers uncontaminated water, "we can exclude those areas from further attention," Gilbreath says.

Positive readings call for further inspection. "We'll then sample smaller watersheds higher up in the same system and try and get closer and closer to the source property," she says.

Eventually, the detective work is passed on to local officials and scientists like Chris Sommers, a consultant working with city governments on PCB abatement projects. Their job is to locate the exact source: not a simple job in a crowded urban area.

"It can take eight to ten years to get to the point where we can say, 'That property is leaking PCBs into the environment,'" says Sommers of Oakland-based EOA, Inc. Eventually, the remediation work itself begins. That's also a slow process that can involve years of taking apart structures built with PCB-loaded materials and trucking the debris away to hazardous-waste sites.

Rainy days sampling. Photo: SFEI

Green infrastructure projects have meanwhile gained popularity as a simpler tool for cost-effectively treating and filtering runoff that can carry contaminants into storm drains and the Bay. Thousands of such projects have been built across the Bay Area since about 2003, when the Regional Water Quality Control Board began requiring them as components of certain developments. Indeed, the board is eagerly awaiting the region's first round of official municipal green infrastructure plans, due this September (see p. 8).

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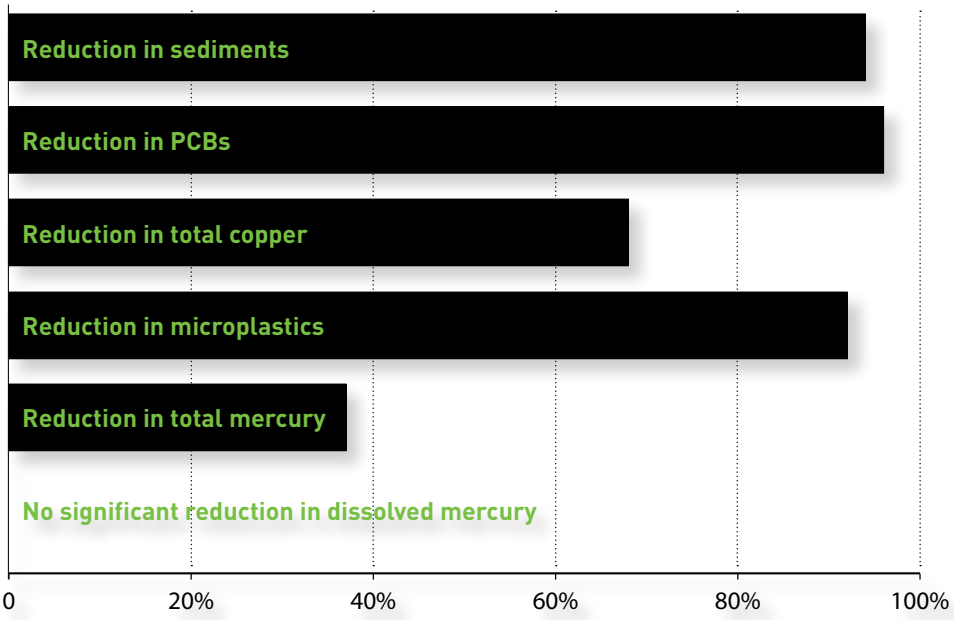
CONTAMINANTS REMOVED BY GREEN INFRASTRUCTURE



Source: SFEI

Sommers says green infrastructure projects are slowly transforming Bay Area streetscapes. "You're going to start seeing a lot more vegetated urban streets," he says. Research shows they're working, too. For instance, a series of simple sidewalk garden cells planted in 2010 along San Pablo Avenue in El Cerrito has retained in the soil 90 percent of the microplastic particles that otherwise would have entered the Bay, according to monitoring by the San Francisco Estuary Institute. The gardens also appear to be retaining PCBs and methylmercury, the highly toxic form of mercury that bioaccumulates in the muscle tissue of Bay fish.

But in spite of progress in stemming the flow of toxins into San Francisco Bay, the ecosystem remains contaminated, and probably will remain so for decades. Jay Davis, a senior scientist at the Estuary Institute, says this is because "the Bay acts like a big sediment trap," a place protected from the flushing action of the ocean. "This makes the Bay in general slow to respond to load reductions of persistent pollutants like mercury and PCBs."

And there is another complicating factor: Just as past generations used chemicals that left a toxic imprint on the environment, we are likely leaving a similar legacy in the form of what scientists classify as "contaminants of emerging concern."

The Estuary Institute's Rebecca Sutton leads studies in this field. She says the research community at large is increasingly monitoring a class of water- and oil-repelling chemicals called per- and polyfluorinated alkyl substances, or PFAS. They are still used in household fabrics and upholstery products marketed as stain- or water-resistant. They are also used in firefighting foams, and, Sutton says, "have been found in Bay harbor seals and bird eggs at levels of concern."

Microplastics, she says, will also leave their legacy. In about three decades, in fact, the ocean may contain more plastic than fish, scientists warn — a pollution problem that may end up equaling or surpassing the current challenges with PCBs and mercury.

As far as those legacy contaminants go, McKee and Gilbreath say the Institute's sampling hasn't shown any trends in inputs from stormwater yet. But work began only 17 years ago, and even longer-term datasets are needed to detect trends in noisy data, where patterns can be difficult to see amid so much variation.

Looking ahead, the Institute is already working to identify PCB trends in stormwater over the coming years as more and more of the management effort that Sommers talks about comes to fruition. The Institute has also developed a method for a longer, higher-resolution look back using wetland sediment cores. A 20-centimeter sample, collected using a long cylindrical tube, can represent roughly 50 years of sediment deposition, vertically arranged in a tidy chronological summary of long-term trends in water quality.

Davis says wetland core samples from around the Bay consistently show a peak in PCB loads around the 1960s and a steady decline ever since. One site — Wildcat Marsh, in San Pablo Bay — registered a massive decline from 290 parts per billion of PCBs to just 10. Mercury concentrations have also been declining, Davis says, with core samples showing similar peaks in the 1950s and 1960s.

Putting an end to the inflow of contaminants to the Bay won't immediately make all local seafood safe to eat again, but it will mark the beginning of a healing process. "Even if we reduced inputs by 90 percent, it's still going to take decades," Gilbreath says, "but the sooner we can stop the inputs of these contaminants, the sooner the Bay can have a chance to start to recover."

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Super-Shore of the Future: A Multi-Habitat Experiment

REPORTER ARIEL RUBISSOW OKAMOTO

Interview anyone of any stripe about the Giant Marsh living shorelines project and the same two words will be in every other sentence: high tide.

Each construction step of this California Coastal Conservancy-led effort to build new native oyster reefs interspersed with eelgrass off the Contra Costa County shore must consider the timing of tides. High enough to float a barge or Boston whaler into the shallows, do a day's work, and get back out again on the next cycle. Three feet at least of draft — the amount of boat below the surface which varies depending on its weight — and preferably not in the middle of the night.

On April 18, as the contractor Triton Marine placed 180 1000-pound reef balls topped with clean Pacific oyster shell in the shallows off Point Pinole Regional Shoreline, the day time high tide occurred at 12:44 pm and lasted longer than in other seasons. That's several feet above mean lower low water (MLLW), a mouthful of metric related to the high-low tidal cycle caused by the pull of the moon on the ocean and familiar to most people designing, building, or permitting projects within San Francisco Bay.

"What we didn't expect was for Triton to want to rest the barge on the mudflat at low tide," says Renee Spenst of Ducks Unlimited, which managed construction. Despite initial worries about damage to the bay floor, regulators concluded the footprint was small and the local organisms in the oozes would rebound — a decision that helped optimize work periods for Triton, avoided night work that would bug the birds, and eliminated the need to explore alternatives such as heavy-lifting by helicopter.

"Subtidal work is not for the weary," says the Conservancy's Marilyn Latta, who led the three-year, 19-partner effort to birth this new living shoreline. The $3 million dollar project is designed to test the ecological and shoreline protection benefits of nature-based infrastructure in San Francisco Bay, and was partially paid for with *Cosco Busan* oil spill settlement funds.

Triton Marine lowers a reef ball from crane. Photo: Avra Heller

Scaling up from the Marin Test Run

When Latta and a team of scientists from the SFSU's Estuary & Ocean Science Center (EOS), the Smithsonian Environmental Research Center, UC Davis, and others built a pilot oyster reef on the San Rafael shore in 2012, four million native Olympia oysters settled on the new structures. The Marine pilot tested a variety of reef structure types and planting methods for associated eelgrass, and measured the response of wildlife. The results of these tests are informing the scale up of the project at Giant Marsh on the East Bay shore.

The impetus of all this experimentation is to beef up biodiversity. "Oysters and eelgrass are what we call foundation species," says Katharyn Boyer, lead scientist for the San Rafael and Giant Marsh Living Shoreline projects, and a ecologist with the EOS Center. "This means they provide habitat and functions that benefit other species."

There's much more to the Giant Marsh project than expanding habitats for a mollusk and a seagrass, however. A map of the design shows a mosaic of plantings, oyster reef structures, and experiments extending from Bay shallows all the way to the edge of the uplands, and encompassing the tidal marshes in between. Seven habitat treatments with a footprint of about two acres are scattered across this shore zone habitat gradient over an area totaling 350 acres. In one spot, biologists are reintroducing the locally extinct California

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sea-blite — a salt tolerant succulent. In another spot, they will collect cobbles to on which Pacific rockweed has attached itself and place them around some of the new reefs to add shelter and shade for the oysters. In still another, they will remove invasive Atlantic cordgrass and hybrids, and replant with the native species, then monitor the site to make sure the invader doesn't make a comeback.

"We're integrating eelgrass and native oyster restoration with wetland and upland transition zone restoration treatments at one location in the Bay for the first time," says Latta.

Every piece of the new eastshore project is based on lessons learned and research questions raised by its predecessor on the Marin shore. On the west side, for example, they learned that some reef designs held up better than others, and that eelgrass did better on the shoreside rather than the bayside of reefs.

The reefs elements were constructed out of a material Marilyn Latta calls "baycrete." Baycrete is a mixture of sand and fossilized oyster shell mined from the Bay and Portland cement.

"When layered up in our reef elements, shell offers lots of nooks and crannies that provide plenty of attachment space, shade, and moisture," says Chela Zabin, an artist (see cover) turned biologist with the Smithsonian Environmental Research Center also on the Giant Marsh team.

At the San Rafael test site, a number of patterns also emerged that caught Zabin's eye. "We saw more oysters lower down, more oysters on north sides, more oysters on horizontal than vertical surfaces. Taken all together, we're thinking this is a signal that heat stress affects oysters."

Which is one reason why Giant Marsh project will be the first living shorelines project to try to incorporate rockweed, one of the brown seaweeds that naturally drape over rocky intertidal zones around San Francisco Bay.

"Rockweed doesn't mind getting dried out to a crisp, so it could help oysters with heat," says Zabin. "If rockweed really helps oysters survive better when the tide's out, it could be important with climate change, as oysters are exposed to higher and higher temperatures and risk of desiccation."

At Giant Marsh, the team hopes to recreate or enhance the historic function of each kind of plant, habitat, and species in the shore zone. It also hopes to confront sea level rise head on in the habitats of the last few California Ridgway's rails and salt marsh harvest mice. Nature-based infrastructure may be able to help both these endangered species, and people and property on the bayshore, adapt in ways seawalls cannot.

Oysters attach to all kinds of surfaces, even a deflated ball adrift in the Bay. Photo: Chela Zabin

"Fourteen years ago we were doing small scale trials, everything from Save the Bay hanging oyster shell necklaces off piers to see if they attracted more oysters to our teams experimenting with planting methods for eelgrass," says Boyer. "While we learned quite a bit about how to restore these species for their own sake, the big evolution in our thinking is to do restoration for all the possible ecosystem services provided by their habitats."

"The project is a great opportunity to understand what's possible," says Matt Graul of the East Bay Regional Park District, which shares ownership of the property dedicated to this big experiment with the State Lands Commission.

Understanding the Site Dynamics

Point Pinole was one of seven sites in the waters off four Bay Area counties that the living shorelines team explored as candidates for their next big experiment.

"We were looking for a site to test natural infrastructure that had some wind causing natural shoreline erosion, but not such strong winds or big waves that reef elements wouldn't help. We wanted our structures to be effective," says Michelle Orr, an engineer for ESA (Environmental Science Associates), who has designed dozens of marshes, floodplains, and habitat restoration projects along the West Coast and on inland waterways.

Initial data from the San Rafael pilot site had shown that the reefs reduced wave energy up to 30 percent. Historic research at Point Pinole had documented the erosion and retreat of the shore by up to 500 feet between 1855 and 1993, making it a good candidate for trying natural infrastructure.

In planning the project, Orr and the team also had to think about shape and softness of the Bay floor, the swirl of sediment around any new structures, and the design, arrangement, and size of the oyster reef elements. The team designed the reefs at different angles, densities, and distances from the shore to make the most of this living experiment (see map opposite).

"The longer the reef, the less waves can bend around it," says Orr. "It can't just be solid, you have to have ecological connectivity on both sides of the wall. That's why we designed it in a checkerboard pattern."

Orr and the Giant Marsh team settled on three reefs situated 500-1,500 feet from the shore. The reef treatment farthest offshore is designed to achieve maximum ecological benefits for deeper water organisms, fish, and fowl. The treatment nearest to shore offers a combination of ecological, wave attenuation, and shoreline erosion prevention benefits that amount to the kind of natural infrastructure we may need in the future as the Bay rises. The treatment in the middle is a hybrid.

"From an engineering perspective, we spent the most time on the nearshore treatment," says Orr. While the team's surveys of oyster recruitment rates at different tide heights suggested the highest oyster densities occurred at MLLW, Orr knew she couldn't create the reef at that level because it would be too far from shore to slow waves: "We tested the design closer and closer to shore, and higher and higher in the tidal range, and found there was a sweet spot at 1.5 feet above mean lower low water. It was a bit of tradeoff, fewer oysters but better wave attenuation. As sea levels rise, however, the nearshore reefs will get deeper and be covered by tides more often, so they will support more oysters into the future, which gave us some comfort."

Treatment Plan for 350-acre Giant Marsh living shorelines site. Map: ESA

Fill with Frills

It's no surprise to anyone familiar with the Bay regulatory environment that this project — in all its multi-species, multi-habitat complexity — took time to get approved. Three years passed between inception and implementation, and two of those years involved permits.

"There have been oyster reef ball projects permitted and installed before, but never on this scale in California or the West Coast," says US Army Corps of Engineers project manager Myla Ablog. "The process took longer. In addition, 2017-2018 was the year we had so much rainfall and so many fires we had more emergency permits to approve than in all years prior. It was also the year of the federal shutdown. So the oyster reefs came in two seasons behind on the installation."

Oyster blocks

Initially, project leaders hoped Giant Marsh might be approved under the forward thinking nationwide permit for living shorelines the Corps released in 2017. But for the subtidal work, permit conditions geared towards the East Coast and the Gulf Coast didn't fit local conditions.

Another setback came when Triton Marine finally worked out the details of how they would do the work, which didn't quite match up with original permit conditions. Instead of working only during high tides, which limits the work window, they asked if they could rest their barges on the bayfloor at low tide.

"We have these beautiful wide mudflats that feed all the shorebirds around the Bay but create difficulties in terms of constructing new habitats in subtidal or tidal areas," says the Bay Conservation and Development Commission's Brenda Goeden. For the Hamilton tidal restoration project, she remembers, they had to run five miles of pipeline over the mudflats to move marsh-building material in the form of mud to the site — an expensive early experiment. "It's really challenging to get barges into such shallow water. When Triton asked if they could just sit on the mudflat, we had to ask for how long, and what the square footage of the footprint would be?"

Another unexpected twist in the approvals process was the discovery of a number of seasonal hunting blinds right where the project was planned.

"We ended up relocating everything farther north, which was a little hard because the bathymetry changed," says ESA's Michelle Orr. "But we didn't want boats running into our reefs, or hunters shooting near our restoration sites."

Of course the project had one big factor going for it — it aimed to make habitats for fish and wildlife better not worse. According to Ablog, "Projects that benefit the environment, or get done under the nationwides, rarely get a lot of press. [Everyone thinks] the federal government is slow and rejects everything, so applicants come in with knees knocking, afraid they're not going to get a permit. But 95 percent of all applications do get permitted across the US. In California, our division permits billions of dollars worth of public, private, and NGO projects every year."

Forward Thinking

The Giant Marsh project sits on a county shore that's getting lots of attention in terms of innovative, forward thinking improvements. At nearby Point San Pablo, conservation agencies recently removed derelict creosote-coated piers and the Red Rocks warehouse (hauling away 445 tons of debris). At Point San Pablo, an earlier 2016-2018 Conservancy project has already placed 200 oyster reef elements and planted four acres of eelgrass in the area. At another site, Chevron has worked with Baykeeper and the City of Pinole to open Point Molate Beach Park. All these projects also dovetail with the North Richmond Shoreline Community Vision that not only recommends implementation of the Giant Marsh project but also addresses local concerns about affordable housing and environmental justice.

continued on back page

REGULATION

Permitting Opens a Fast Lane

REPORTER CARIAD HAYES THRONSON

Restoration projects eligible for Measure AA funding will find their path through the daunting thicket of permit applications considerably smoother come fall, when the Bay Restoration Regulatory Integration Team begins accepting applications. The initiative is designed to accelerate the pace of regulatory approvals for large-scale projects, long bedeviled by a cumbersome multiagency permitting process.

The Bay Restoration Regulatory Integration Team (BRRIT) consists of one staff member each from the six state and federal regulatory agencies involved in restoration permitting: the Bay Conservation and Development Commission (BCDC), San Francisco Bay Regional Water Quality Control Board, California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and U.S. Army Corps of Engineers. Team members will work exclusively on permitting multi-benefit restoration projects.

"Capacity at regulatory and resource agencies has been one of the big issues," says the State Coastal Conservancy's Amy Hutzel, noting that a permit application to one agency often requires consultation with others. "That consultation can take quite a while, just because agencies don't have adequate permitting staff." Beginning in the fall, instead of working sequentially, the six agencies will work together on parallel tracks to review projects and resolve issues.

Although restoration boosters have longed for years for a more efficient permitting process, concrete progress toward that goal was elusive until last June, when the San Francisco Bay Restoration Authority committed $650,000 per year to fund the BRRIT. Four other agencies —the Coastal Conservancy, Santa Clara Valley Water District (now known as Valley Water), Bay Area Toll Authority, and East Bay Regional Park District — provided matching funds.

"Innovating in government is easiest done when there are incentives," says BCDC's Brad McCrea. "Funding can't be emphasized enough." He adds that it's critical to have "a group of people from different agencies who trust each other, recognize that there is a problem, and are open-minded about trying new ideas."

"The Restoration Authority is really excited about this," says Hutzel, who led the funding drive. "I see three issues that keep restoration projects from moving forward rapidly: funds, mud, and permits. We are addressing the funding with Measure AA, and [steadily] improving sediment management. Increasing the efficiency of permitting these projects is really the third leg of the stool."

Overseeing the BRRIT is the Policy and Management Team, composed of management personnel from each agency, as well as the U.S. Environmental Protection Agency. The policy team has been meeting since last fall to lay the groundwork for the BRRIT, says McCrea, who currently serves as policy team chair. "We want to make sure that the BRRIT gets started on the right foot. We really want the initial BRRIT applicants to be able to share success stories."

According to McCrea, the policy team will support the BRRIT by addressing issues it can't resolve on its own or that adversely affect permitting of restoration projects. One such issue involves possible revisions to Bay Plan policies regarding fill. A proposed new BCDC policy "to be intentional about the need for filling the Bay to improve habitat" will receive its first public hearing on June 20, says McCrea.

Although there have been other efforts to simplify permitting, such as the Coastal Commission's programmatic permits for restoration projects in the coastal zone, those streamlining efforts "usually try to tackle it by narrowing the field — 'If you do this kind of project, under these conditions, and you keep it to this size, then we can get your permit turned around in a few weeks,'" says the EPA's Luisa Valiela. "The BRRIT is the exact opposite, acknowledging that the really big projects that we want to see happen are super complicated and super difficult and they involve every single agency and authority. That's why everyone's been working so hard to make this happen — the promise is so bold, we will really finally crack these super hard nuts."

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Photo: Rick Lewis

S P E C I E S

Tailing a Thrush

REPORTER JOE EATON

Banding ("ringing" to the British) is the old-school approach to studying songbird migration. Useful for documenting year-to-year survival, it's only informative about routes and destinations if the bird happens to be captured or killed on its wintering grounds or in transit. For smaller birds like warbling vireos, banding is still state-of-the-art. With somewhat larger birds like Swainson's thrushes, though, new technology is providing an unprecedented level of detail about migratory connectivity. Researchers like Point Blue Conservation Science ecologist Tom Gardali have equipped thrushes, weighing just over an ounce (31 grams), with one-gram GPS tags, fastened to their legs and resting on the lower back. If recovered, the tag shows the thrush's exact winter destination, information vital to border-spanning conservation efforts. The devices don't seem to impair the birds: recapture rates for GPS-equipped thrushes are similar to those for untagged birds.

For anyone who's spent time in California's riparian zones, the thrush and the vireo are familiar nesting-season voices. Not as colorful as orioles, grosbeaks, warblers, or tanagers, these neotropical-migrant songbirds compensate with their vocal chops. Their styles differ: warbling vireos have loud, cheerful songs, sometimes delivered from the nest (a seemingly maladaptive trait), while the ethereal woodwind tones of the Swainson's thrush have inspired panegyrics from generations of nature writers.

What the two share, apart from being Riparian Habitat Joint Venture focal species, is an annual circuit between California breeding grounds and more southerly wintering quarters. Banding indicated that California nesting populations of both species winter somewhere in western Mexico. GPS tags now allow pinpoint accuracy, revealing unexpected patterns of thrush migration. While coastal-breeding Swainson's do head for Mexico, thrushes tagged in the Cascades and Sierra go considerably farther. The difference may help explain the decline of the Swainson's thrush in the California mountains — what Edward C. Beedy and Edward R. Pandolfino, in *Birds of the Sierra Nevada*, called "one of the unsolved ornithological mysteries of the Sierra."

Photo: Point Blue

For over 50 years, Point Blue has caught songbirds in mist nets at its Palomarin Field Station near Bolinas, equipped them with coded leg bands, and logged the extremely rare recaptures from other banding stations. Banding, along with breeding-season surveys, gives a broad picture of population trends. In 2000, Gardali and colleagues reported a sharp decline in warbling vireo numbers, apparently linked to low reproductive success. Loss of suitable wintering habitat in western Mexico (riparian gallery and other tropical evergreen forest types, mixed forests, shade coffee plantations) may also have played a role, but the effect was unclear.

Unlike the vireos, Swainson's thrushes are robust enough to accommodate sophisticated tracking technology available within the last 10 years. In 2010, researchers attached light-level geolocators to 35 thrushes in Marin County, and recovered 12 over the next two years. Eleven of the birds had migrated to the Jalisco region of western Mexico, two moving east into the Mexican mountains. But geolocators couldn't capture their locations at twilight or near the equinox.

Three years ago, Gardali and researchers from the Tahoe Institute for Natural Science began using GPS tags, greatly improving resolution.. "You only get a few readings; there's not much battery life," he says. "And you still need to get the tag back. We expect about a 30 percent return rate. But GPS goes to a spot on a map. This is Holy Grail stuff. One Swainson's thrush went to a former prison island, now a biosphere reserve, off the coast of Mexico. We could put the bird right on that island."

Coastal-breeding Swainson's thrush populations appear stable. In California's mountains, though, the birds had vanished from historic nesting sites by the 1960s, despite intact riparian habitat. Parasitism by brown-headed cowbirds didn't appear to be a factor.

Sierra/Cascade thrushes were presumed to migrate to Mexico like their coastal cousins. When researchers included thrushes from Mount Lassen and Lake Tahoe in their GPS work, they learned otherwise. "The mountain birds are going from Mexico to Panama, possibly as far as Colombia," Gardali explains.

In addition to the longer route, mountain conditions impose a shorter breeding season, raising the stakes for reproductive success. "Shorter-distance migrants are more flexible in terms of adjusting their timing to matching resources on the breeding grounds," he adds. This would include adapting to climate-induced changes in the life cycles of their insect prey. Landscape-level changes add another complication: "Coastal thrushes had less forest-stand removal on both their breeding and wintering grounds than mountain thrushes. Greater vegetation change and longer distance increases vulnerability to environmental change."

Neotropical travelers like Swainson's thrushes and warbling vireos aren't the only migrants of concern. Other songbirds nest in the far north, where conditions are also changing, and winter in California. "We're capturing golden-crowned sparrows and fox sparrows in winter and tracking them," Gardali says. He expects it's only a matter of time until vireo-grade GPS tags are in play: "Scientists are doing everything they can to reduce the weight of these devices so that the extra burden carried by a few feisty birds can safely contribute to the conservation of migratory birds across the Pacific Flyway."

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GROUPTHINK

"The State Board has a pretty complete purview over California water operations, so the question [is] how do we incorporate the myriad impacts of climate change into our work. [For example] groundwater is ultimately California's long-term buffer, so how we do groundwater recharge is critical. So are we making sure that we aren't an impediment to recharge? Are we incorporating the need for recharge into how we permit?"

JOAQUIN ESQUIVEL, CHAIR, CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

"Climate change is a threat multiplier that is already occurring, and will exacerbate already growing pressures — sea level rise, droughts, and spread of disease and pests — on critical ecosystems, biodiversity and wildlife. There is a great need for strong research to better equip policy-makers and landowners with tools to address these increasing and complex pressures."

MANUEL OLIVA, CEO, POINT BLUE

"Of most concern for water quality with respect to climate change is the increased frequency of drought conditions and extreme rainfall events. Increased contaminant transport during extreme rain events could reduce water quality in wet years. Decreased flow during drought years could reduce the quality of wastewater treatment plant effluent being released into the Bay. The oscillation between boom and bust water years will likely also have implications for sediment supply to the Bay. Reduced sediment supply will increase the clarity of the water, which may fuel algal blooms. A lack of sediment also hinders the ability of marshes to keep pace with sea level rise. The long RMP time series can be used to assess trends and water quality during these extreme conditions."

MELISSA FOLEY, MANAGER, REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

OPINION

New BCDC Leaders Talk Climate Change

Jessica Fain, Planning Director for the Bay Conservation and Development Commission (BCDC) since October, and Dana Brechwald, Manager of BCDC's Adapting to Rising Tides (ART) project, spoke with ESTUARY magazine about how climate change is challenging the agency, and how it is responding.

FAIN: The agency was created to stop the filling of San Francisco Bay, but that mission has fundamentally changed now that the Bay is expanding. We've been in the sea level rise business for years, but now BCDC, in partnership with stakeholders and local jurisdictions, is preparing to lead the next chapter by embarking on the creation of a regional shoreline adaptation plan for the entire Bay. As we do so, a number of questions are on our minds: How do we pivot from being the agency created to stop the shrinking of the Bay to the agency that manages its growth due to rising seas? How can we focus in on issues of regional significance beyond local capacity but also ensure that it reflects community priorities? And how can we organize as a region to fund it?

BRECHWALD: "We can't get anything done without widespread public support for increasing the urgency of this issue in the eyes of our elected officials, and support in [in the form of votes] for actions that may feel uncomfortable but that preserve the Bay Area in the long run. [Examples include] taxing ourselves to pay for infrastructure or giving up some local land-use control to ensure that some cities aren't making decisions that have unintended negative consequences for others.

FAIN: Government folks have been thinking about sea level rise [for some time] but it's not a front-of-the-mind issue for many Bay Area residents. [To bring it forward, we may need to think about] an educational campaign, partnerships with local groups, and local integration of sea level rise issues into general plan updates or other mechanisms.

BRECHWALD: The biggest challenge is that it is difficult for people, including decision-makers, to plan for uncertain, long-range challenges. We know that in order to make the greatest impact, especially through nature-based solutions, we need to start now.

FAIN: We need more of a regional strategy that links planning to permiting. I think we're getting to the point where there's some agreement on what the regional priorities are and how to think about sea level rise on a Bay-wide scale.

BRECHWALD: So far, the focus of ART has been to deeply understand the vulnerability of the region to sea level rise, and lay out a set of tools and actions that can be responsive to this vulnerability. Our future challenge is integrate that information into daily local and regional decision-making.

FAIN: Equity and environmental justice are really important. In thinking about regional adaptation work, a key focus is looking at vulnerable communities. We have a community vulnerability index with 14 socioeconomic characteristics identifying communities [that are] less resilient to climate change. There's ongoing mapping and analysis work, along with some more direct community engagement in partnership with local nonprofit groups.

BRECHWALD: Climate change, more than anything we've faced in the past, is a problem of the commons—everyone's actions impact everyone else. We do not live in a society that knows how to deal with these commons problems very well, but it is the only path forward.

QUESTION OF THE MONTH

What is the elephant in the room in your Estuary work?

LOUISE CONRAD

Science Program Director
Delta Stewardship Council

"Climate change is the elephant in room for delta science. As our independent science board recently suggested, we need to start shifting our science approach from explanatory — how things work now — to predictive — what will conditions be like later? And are we ready for these changes? And what are going to be challenges for managing species of concern years down the road?

"Where the council's science program will go deep, initially, is with respect to the ecosystem. We can review existing data, for example, to see if we can find specific signals of climate change now in specific [natural] communities. We already know a lot about temperature stress on salmon and other species. Now we need to put ourselves in the shoes of various organisms and project what may happen as salinity rises or newly restored habitats change.

"Another big gap is on the human side — what will climate change mean to communities and economies at risk in the Delta? This social science piece is huge, and we are working to enhance our capacity for that now at the council. This year, the council has engaged a social science task force made up of regional experts, with a report due out later this summer that will provide guidance to our community in developing social science research for climate change purposes and for other needs.

"In general, in terms of climate change, I'm hearing within the agency that we have some urgency around this. We need to partner with other agencies to infuse more dollars into innovative, competitive climate science, harnessing the creativity in universities, nonprofits and other programs both here and out of state. You can't underestimate what that collaboration can do for you."

Louise Conrad grew up in Philadelphia, developed an interest in conservation on family road trips to national parks, learned to like fish at UC Davis, and managed DWR's estuarine science and synthesis program before joining the Delta Stewardship Council.

www.sfestuary.org/estuary-news-question-of-the-month

YOUTH, *cont'd from page 7*

The trust that Moore engenders in his pupils is obvious at Malcolm X Academy. Students are not only eager to share their work with adults whom they haven't met, but seem unfazed by the puzzled bemusement adults often express when presented with the work of a child. Take for instance, Amir J., a shy boy who quickly warmed up and showed me his contribution to the diorama he had worked on with Antahj: A circular park on the bayshore featuring a tall statue and a wooden device he explained was for filtering trash out of the bay water. I asked him who the statue was of, but he didn't really have an answer, just shrugged and said something to the effect of "anybody really." It speaks to the value of a malleable mind given room to grow. Why do statues have to be of somebody? Why not just one of no one in particular, cleaning up trash along the shoreline?

San Francisco Estuary Partnership
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www.sfestuary.org

San Francisco Bay and the Sacramento-San Joaquin River Delta comprise one of 28 "estuaries of national significance" recognized in the federal Clean Water Act. The San Francisco Estuary Partnership, a National Estuary Program, is partially funded by annual appropriations from Congress. The Partnership's mandate is to protect, restore, and enhance water quality and habitat in the Estuary. To accomplish this, the Partnership brings together resource agencies, non-profits, citizens, and scientists committed to the long-term health and preservation of this invaluable public resource. Our staff manages or oversees more than 50 projects ranging from supporting research into key water quality concerns to managing initiatives that prevent pollution, restore wetlands, or protect against the changes anticipated from climate change in our region.
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COVER IMAGE: *Fucus* Fantasy, a water color painting by Chela Zabin. *This image may not be reproduced without the artist's permission.*

GIANT MARSH, *cont'd from page 19*

The Giant Marsh project also nests nicely within recommendations of a new Adaptation Atlas co-published by the San Francisco Estuary Institute and SPUR. Finally, it also reflects further progress in implementing the 2010 Subtidal Habitat Goals. Giant Marsh is the fifth and largest pilot living shorelines project to be built since 2010.

The team and the construction crew hope to complete the oyster, eelgrass, and rockweed elements of the Giant Marsh project by July 2019. But even that won't be the end of it. The project includes additional cordgrass and transition zone plantings, and a comprehensive monitoring plan that will measure everything from plant survival rates to wave energy deflection to biological response.

"We're even trying to measure the degree to which these restoration projects sequester carbon and reduce acidification," says Boyer, referring to planned tests of carbon levels in live and dead plant material above and below the soil. Low pH (high acid) waters hamper the ability of oysters to make shells. But eelgrass, through photosynthesis, can draw carbon from the water and raise pH. "The question we hope to answer is 'Can we use restoration of eelgrass to promote that process? Can we actually measure a lasting effect locally?" says Boyer.

'We're encouraged to see experimentation with alternative methods moving forward," says Goeden.

"We are going to see sea level rise effects magnify. We need to know what tools are in our toolbox sooner rather than later," says Boyer.

Experimenting with training California sea-blite to grow over eucalyptus limbs culled from nearby trees on a Marin Beach. This method endeavors to create taller arbors where birds and mice can escape high water, an approach now being tested at Giant Marsh. Photo: Melissa Patten

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DEEPER DIVE

Extended story with technical details +Video including partner interviews

www.sfestuary.org/estuary-news-Giant-Marsh-living-shoreline/