SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
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TO: Commissioners and Alternates

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SUBJECT: Analysis of a Tidal Barrage at the Golden Gate
(For Commission information only)

Summary

Global warming is likely to cause an acceleration of sea level rise, which has already increased water levels in San Francisco Bay seven inches over the past 100 years. Concerned that water levels in San Francisco Bay could rise nearly one meter by 2100, BCDC determined that over 200 square miles of land and development worth over $100 billion could be at risk.

To protect these low-lying areas, hundreds of miles of levees, dikes and seawalls may have to be built along the Bay shoreline. Believing it inevitable that someone will propose building a dam across the Golden Gate as an alternative to these extensive shoreline protection structures, the Commission's staff decided to undertake a cursory evaluation of such a structure. In addition to investigating whether it would be effective to build a tidal "barrage" (the technical term for a barrier across a waterway), the staff decided to evaluate whether it would be possible to incorporate a tidal energy generation system into the barrage, which could allow a single project to both provide clean energy and address the impacts of sea level rise.

To carry out this investigation, the Coro Center for Civic Leadership assigned a Coro Fellow, Kirstin Conti, to spend a month at BCDC to evaluate the advantages and disadvantages of such a proposal, assess the economic and environmental impacts of such a project, and determine what additional information and studies are deeded to evaluate such a proposal.

This report briefly details the potential effects that placing a barrage at the Golden Gate may have on the Bay's ecosystems, economy, and people. Ms. Conti developed the scenario and location based on her research and best professional judgment. Overall, the results of this investigation indicate that constructing a barrage at the mouth of San Francisco Bay would likely be physically and economically impractical, as well as ecologically damaging. Additionally, large-scale tidal energy projects at the Golden Gate Bridge are unlikely to be cost effective or feasible. Given the enormous

cost, limited effectiveness, questionable feasibility, and probable significant adverse economic and ecological impacts of such a project, it does not seem prudent to seriously further consider such a proposal.

Staff Report

Background. In the Bay Area and globally, discussions regarding the impacts of climate change, and particularly sea level rise, reach from local communities to the highest levels of government. Much of this discussion centers on how to minimize carbon dioxide emissions into the atmosphere, thereby slowing global warming and related sea level rise. Using fossil fuels for energy increases carbon dioxide in the environment. Therefore, communities are increasingly looking to renewable energy sources such as hydro, solar and wind power. At the same time, scientists have concluded that the earth is currently warming at an accelerated rate not seen in human history, and any reductions in carbon dioxide emissions made today will perhaps slow the predicted changes, but not eliminate them. Some estimates predict that the sea level in the Bay Area will rise approximately one meter over the next 100 years as shown in Figure 1, or approximately 16.5 inches in the next fifty years.

As policy makers contemplate the potential effects of sea level rise on shoreline properties and communities, adaptation measures such as seawalls and retreat are increasingly under consideration. Important investments in homes, businesses, transportation, and habitats need protection. Keeping the Bay shoreline stable at first blush seems desirable and the idea of creating a barrage at the entrance to Bay appears to be a possible solution. (A barrage is essentially a dam used to control water levels in a waterway). This report examines the potential for a tidal barrage combined with tidal energy production to reduce or eliminate impacts of sea level rise in the Bay Area while generating "clean energy" for Bay Area communities.

The Scenario. The barrage would be built on the Bay side of the Golden Gate Bridge, depicted in Figure 2, the optimal location for tidal energy generation. It would be approximately three kilometers (1.9 miles) in length and exceed 150 meters (492 feet) in height. "Open hydro[1]" turbines similar to those shown in Figure 3 would be enclosed within the barrage walls. A lock system would be incorporated to allow vessel traffic into and out of the Bay and thus would extend from the barrage into the Bay. Finally, although the open hydro turbines would allow some fish passage, fish gates and ladders would likely be necessary to ensure fish and marine mammal passage and compliance with the Endangered Species Act.

SF Bay Barrage	
Feature	**Rationale**
Prevents Sea Level Rise	Protect investments
Open Hydro Turbines	Source of renewable energy
Ship Lock System	Allows vessel passage
Wildlife Gates	Allows passage/migration of commercially and ecologically important

[1] Open hydro technology uses a turbine with no center part. This significantly reduces the weight of the turbine making it easier for the tides' power to turn it. Magnets on the spinning turbine are used to generate electricity. This technology originated in Canada.

	species

The features proposed above have never before been combined into a single structure, presenting challenging engineering considerations. Building the barrage in "dry" conditions would require large cofferdams or caissons[2] to hold back the ocean on one side of the construction site while holding back water draining from forty percent of the state on the other side, a significant engineering feat. It is more likely that the barrage would be built in prefabricated sections, that would then be placed and joined in waters over 300 feet deep and with strong tidal currents. In addition, the structural stability of building a concave structure likely cannot be realized at the mouth of the Golden Gate due to the uneven water pressure that would be exerted on either side of the barrage. Another challenge is the tremendous volume of raw materials needed to construct the barrage. The Three Gorges Dam in China, discussed below, is smaller in size than the proposed project, but required 28 million cubic yards of concrete for construction.

The Three Gorges Dam is currently the largest and longest dam in the world. It is similar in length to the proposed barrage, but significantly shorter height. A brief case study of the Three Gorges Dam is in the box below. It details the main characteristics, and ecologic and social consequences of the dam.

Case Study: Three Gorges Dam – Yangtze River, China

The Three Gorges Dam is the longest and largest dam built to date. Construction began in 1996 and completion is projected in 2009. By the time it is finished, it will have taken 15 years to build and cost over $15 billion. The primary function of the dam is flood control, but it also produces 18,200 MW of hydroelectric power. The dam's foundation is built of granite and it is 175 meters high and 3,000 meters long.

The project has been highly controversial because of the social and ecological impacts of building the dam. Scientists estimate that annual fish catches may be reduced by 1 million tons as a result of decline in freshwater and downstream sedimentation. The decline in fish has also contributed to the functional extinction of the Chinese River Dolphin. Over 1.3 million people living next to the river were forcibly relocated, with 40 percent of the project costs being relocation compensation.

Upstream increased sedimentation is creating ecological impacts as well as affecting the physical stability of the dam. Built-up sediment is reducing the dam's lifespan before it is complete, making the overall benefits of the project increasingly questionable.

Given China's traditional, carbon-intensive methods of development, supporters of the project herald the development of hydropower as China's primary means of reducing greenhouse gas emissions. However, recent studies have shown that decomposing vegetation, organics and silt at the now exposed river bottom are releasing large amounts of greenhouse gases downstream of the dam.

[2] A caisson is a watertight structure that aids in the construction of dams, bridges and piers. They are similar to large tubes where water can be pumped out and the work environment kept dry.

Dams have been built for thousands of years for irrigation and flood control purposes. Today many have the additional capacity to provide hydroelectric power to the cities and countries where they are built. Most recently, dams have been criticized due to their negative ecological and social impacts. The ecological and social impacts of the Three Gorges Dam are fairly representative of the effects experienced by ecosystems and societies near large dams and similar structures around the world. For the purposes of this analysis, the effects of a barrage in the San Francisco Bay also should be analyzed in conjunction with the feasibility of developing a tidal energy system and its potential impacts. In addition, it is important to discuss the specific effects a barrage may have on the San Francisco Bay's economy and ecology.

Tidal Energy. Although the concept of harnessing tidal energy is sound, there are technical and environmental constraints to doing so. Not every location that has tides can successfully generate tidal power. Tidal energy analysts have determined that locations with tidal currents of at least 4 meters per second, or 8 knots, and/or that have a 3-meter height difference between high and low tides make viable tidal energy projects. This requirement significantly reduces the number of places where tidal power is feasible. Studies by URS and others are currently underway to see if these and other criteria are met at the Golden Gate.

There are two high tides and two low tides each day along the West Coast. The Bay's tidal currents are approximately 2 meters per second and the difference in height between the high and low tides is 1.5 to 2 meters. This means that the Bay's tides are about half the speed and half the height needed for efficient tidal energy generation.

In addition, only a portion of the Bay's tidal energy can be used to generate power, as a certain amount of energy transfer is necessary to maintain the functions of a tidal system. That is to say, if all of its tidal energy were extracted, there would be no tides within the Bay. Approximately 5 percent of the total available tidal energy in the Bay Area is estimated to be extractible without undue environmental impacts. Extracting only this amount of tidal energy from the Bay would result in about 1 to 3 Megawatts (MW) per day of extractable power[3]. The City of San Francisco alone uses 850 MW of power each day.

Another problem impeding tidal power generation would result from the barrage's role to protect the Bay Area from sea level rise. The barrage would need to hold back that portion of ocean tides which are higher than the water level needed to protect shoreline structures from sea level rise; essentially clipping off the upper part of the tidal range. Therefore, if there were to be a one-meter rise in sea level, the tidal range in the Bay would be cut by half. This would diminish the energy available to generate power.

Tidal energy has been harnessed on a small scale for centuries. More recently people have begun to use it to power cities and larger regions. In 1967, the world's longest functioning tidal energy barrage became fully operational on the Rance River in France. The barrage produces 240 MW of energy at its peak. Outside of this, there are only a few examples of functioning and efficient tidal energy projects.

Economy and Ecology of the Bay. The San Francisco Bay Area is one of the most unique and coveted areas of the world today, not only because of its Mediterranean climate but also because of the high standard of living. A complex network of ecological and economic systems exists in the Bay Area. In order to understand how adding a tidal barrage may change the Bay it is important to understand how these systems currently function and interact.

[3] This number is based on the most recent study of the tides by URS Corporation. It was earlier believed that there was 35 MW of extractable power but that was an error due to a mistaken calculation.

The Bay-Delta Estuary has extremely high ecological value to California in terms of water resources and wildlife habitat. It has a mix of salinity regimes ranging from seawater, through brackish water, to fresh water, creating a mosaic of different habitat types, including 10 percent of the state's remaining wetlands, which support over one thousand species both as residents and migrants. Over 50 percent, or more than one million, of the birds using the Pacific Flyway land in the Bay Area each year, while the Pacific Coast salmon, Dungeness crab and herring fisheries use the Bay as a central support system in their lifecycles.

Overall the Bay is wide and shallow, but the area under the Golden Gate is 100 meters (328 feet) deep and narrow. This dichotomy creates strong tidal currents pumping 400 billion gallons of water that pass in and out of the Bay each day. At the same time, fresh water from over 40 percent of the state drains out of the Golden Gate each year. When salt and fresh water mix they create shifting temperature and salinity gradients both towards the Delta and down into the South Bay that creates habitat diversity. The tides also bring ocean nutrients, plankton and wildlife into the Bay, creating a rich ecosystem.

The Bay's physical and ecological features also support a multi-billion dollar economy. If it were its own country, the Bay Area would have the 21st largest economy in the world––larger than Sweden or Austria. The Bay attracts thousands of visitors each year, and has an active recreational community that includes sailing, fishing, bird watching and beachgoers. The Bay Area has attained this economic prowess not just through its physical characteristics, but in part because the Bay serves as the basis of a thriving port and refinery network. In addition, the Bay receives discharges of many industrial, municipal and agricultural wastes that must be assimilated by mixing and other Bay processes.

Future Changes in the Bay. Over the next 25 years, the Bay Area will change dramatically due to climate change, economic and population growth, and social development that will further strain Bay ecosystems. By 2030, the population is predicted to rise from 7.1 million to 8.7 million. Energy costs will likely rise as we move away from fossil fuels. The mean temperature in the Bay Area is predicted to rise between 1 and 2.3°F from past discharge of carbon dioxide, regardless of how much carbon dioxide is emitted in the coming years.

Profound ecological changes to the Bay will result from climate change. Although climate models predict only small changes in overall precipitation, there will be more rain than snow. Increased liquid precipitation will require increased storage capacity for water. The snow pack in California is predicted to decrease as much as 70-90 percent by 2100. There will also be increased wildfires as well as a reduction in quantity and quality of certain agricultural products.

Impacts and Feasibility of a San Francisco Bay Tidal Barrage. Assuming the barrage would be built with the features described above, the potential ecological, economic and social consequences of building it must be assessed. In order to approximate its effects, similar existing structures were examined. This analysis is based on combined study results on the impacts of dams, tidal energy projects, and other environment altering structures from the Bay Area and other parts of the world.

1. **Ecological Consequences of the Barrage**. The ecological consequences of the barrage would likely be very high. It would affect sedimentation, wetlands, fresh and salt water mixing, animal migration, and endangered species. More than likely it would change the landscape of the Bay Area, affecting the North Bay and South Bay most heavily. The following subsections delineate specific possible consequences.

    a. **Fresh and Salt Water Mixing.** The current average salinity composition of subregions of the Bay is shown in Figure 4. Damming the Bay would result in less salt water entering the Bay and more fresh water being trapped within. Overall the Bay would become more brackish and less saline. Reducing tidal currents into the Bay would decrease overall mixing and may result in a freshwater layer being present at the top with a more saline layer underneath, reducing vertical migration of both plankton and nutrients leading to depleted oxygen in the water column. Exchange of nutrients and plankton between the ocean and Bay would also be greatly reduced. There would be reduced ability to assimilate wastewater discharges, resulting in reduced water quality and the need for expensive modifications to wastewater treatment facilities.

b. **Sedimentation**. According to the U.S. Geological Survey, four to six million cubic yards of sediment flow out the Golden Gate, while an unknown quantity is imported each year from the Pacific Ocean. A barrage would likely greatly decrease sediment exchange between the Bay and the ocean. The reduced sediment load has the potential to increase coastal erosion. Additionally, reducing tidal energy would reduce scour and cause fine-grained sediment to be deposited further downstream, potentially converting now sandy areas of the Bay bottom into mud, reducing water clarity, and impacting phytoplankton and eelgrass production.

c. **Wetlands.** Wetlands rely on tidal exchange to provide nutrients, maintain salinity and to push water up into higher elevations and distant reaches of the Bay such as the South Bay and Suisun Marsh. Reducing tidal energy and exchange with the ocean would change the coastal salt marshes to brackish marshes and brackish water marshes to fresh, change the entire structure of Bay wetlands and eliminate habitat for endangered species. Currently scientists and planners are examining whether the existing wetlands will be able to keep pace with sea level rise. As sea level rises in the ocean and the barrage decreases tidal range in the Bay, there would be less intertidal areas and more subtidal areas, further decreasing Bay tidal flats and wetlands.

d. **Wildlife.** The effects that the barrage would have on animals depends on the design of the dam. Fish and marine mammals are likely to be the most affected as migratory pathways would be greatly reduced, and species using the Bay as a nursery ground, such as dungeness crab and many species of flat fish, would be blocked. Changing the salinity regime would also change the entire ecological system, eliminating species that require higher salinities. Birds that are dependent on marine fish for food and shorebirds that depend on the mud flats would likely have to relocate. Science has shown that the Bay is one of the most important stops of the Pacific flyway, altering this habitat would have global effects on birds stopping here on their migration each year.

e. **Endangered Species.** The Bay is home to numerous threatened and endangered species such as Chinook salmon, steelhead and green sturgeon. Some fish may be able to pass through the open turbines. Sturgeon have been known to go through lock systems but only on an accidental basis. Placing fish gates and ladders in the barrage would alleviate some of the issues, but creating obstacles for already stressed and endangered species only pushes them further towards extinction. Reducing fish populations would also affect endangered least terns and brown pelicans, reducing their chances for survival.

f. **Coastal Erosion.** The placement of the barrage would likely cause redistribution of sediment in the sand bar outside the Golden Gate. What this would mean is unknown as sediment transport between the Bay and the ocean is not well understood at this time. It is possible that reducing the tidal and sediment exchange may reduce volume of sediments deposited onto Ocean Beach and Stinson Beach.

g. **Flooding**. While creating a barrier to sea level rise may seem to solve flooding issues due to storm surges and rising ocean waters, it may exacerbate flooding inside the Bay during heavy winter storms. As described above, a larger percentage of precipitation will fall as rain in the future, causing larger volumes of fresh water to move through the system within shorter periods of time, while the storm surges would reduce the ability of the water to drain through the barrage. Reducing the ability of fresh water to be released into the ocean would cause severe flooding if the water has no place to go. If long term sea level rise exceeded 2 meters, then tidal flows would no longer be possible and outflow from tributaries would need to be pumped through the barrage.

2. **Economic Feasibility**. According to the International Rivers Network, the cost of building the Three Gorges Dam will be $25 billion by the time it is completed, including relocation expenses for communities inundated by the dam. It is likely that building the barrage in the Bay Area would likely be double or triple the cost of building a similar structure in China.

   The idea of constructing the barrage also raises a larger question. How do the costs and benefits of building the barrage compare with the costs and benefits of adapting waterfront areas to sea level rise? The Pacific Institute's 1990 economic evaluation of infrastructure threatened by sea level rise estimated the value of Bay Area structures and property at $48 billion. The Institute also estimated that it would cost approximately $1.5 billion to build levees and reconstruct infrastructure to protect it from rising waters. Although these figures do not account for relocation costs or lost value of ecosystems this is a significantly lower figure than that of the cost of building the barrage.

   Consideration must also be given to the potential for power generation by the project. Given the small amount of extractable energy and the high cost of production, tidal energy may not be practical in the barrage or the Bay Area. The price of tidal energy extraction is estimated at 50–70¢ per kWh compared to the 3¢ per KWh produced from Hetch Hetchy dam. The physical properties of the Bay's tides do not allow economically efficient energy production with current technologies.

   Building the barrage would generate thousands of jobs for a minimum of fifteen years, and then likely provide up to one hundred in the years beyond. The project would also consume massive amounts of concrete, water and steel, which would have to be transported into the Bay Area, increasing shipping and carbon dioxide releases into the atmosphere.

   Two of the major economic drivers in the Bay Area are the port system and tourism. The ports and tourism generate annually over $10 and $5.5 billion, respectively. Requiring the thousands of ships transiting the Bay each year to go through a lock system would significantly slow ship passage. This delay could reduce the ports' revenues by half (based on transit time through the Panama Canal). The barrage would potentially affect tourist revenues as well. Much of the appeal of the Bay Area as a tourist destination comes from the unobstructed views of the Golden Gate. However, it is possible that the barrage itself would become a tourist attraction if the Bay remains a healthy and attractive ecosystem.

3. **Political Feasibility of the Barrage**. Like any project that would affect the State of California, this project will undergo political scrutiny. The major stakeholders in this project include the environmental community, Bay Area residents, the ports, energy companies and the business community.

   Opponents of the project would likely include the environmental community, the ports, residents and recreational users of the Bay. The environmental community would likely focus on environmental impacts as would recreational users and the general public. The ports would likely come out opposed due to impacts on commerce.

   Potential proponents of the proposal could include local governments, labor unions, and energy companies. Local governments might support the project if it limited impacts to their community from sea level rise. Organizations promoting job creation might also support this project because of the number of new jobs it would create in the local economy. Energy companies might see the project as an opportunity to diversify energy sources if the technology were improved.

The project would likely be under the purview of the U.S. Army Corps of Engineers, and might be both designed and built by this agency. BCDC, , U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, NOAA National Marine Fisheries Service and the California Department of Fish and Game would all have regulatory jurisdiction over the project.

The Commission's Role. The Commission would have to find this project consistent with the *San Francisco Bay Plan* (Bay Plan) to approve its construction. The project would require consideration of several policy sections of the Bay Plan including: Fills in Accord With the Bay Plan; Water Quality; Water Surface Area and Volume; Subtidal Areas; Fish, Other Aquatic Organisms and Wildlife; Dredging; Safety of Fills; Public Access; Tidal Marsh and Tidal Flats; and Mitigation. It is also likely that this project could not be permitted under the Commission's current laws and policies due to the potential to address sea level rise with upland alternatives. The Commission may have to consider the following issues under the Bay Plan's current policies:

1. **Incorporate dredged material into construction.** The Bay would likely have to be dredged to build the barrage. The project sponsors may propose to mine sand from the Bay to use in the concrete. Due to increased sedimentation, the maintenance dredging at the ports and marinas would possibly increase.
2. **Require public access to barrage.** The requirements for public access could be met if the barrage had a walkway or road for people to use. Public access to the barrage would have to be balanced with Homeland Security issues.
3. **Increase wetlands restoration.** The effects of the barrage on sedimentation and wetlands would need to be closely monitored. Increased sedimentation could create larger wetlands and mudflats over time, reversing the current trend of erosion, but the more likely impact of the barrage would be to reduce Bay salt marsh.
4. **Require fish passages and migratory bird support.** Impacts to wildlife may be significant. The Commission would need to balance the need for the structure with the impacts to the Bay ecosystem and determine appropriate minimization and mitigation measures.
5. **Assist local government.** The Commission should consider assisting local governments in generating complete and accurate studies of ecological, economic and social impacts to local jurisdictions to the extent possible.

Conclusion. In 1942, actor and teacher John Reber was inspired to transform the San Francisco Bay Area by the creation of two dams that would convert 85 percent of the Bay into two freshwater lakes, provide excess fresh water to Southern California, and allow millions of homes to be built along the water's edge. The proposed dams would have been located near the Richmond-San Rafael Bridge is now located and just south of the Bay Bridge.

Initially, the Reber Plan received widespread public support and generated a devout following. However, as time passed a number of logistical and political factors caused the plan to falter. Logistically, access to the ports, salt intrusion and potential levee damage proved difficult problems. Politically, lack of federal support and the Korean War virtually ended the project. However, the U.S. Army Corps of Engineers seriously considered the plan and tested it using the newly built Bay Model. The Corps' study found that the Reber Plan was "infeasible by any frame of reference" because evaporation rates in the dammed lakes would be too high to sustain the reservoirs over time.

The San Francisco Bay Barrage and Tidal Energy Project could in some ways be considered a "Reber Revisit." However, this project is distinct from Reber's in that it proposes to block off the entire Bay rather than just the northern and southern parts. After evaluating the various physical, political, economic, and environmental constraints, the project may, like the Reber Plan, be "infeasible by any frame of reference."

Although constructing this barrage is probably physically possible, the long-term impacts on the Bay Area ecosystem and economy are likely to be overwhelmingly negative. A barrage may allow the Bay Area to avoid certain small-scale sea level rise adaptation costs such as population relocation and levee construction. However, the economic and ecological price that the Bay area would pay for constructing a barrage would likely be significantly higher than the total costs of these many smaller-scale projects adapting to sea level rise. In addition, relying on a single structure to protect the entire Bay Area from flooding creates much greater risk to human life and property in the event of failure than a diversified approach that combines local efforts to protect and relocate homes and other important infrastructure.

Figure 1. One-Meter Sea Level Rise in the Bay Area

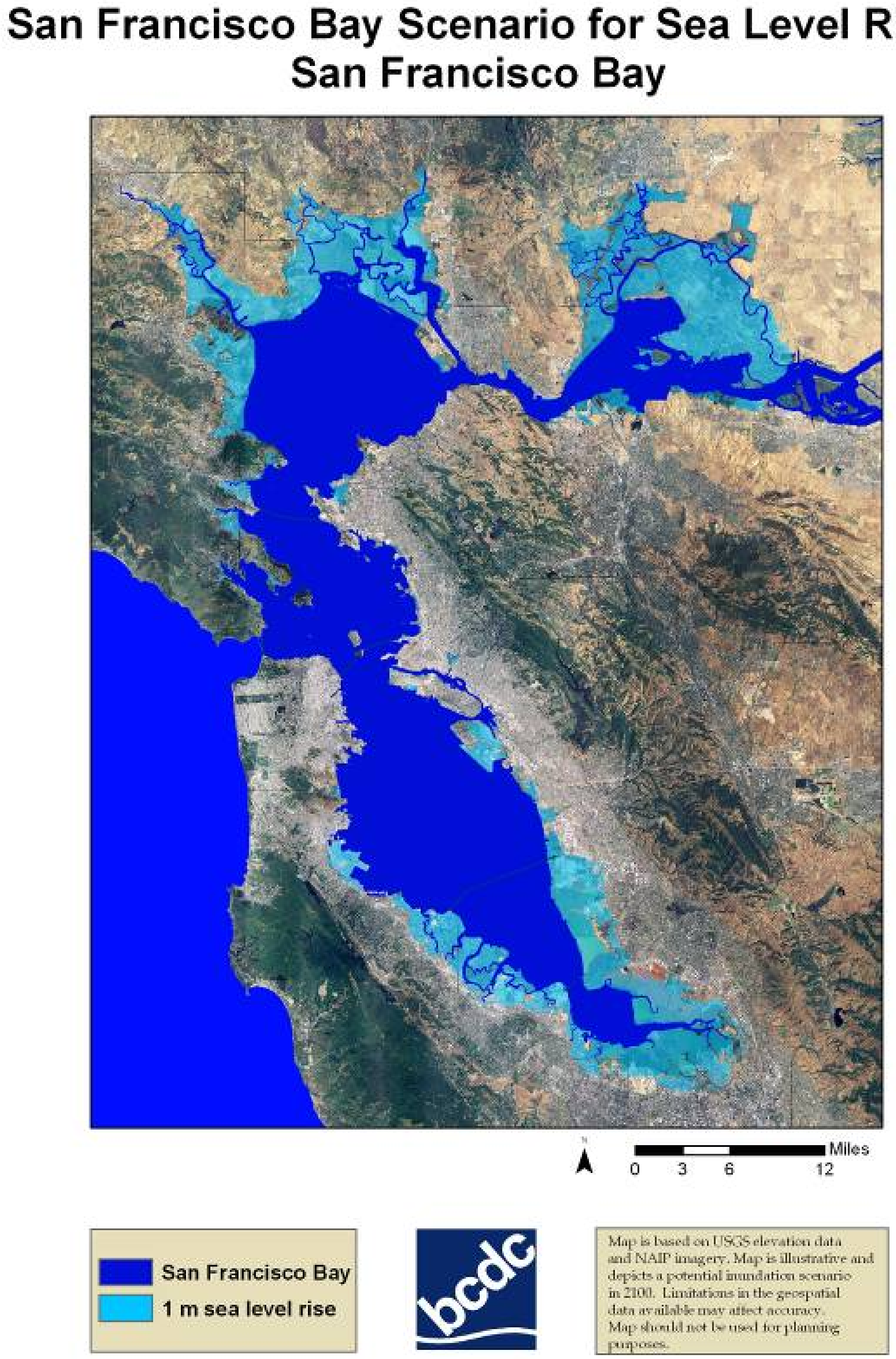

Figure 2. Potential Barrage Location

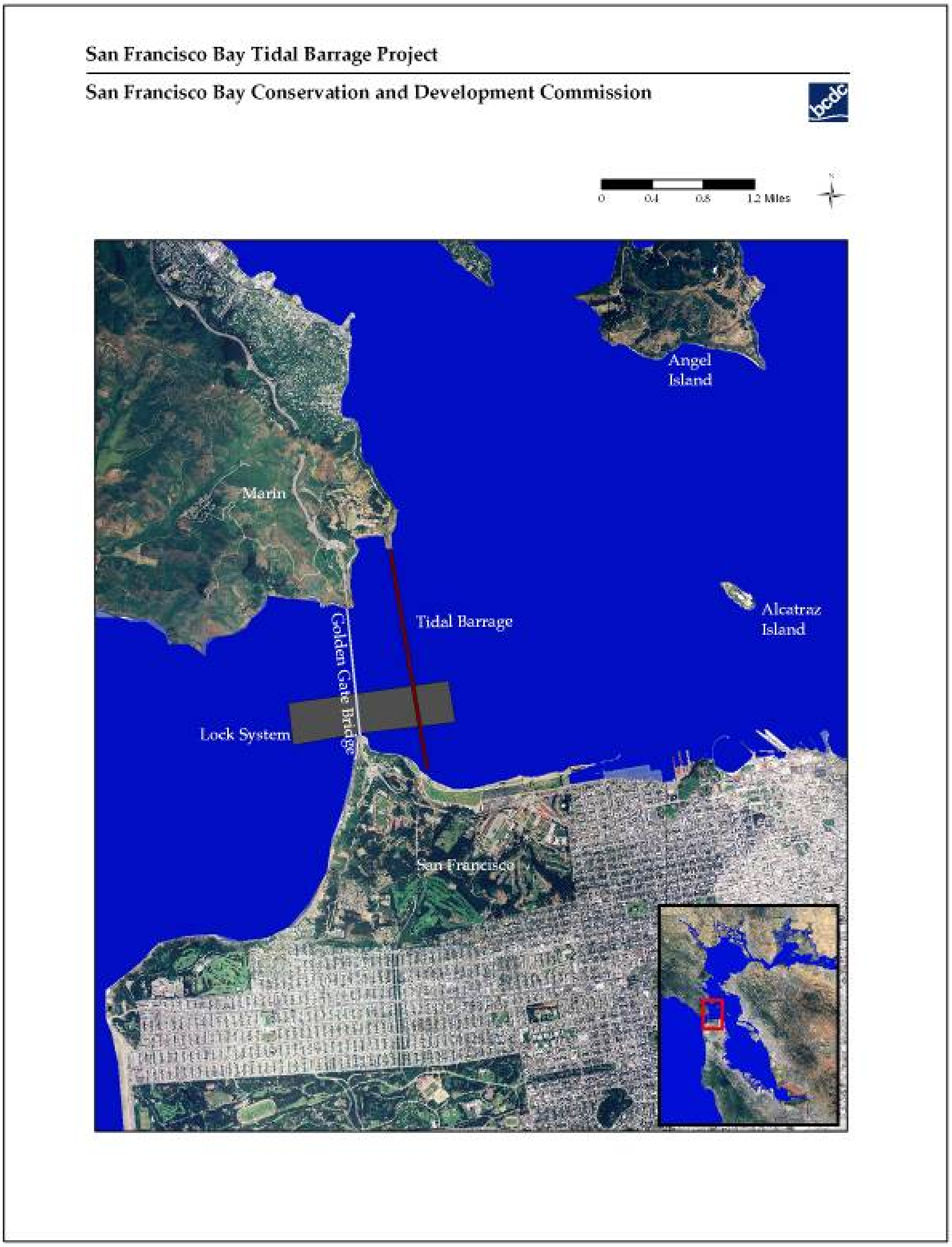

Figure 3. Open Hydro Tidal Energy Technology

Figure 3. Salinity Zones of the Bay

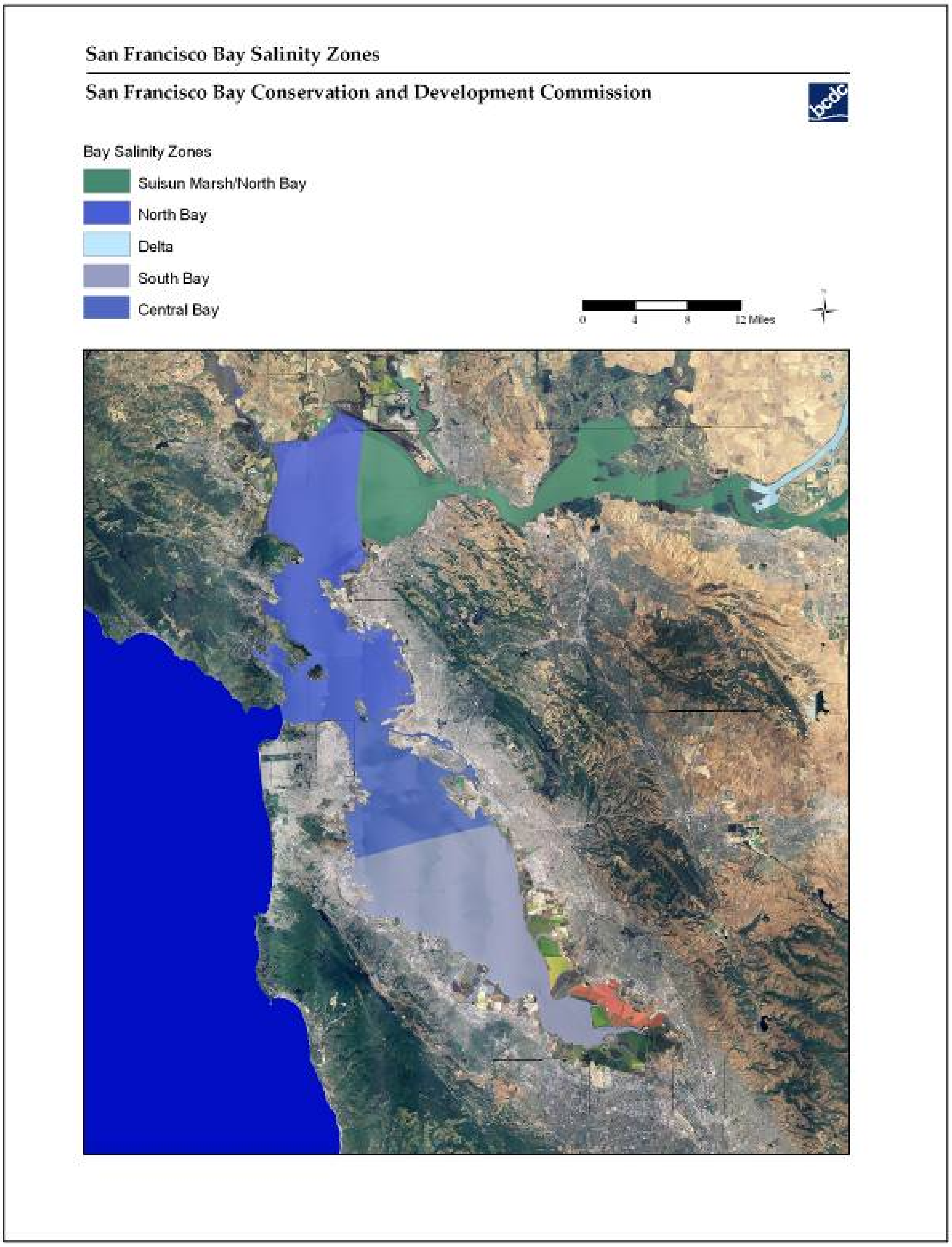

Table 1. Species Potentially Threatened by One-Meter Sea Level Rise

Common Name	Scientific Name
Adobe sanicle	Sanicula maritima
Alameda Island mole	Scapanus latimanus parvus
Alkali milk-vetch	Astragalus tener var. tener
American badger	Taxidea taxus
Antioch Dunes evening-primrose	Oenothera deltoides ssp. howellii
Arcuate bush mallow	Malacothamnus arcuatus
Bank swallow	Riparia riparia
Beach layia	Layia carnosa
Bent-flowered fiddleneck	Amsinckia lunaris
Big free -tailed bat	Nyctinomops macrotis
Big tarplant	Blepharizonia plumosa
Black skimmer	Rynchops niger
Black-crowned night heron	Nycticorax nycticorax
Bristly sedge	Carex comosa
Brittlescale	Atriplex depressa
Burrowing owl	Athene cunicularia
California black rail	Laterallus jamaicensis coturniculus
California clapper rail	Rallus longirostris obsoletus
California least tern	Sterna antillarum browni
California linderiella	Linderiella occidentalis
California red-legged frog	Rana aurora draytonii
California seablite	Suaeda californica
California tiger salamander	Ambystoma californiense
Carquinez goldenbush	Isocoma arguta
Caspian tern	Hydroprogne caspia
Choris' popcorn-flower	Plagiobothrys chorisianus var. chorisianus
Congdon's tarplant	Centromadia parryi ssp. congdonii
Contra Costa goldfields	Lasthenia conjugens
Davidson's bush mallow	Malacothamnus davidsonii
Delta mudwort	Limosella subulata
Delta smelt	Hypomesus transpacificus
Delta tule pea	Lathyrus jepsonii var. jepsonii
Diablo helianthella	Helianthella castanea
Double-crested cormorant	Phalacrocorax auritus
Dwarf downingia	Downingia pusilla
Ferruginous hawk	Buteo regalis
Fragrant fritillary	Fritillaria liliacea
Franciscan onion	Allium peninsulare var. franciscanum
Great blue heron	Ardea herodias
Hairless popcorn-flower	Plagiobothrys glaber
Hoover's button-celery	Eryngium aristulatum var. hooveri
Kellogg's horkelia	Horkelia cuneata ssp. sericea
Legenere	Legenere limosa
Leaf-cutter bee	Trachusa gummifera
Marin knotweed	Polygonum marinense
Marin western flax	Hesperolinon congestum

Marsh microseris	Microseris paludosa
Mason's lilaeopsis	Lilaeopsis masonii
Mimic tryonia (California brackish water snail)	Tryonia imitator
Minute pocket-moss	Fissidens pauperculus
Monarch butterfly	Danaus plexippus
Mt. Diablo buckwheat	Eriogonum truncatum
Mt. Tamalpais manzanita	Arctostaphylos hookeri ssp. montana
Myrtle's silverspot	Speyeria zerene myrtleae
Napa false indigo	Amorpha californica var. napensis
Northern harrier	Circus cyaneus
Pallid bat	Antrozous pallidus
Pappose tarplant	Centromadia parryi ssp. parryi
Petaluma popcorn-flower	Plagiobothrys mollis var. vestitus
Point Reyes bird's-beak	Cordylanthus maritimus ssp. palustris
Point Reyes checkerbloom	Sidalcea calycosa ssp. rhizomata
Prostrate navarretia	Navarretia prostrata
Rayless ragwort	Senecio aphanactis
Ricksecker's water scavenger beetle	Hydrochara rickseckeri
Robust monardella	Monardella villosa ssp. globosa
Robust spineflower	Chorizanthe robusta var. robusta
Rose leptosiphon	Leptosiphon rosaceus
Round-leaved filaree	California macrophyllum
Sacramento splittail	Pogonichthys macrolepidotus
Saline clover	Trifolium depauperatum var. hydrophilum
Saltmarsh common yellowthroat	Geothlypis trichas sinuosa
Salt-marsh harvest mouse	Reithrodontomys raviventris
Salt-marsh wandering shrew	Sorex vagrans halicoetes
San Francisco Bay spineflower	Chorizanthe cuspidata var. cuspidata
San Francisco Forktail Damselfly	Ischnura gemina
San Francisco garter snake	Thamnophis sirtalis tetrataenia
San Francisco lacewing	Nothochrysa californica
San Francisco owl's-clover	Triphysaria floribunda
San Joaquin spearscale	Atriplex joaquiniana
San Pablo song sparrow	Melospiza melodia samuelis
San Pablo vole	Microtus californicus sanpabloensis
Sandy beach tiger beetle	Cicindela hirticollis gravida
Santa Cruz kangaroo rat	Dipodomys venustus venustus
Santa Cruz tarplant	Holocarpha macradenia
Short-eared owl	Asio flammeus
Small groundcone	Boschniakia hookeri
Soft bird's-beak	Cordylanthus mollis ssp. mollis
Sonoma spineflower	Chorizanthe valida
Steelhead - Central California Coast ESUs	Oncorhynchus mykiss irideus
Suisun Marsh aster	Aster lentus
Suisun shrew	Sorex ornatus sinuosus
Suisun song sparrow	Melospiza melodia maxillaris
Suisun thistle	Cirsium hydrophilum var. hydrophilum
Swainson's hawk	Buteo swainsoni
Tidewater goby	Eucyclogobius newberryi
Tricolored blackbird	Agelaius tricolor
Vernal pool tadpole shrimp	Lepidurus packardi

Western pond turtle	Emys (=Clemmys) marmorata
Western snowy plover	Charadrius alexandrinus nivosus
White-rayed pentachaeta	Pentachaeta bellidiflora
White-tailed kite	Elanus leucurus
Yellow-headed blackbird	Xanthocephalus xanthocephalus

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