



Multi-Benefit Design Solutions to Manage Sea Level Rise

Sea Level Rise Adaptation in Marin County Workshop

Sarah Moos Thompson, Senior Associate, Bionic
March 21, 2019

Meet the Projects

- **The Estuary Commons | All Bay Collective**
San Leandro Bay
- **Resilient South City | HASSELL+**
South San Francisco
- **The Grand Bayway | Common Ground**
San Pablo Bay
- **Unlock Alameda Creek | Public Sediment**
Alameda Creek
- **South Bay Sponge | Field Operations Team**
East Palo Alto to Sunnyvale
- **Islais Hyper-Creek | BIG+ONE+Sherwood**
Islais Creek
- **Peoples Plan | P+SET**
Marin City
- **Elevate San Rafael | Bionic Team**
San Rafael
- **ouR-HOME | The Home Team**
North Richmond





bionic

PennDesign

WXY architecture + urban design

Studio for Urban Projects

Enterprise Partners

M Yame

SF State University

Keyser Marston Associates

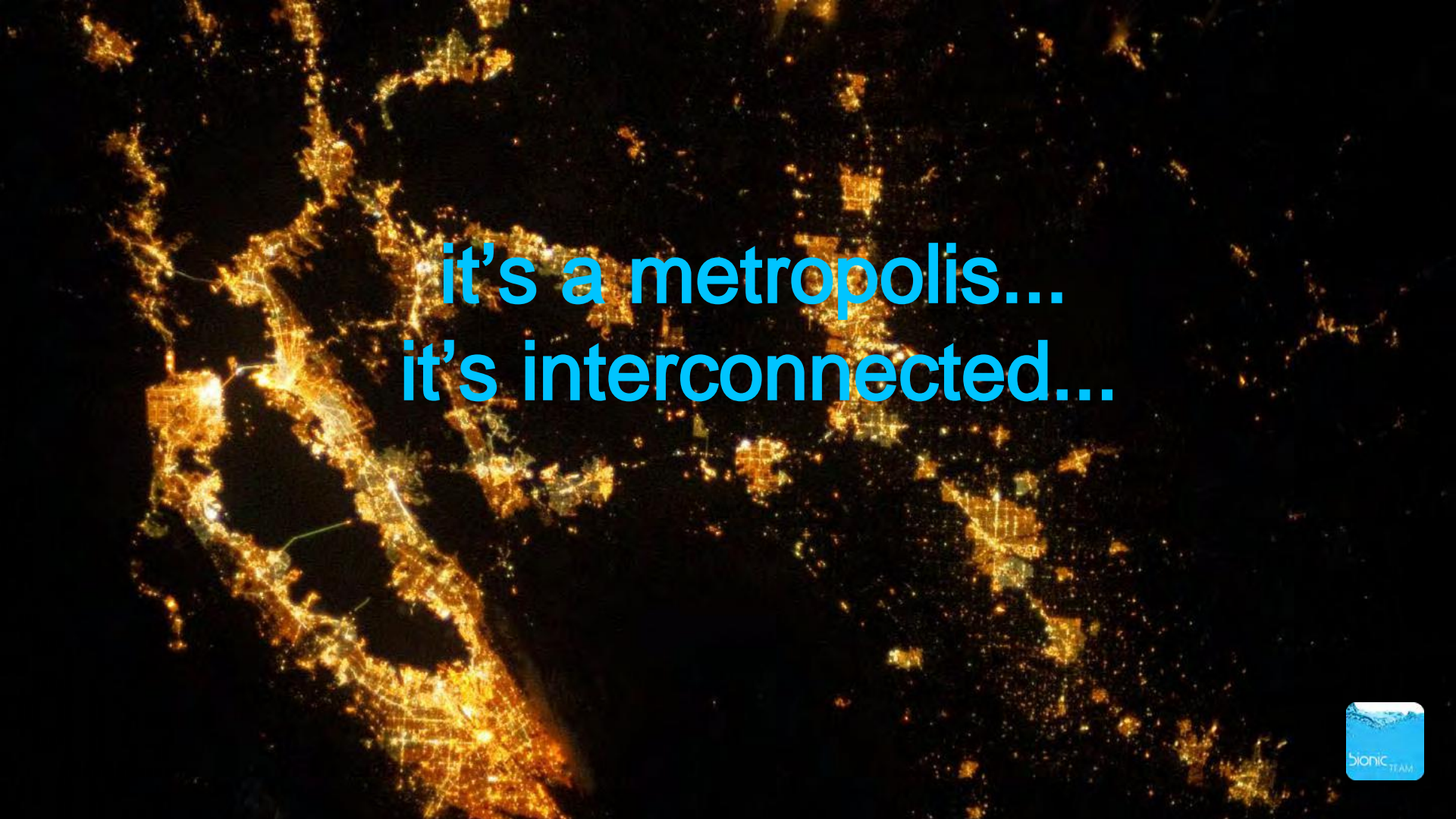
WRA Environmental

RAD Urban

Moffatt & Nichol

SAN RAFAEL
ELEVATE



A satellite night view of a city, showing a dense network of glowing lights and a complex web of connections. The lights are primarily yellow and orange, with some blue and green highlights. The background is dark, representing the night sky.

it's a metropolis...
it's interconnected...

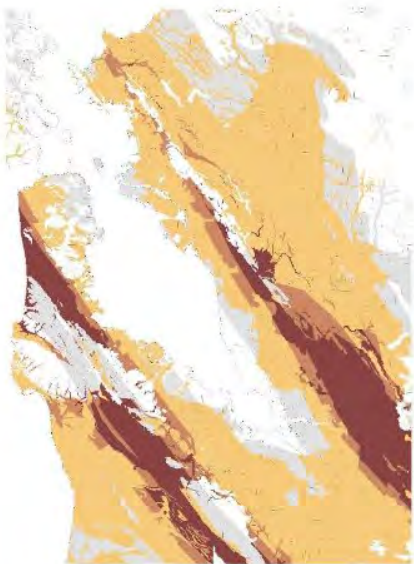


focus on the lowest
areas...on those
who need help first



accelerate!

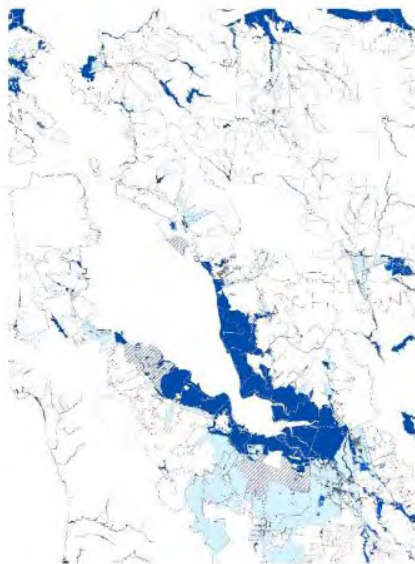




+



+



+



Legend

Earthquake PGA

- VL (0.55 - 0.9507)
- L (0.9507 - 1.1484)
- M (1.1484 - 1.3515)
- H (1.3515 - 1.5492)
- VH (1.5492 - 1.95)

Legend

Liquefaction

- VL
- L
- M
- H
- VH

Legend

FEMA Flood

- 100 yr Flood
- 500 yr Flood
- 500 yr Flood

Legend

Sea Level Rise

- 0' SLR 1yr Event
- 9' SLR 1yr Event

inputs



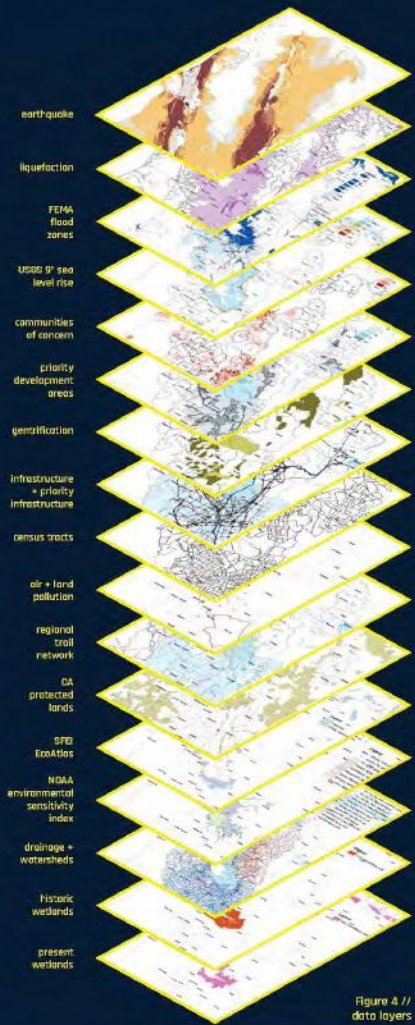
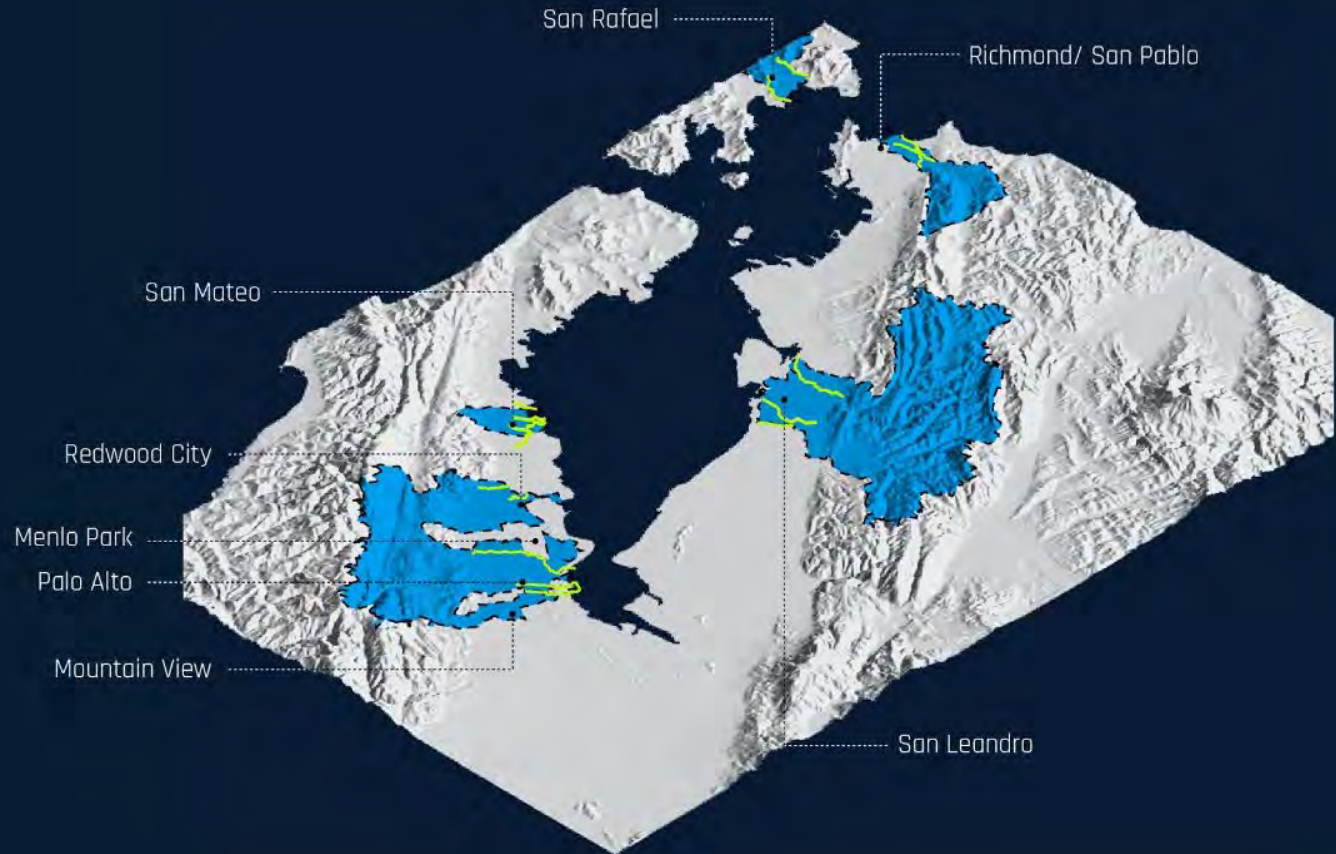
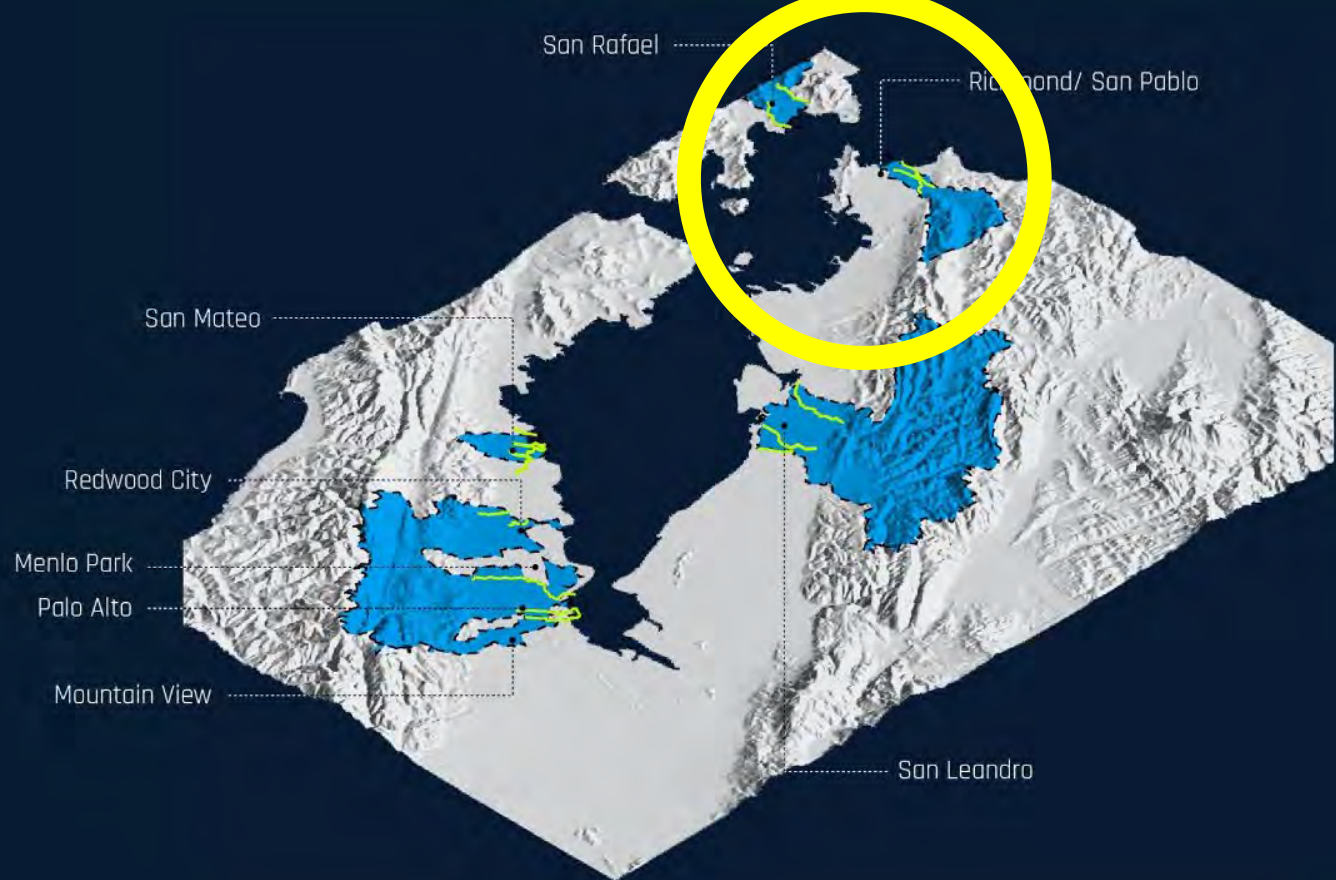


Figure 4 // data layers

INPUTS







Radar data showing ground displacement. The area in San Rafael Bay appears to show a range from 10 which could equal 15" by 2040. http://www.esa.int/spaceinimages/Images/2016/11/Bay_Area_displacement

BAY AREA SUBSIDENCE

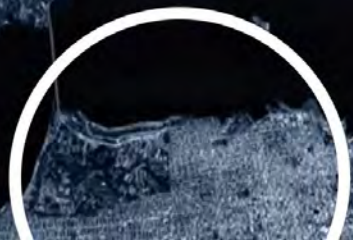
San Rafael



Richmond



San Francisco



Oakland



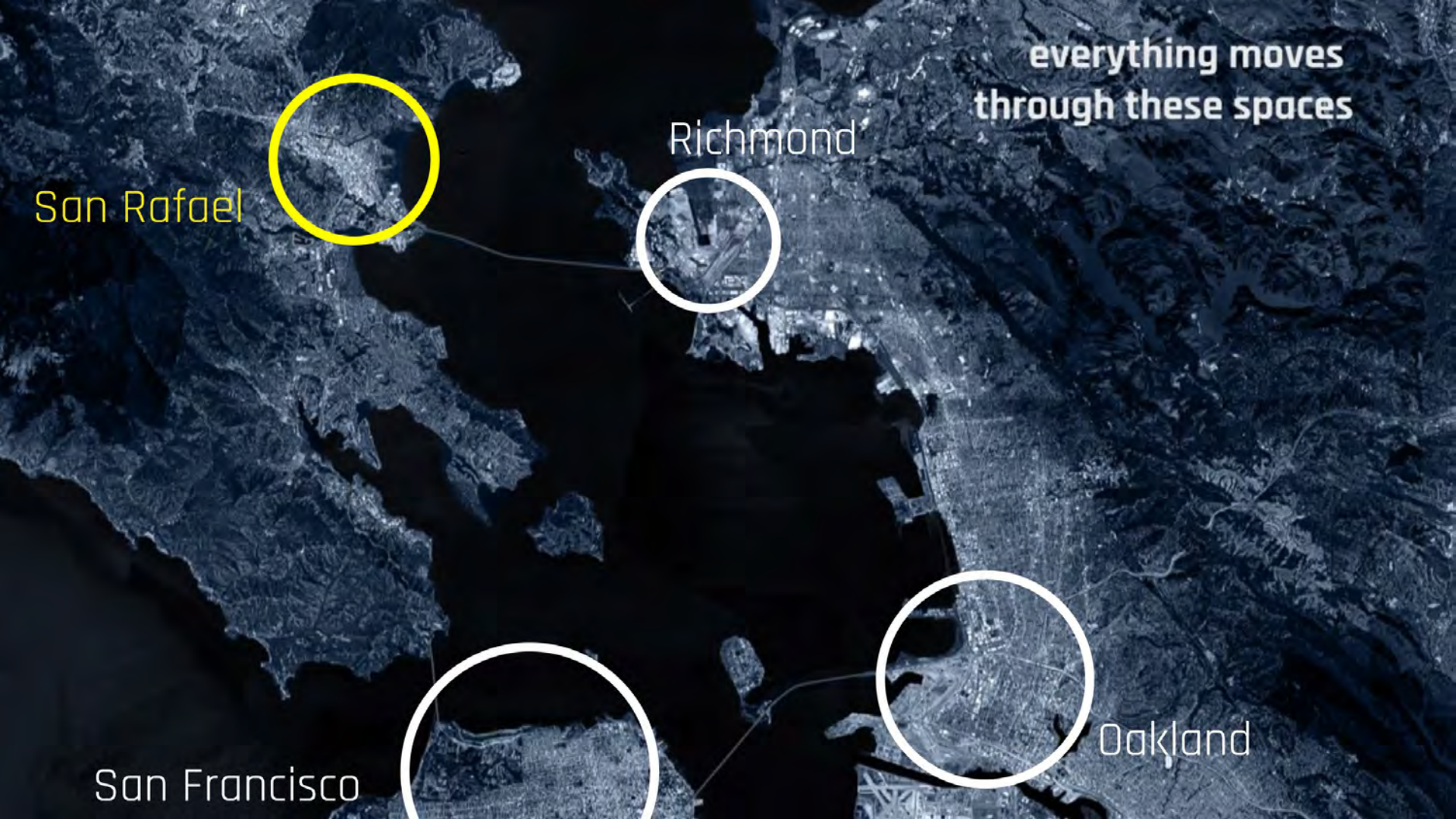
**everything moves
through these spaces**

San Rafael

Richmond

San Francisco

Oakland





everything moves
through these spaces

tides + sediments

minery + port logistics

San Rafael

Richmond

San Francisco

Oakland

San Rafael



Richmond



everything moves
through these spaces

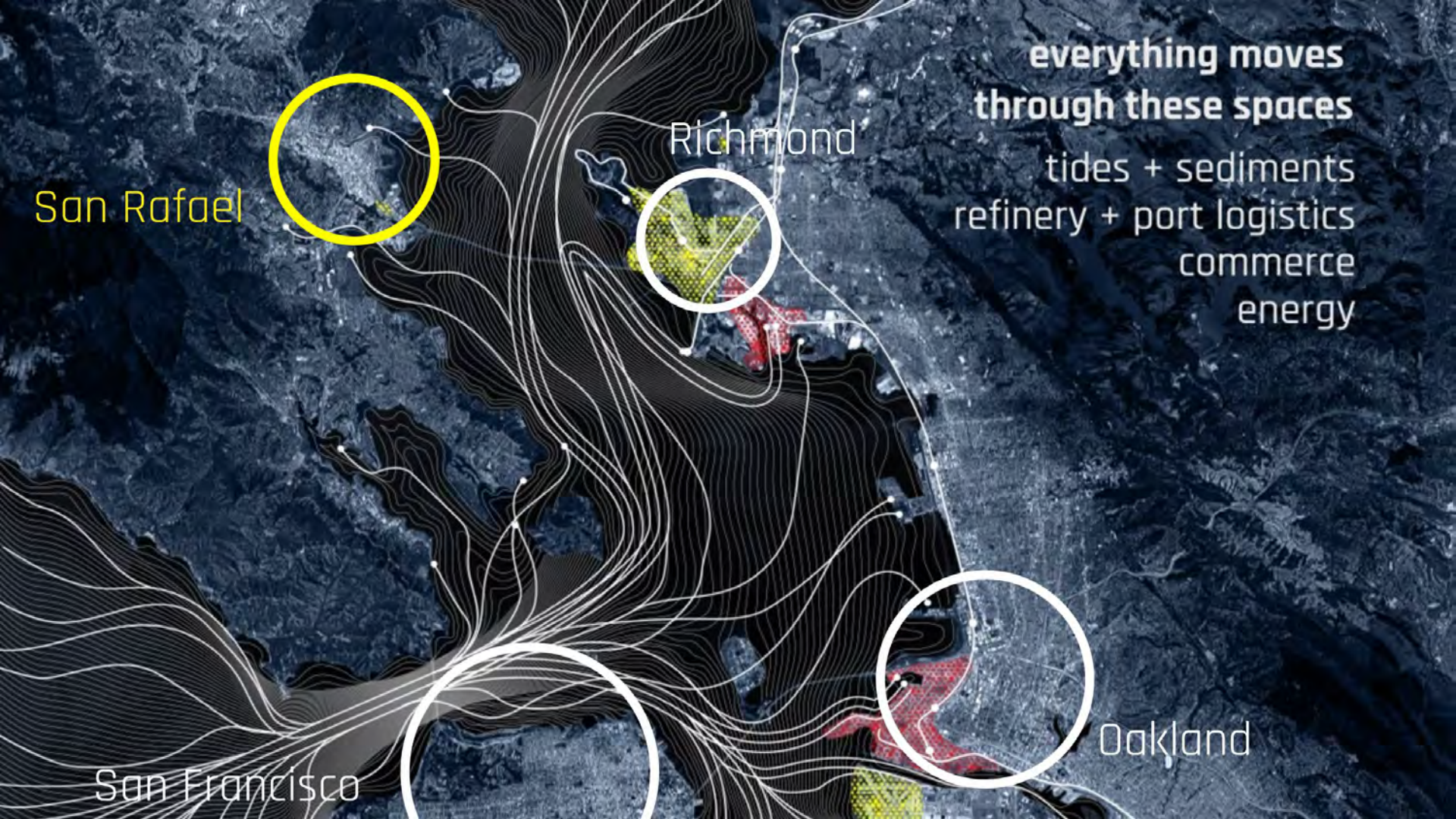
tides + sediments
refinery + port logistics
commerce

San Francisco



Oakland





San Rafael

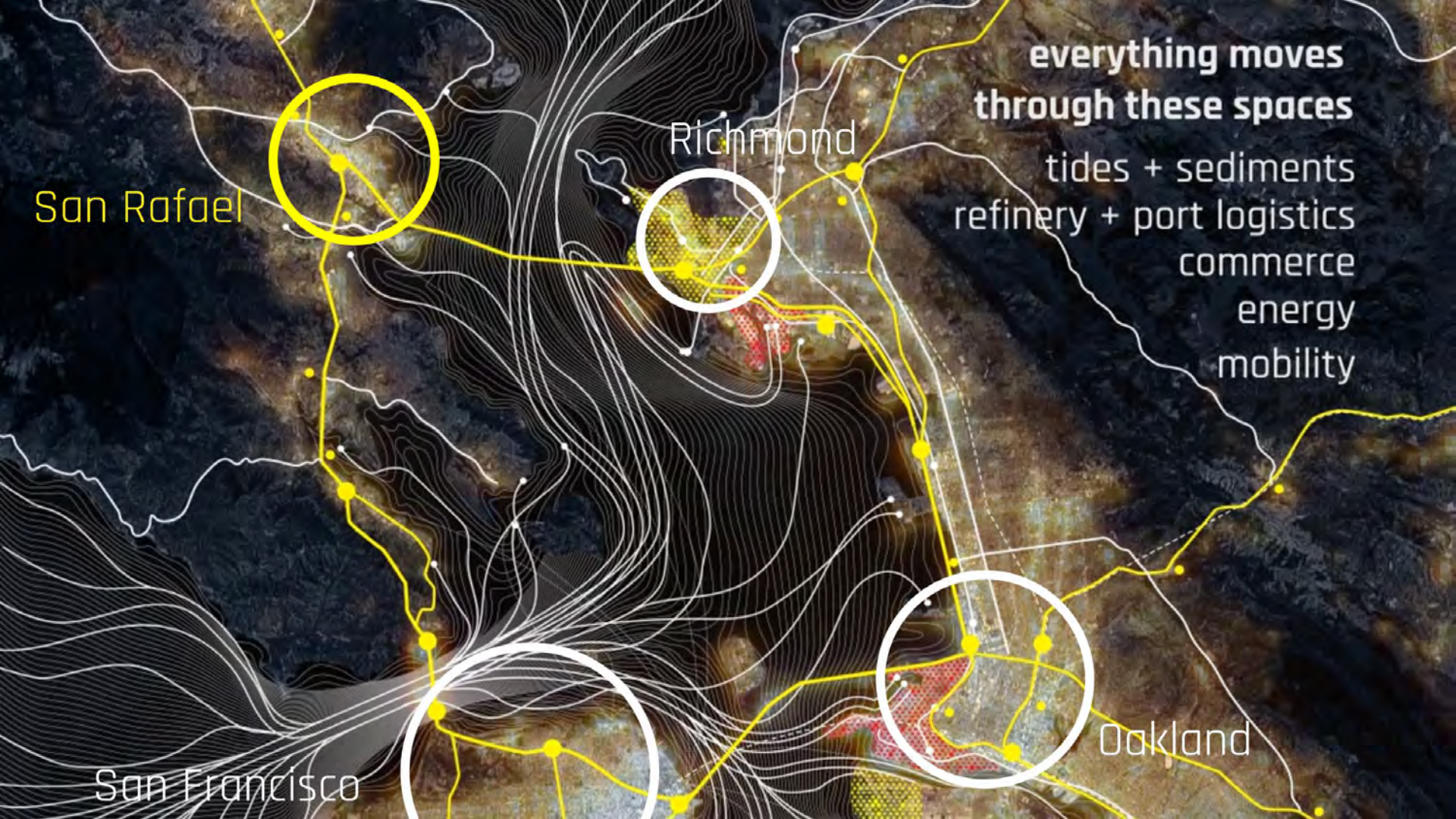
Richmond

San Francisco

Oakland

**everything moves
through these spaces**

tides + sediments
refinery + port logistics
commerce
energy



**everything moves
through these spaces**

- tides + sediments
- refinery + port logistics
- commerce
- energy
- mobility

San Rafael

Richmond

Oakland

San Francisco

101 South
San Rafael
San Francisco

101 South
Santa Rosa
Eureka
1 1/2 mi

Marina Ranch Rd

101 South
Santa Rosa
Eureka

101 South
Santa Rosa
Eureka

20172018





101 SOUTH
San Rafael
San Francisco

101 NORTH
Santa Rosa
Eureka
1/4 MILE

Hanna Ranch Rd
↗

EXIT 102
San Rafael
San Francisco

EXIT 103
Southridge
Boulevard
1/4 MILE

EXIT 104
Linda Moss
College

EXIT
↘

TOYS "R" US

CLOSING DOWN
EVERYTHING MUST GO!

NO PARKING
IN THIS ZONE
EXCEPT AS
NOTED

NO PARKING
EXCEPT AS
NOTED

NO PARKING
EXCEPT AS
NOTED

NO PARKING
EXCEPT AS
NOTED

NO PARKING
EXCEPT AS
NOTED











San Rafael today

San Rafael creek





Bay Trail



habitat potential & restoration



heavily used Pickleweed Park



low lying & weak infrastructure



bridges & connectivity



failing marine structures



outdated & low lying housing



Housing shortage

San Rafael today



The waterfront?

When I think of San Rafael,
waterfront doesn't come to mind.

Is it??

I don't think so...



We have nothing
known to me as
the waterfront,
and I was born
here.

I don't know...

No...

Is there a waterfront in San Rafael?



the community



ward
approach
to
flooding.
es un enfoque estándar
para las inundaciones.
Hay la siguiente información
al respecto más adelante.



ASK ME
I'll be happy to help you
learn more.

If there was a flood,
where

PLAY WITH
THE SUN
DURING
WARM UP



ANDISON

GRACO

GRACO

community stats

PREDOMINANT
RACE/ETHNICITY

HISPANIC

MEDIUM
HOUSEHOLD INCOME

\$43,448.50

FOREIGN BORN

60%

IMMIGRATED IN
LAST 10 YEARS

36%

LIVING IN
POVERTY

**2,920
FAMILIES**

COST BURDENED
RENTER

71%

PERCENT WORK
LESS THAN 10 MILES
FROM HOME

50.8%

PERCENT WORK IN
SAN RAFAEL

24%





NO
TRESPASSING
PRIVATE
PROPERTY
VIOLATORS WILL BE
PROSECUTED





MARIN + CROSS
Ways to protect the coastal from Sea Level Rise

Kim

John

GAT

Show Respect
Solve Problems
Make Good Decisions

TEAMS

FLOOD MODEL





SAN RAFAEL FLOOD RISK

FLOODS AFFECT EVERYONE
AT HOME, AT WORK, AT SCHOOL

WHAT COULD
CAUSE FLOODS IN
SAN RAFAEL?

- HEAVY RAIN
- HIGH TIDE
- SEA LEVEL RISE

WE KNOW
CARBON EMISSIONS
CONTRIBUTE TO
CLIMATE CHANGE

California
FLO-140

- HEAVY RAIN
- HIGH TIDE
- SEA LEVEL RISE

PROPERTY DAMAGE

ROADS CLOSED

HEAVY RAIN

HIGH TIDE

SEA LEVEL RISE

DISPLACED HOMELESS

ROADS CLOSED

HEAVY RAIN

HIGH TIDE

SEA LEVEL RISE

DISPLACED HOMELESS

ROADS CLOSED

HEAVY RAIN

HIGH TIDE

SEA LEVEL RISE

DISPLACED HOMELESS

ROADS CLOSED

HEAVY RAIN

HIGH TIDE

SEA LEVEL RISE



FLOODS AFFECT EVERYTHING
LAS INUNDACIONES AFECTAN TODOS

Yes, that's pretty
much everything...
www.bionicle.com

HOUSES & APARTMENTS
VIVIENDAS Y DEPARTAMENTOS

- SCHOOLS
ESCUELAS
- GROcery STORES
TIENDEAS DE ALIMENTOS
- PHARMACIES
FARMACIAS
- POST OFFICES
OFICINAS DE CORREOS
- GAS STATIONS
ESTACIONES DE GASOLINA
- BUSINESSSES
NEGOCIOS
- RESTAURANTS
RESTAURANTES
- INFRASTRUCTURE
INFRAESTRUCTURA

SAN RAFAEL FLOOD MOBILE

The cool stick figure kids
are using these tags
La figura genial de stick kids usa estas etiquetas

bionic
Landscape Architecture
Urban Design
Planning

RESILIENT
SAC AREA CHALLENGE
DESIGN

@bioniclelandscape
#FloodMobile #
#ResilientByDesign



My car!
¡Mi auto!

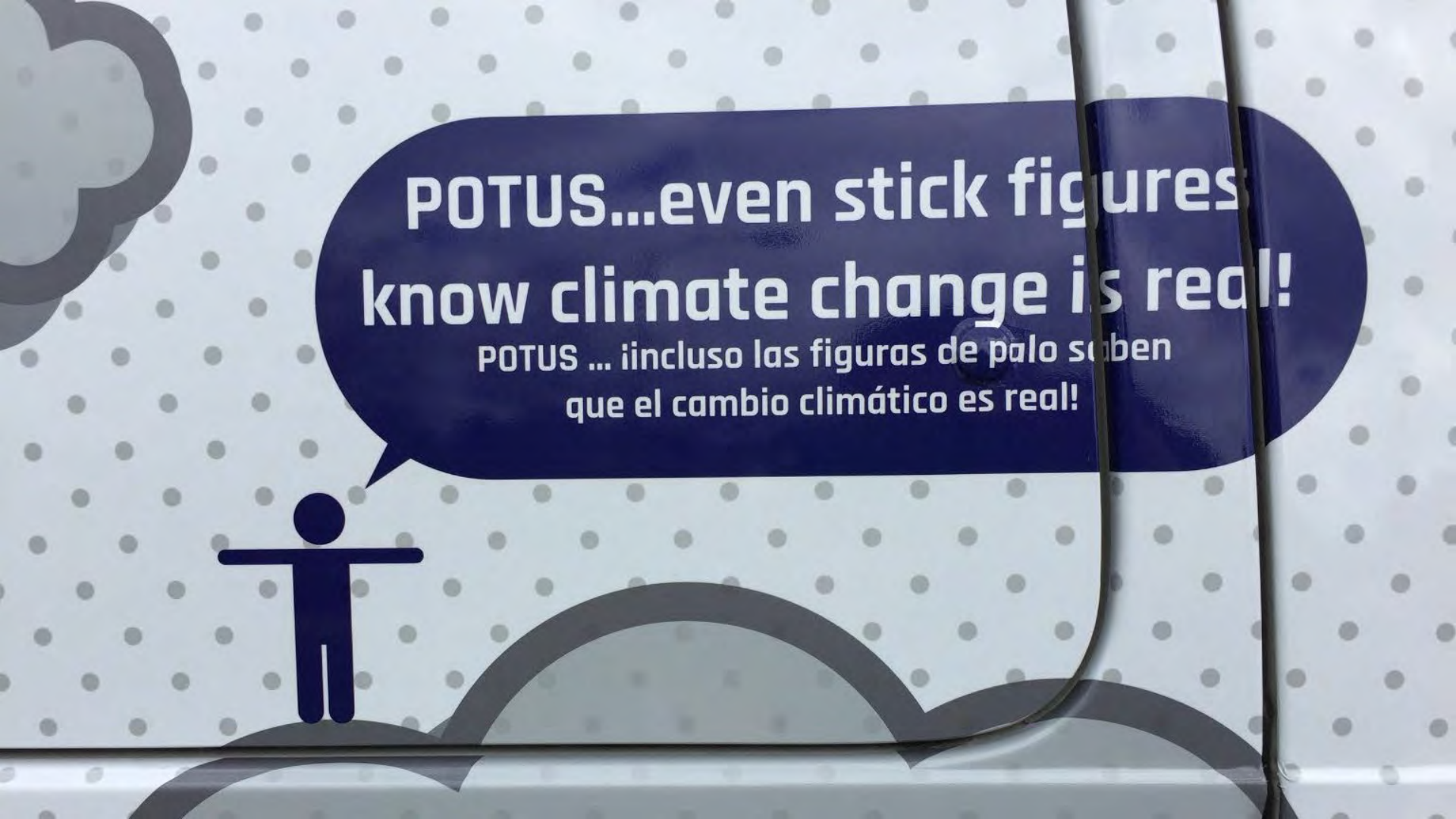


Sorry boss,
still stuck at home...
Lo siento jefe, todavía estoy
atrapado en casa



I live on a hill,
why do I care?!
Vivo en una colina, ¿por qué
me importa?





**POTUS...even stick figures
know climate change is real!**

POTUS ... ¡incluso las figuras de palo saben
que el cambio climático es real!



key takeaways

Protect the community center

Improve parking

Improve traffic

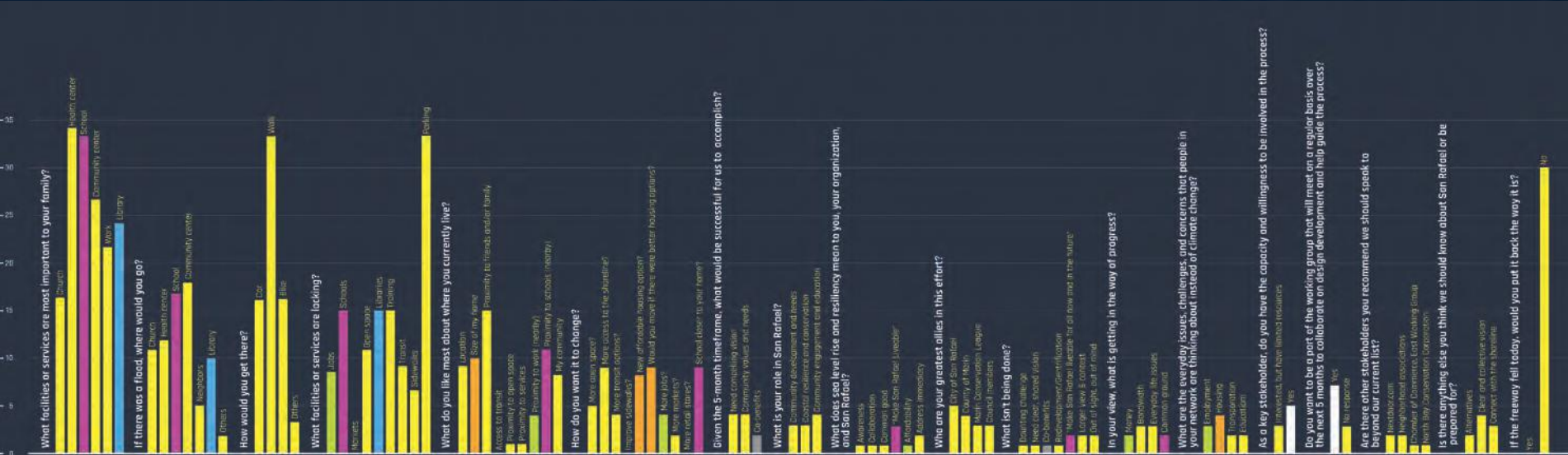
“Make San Rafael liveable for ALL now and in the future”


Protect the schools and health center

Need affordable housing options

Improve access

Identify multi-benefit projects





What is at Risk?

San Rafael will subside 15" by 2040



City of San Rafael

ASSETS AT RISK

500-year event

5,423

residential units

12,826

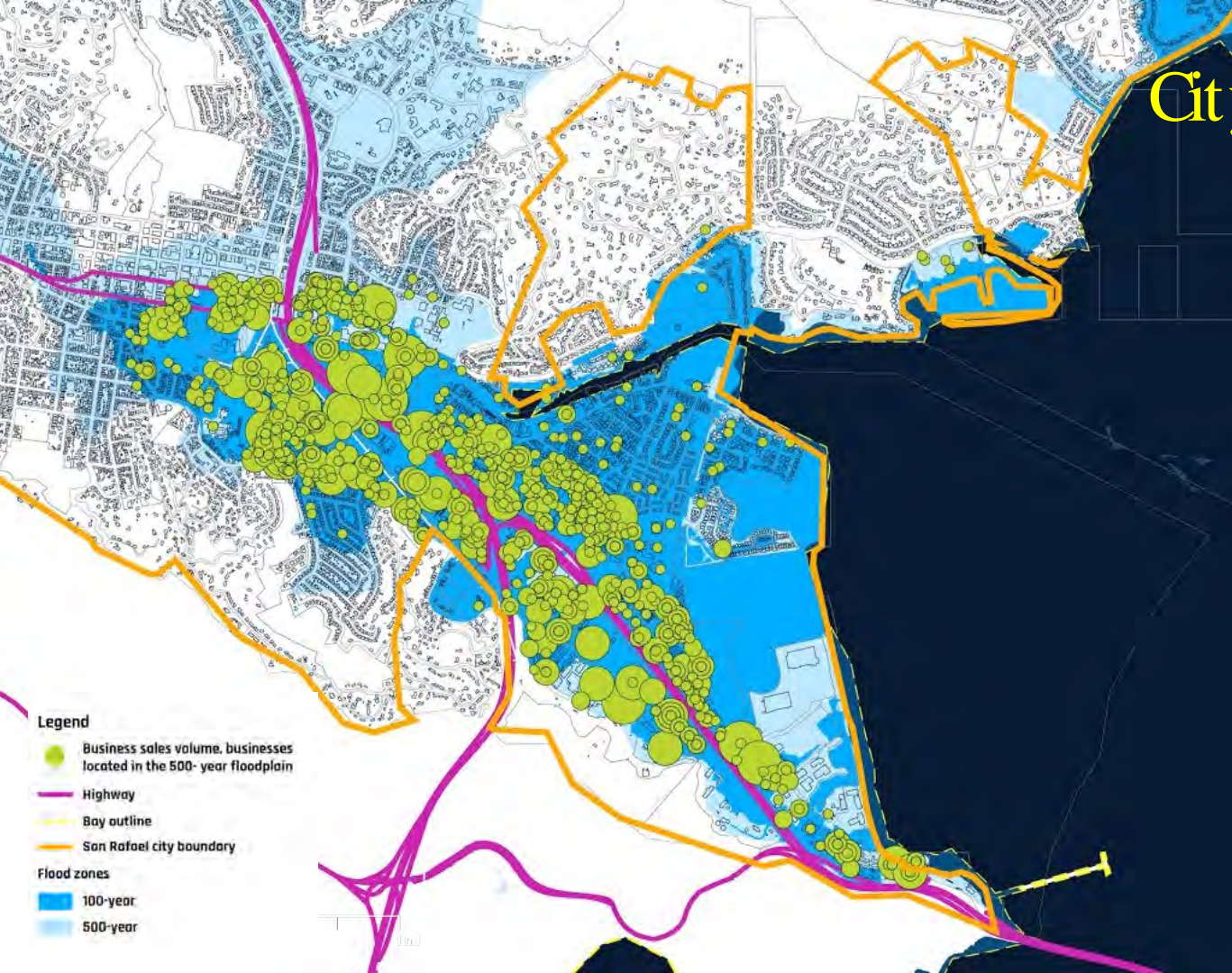
jobs

\$3.95 B

land value

\$2.95 B

business revenue





history

watershed





pump failure scenarios

flood depths in feet



pump failure scenarios

flood depths in feet

2018 – 6.6 ft MHHW



pump failure scenarios

flood depths in feet

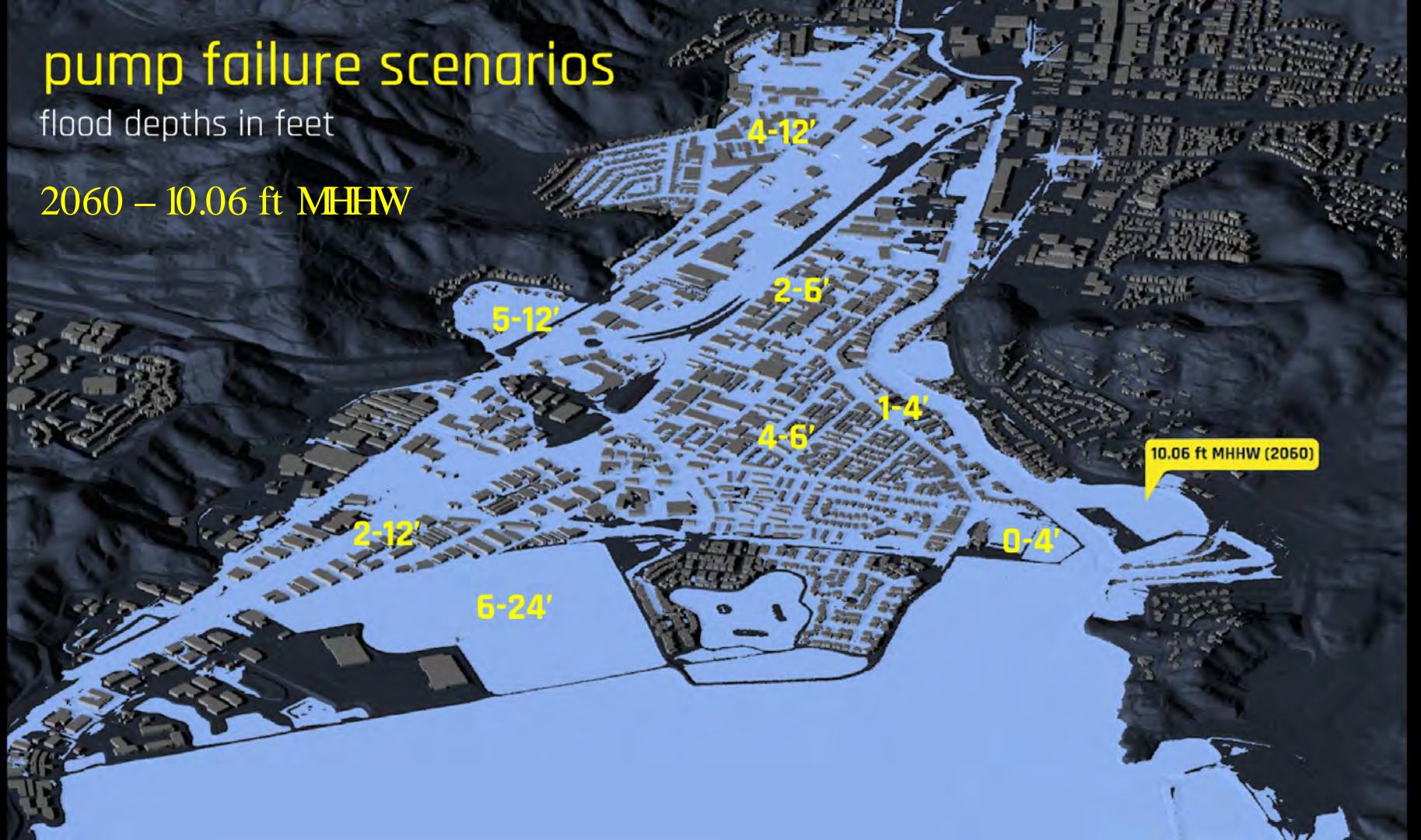
2040 – 7.87 ft MHHW



pump failure scenarios

flood depths in feet

2060 – 10.06 ft MHHW

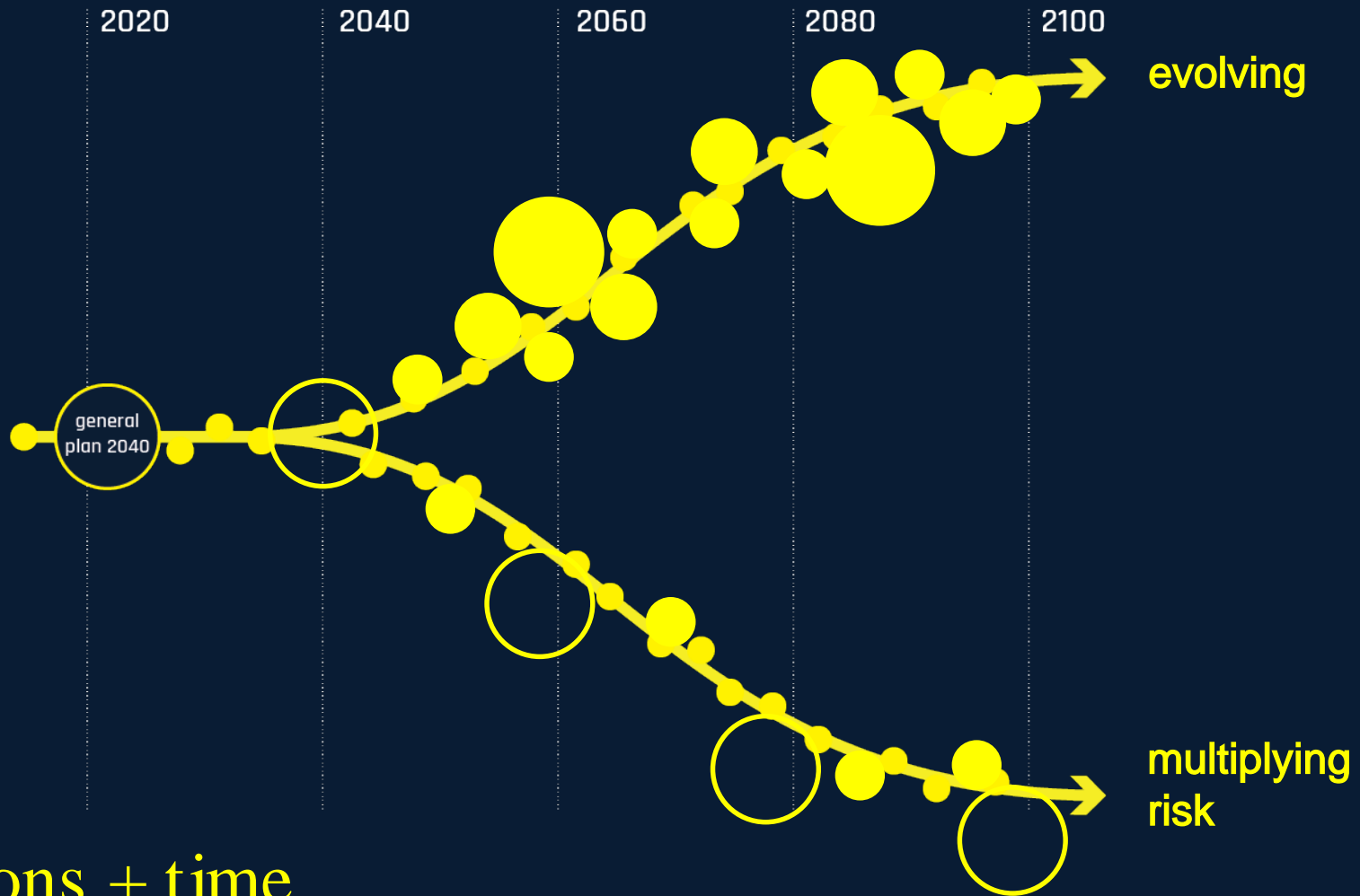


housing risk

+ 4.5 ft flooding

There is a **1 in 4** chance this will happen by 2050

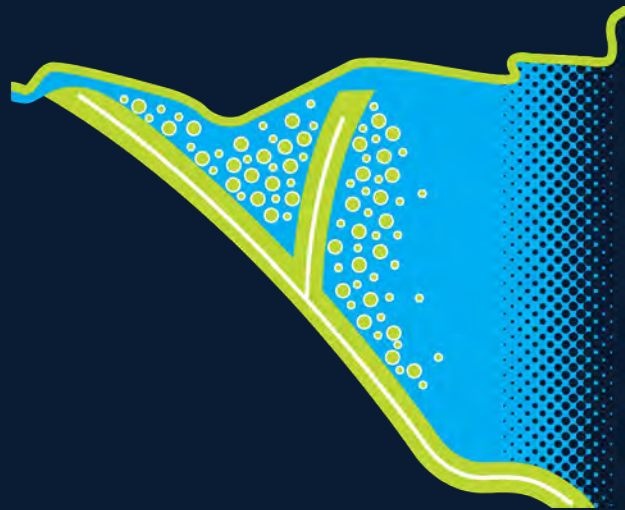




decisions + time



Life versus Bay



Life with Bay

SAN RAFAEL
ELEVATE



elevating the short term

catalyst project 1 //

Resilience Now



Pickleweed park today



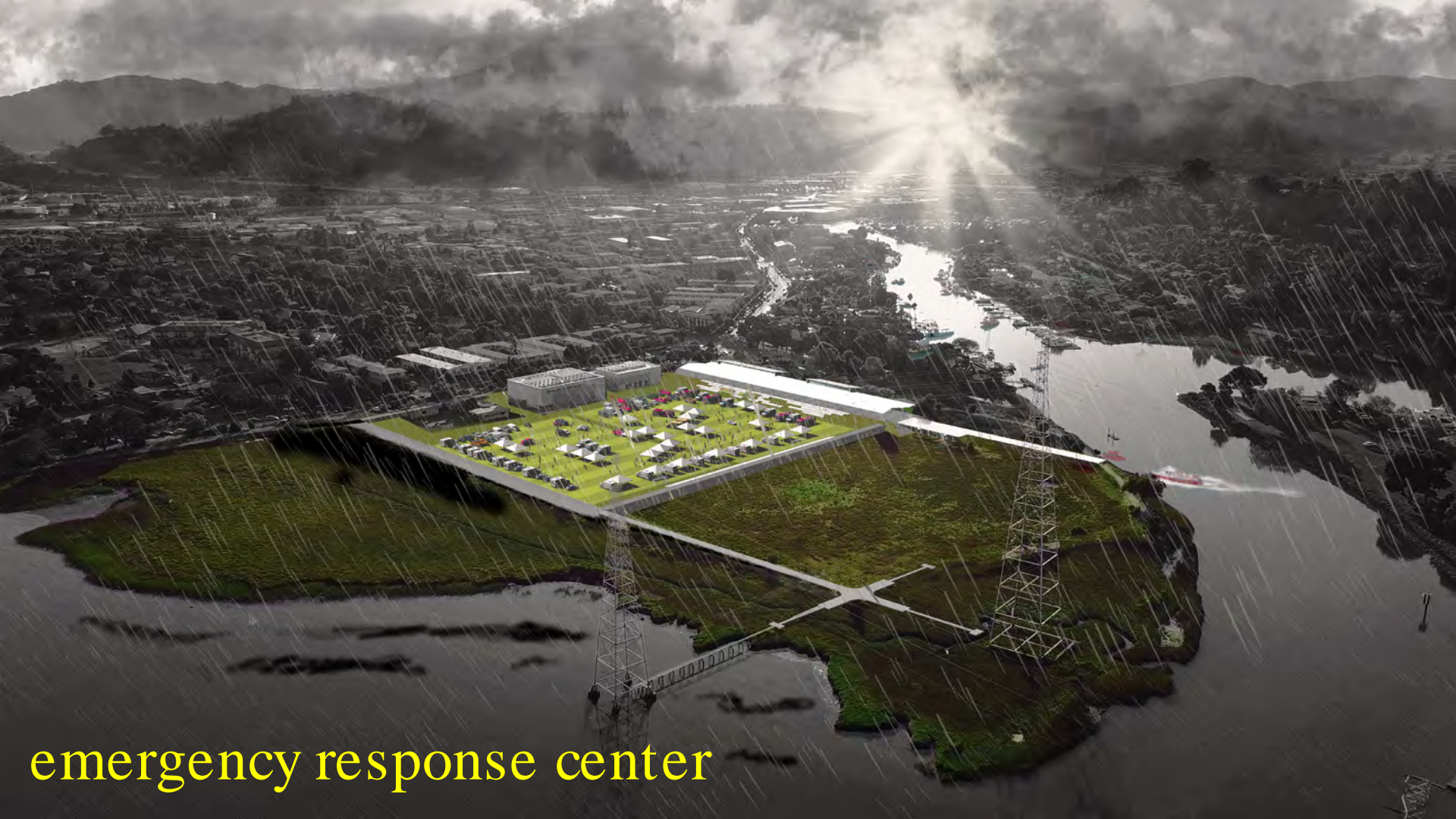
Protect Pickleweed Park

upgraded community sports facility





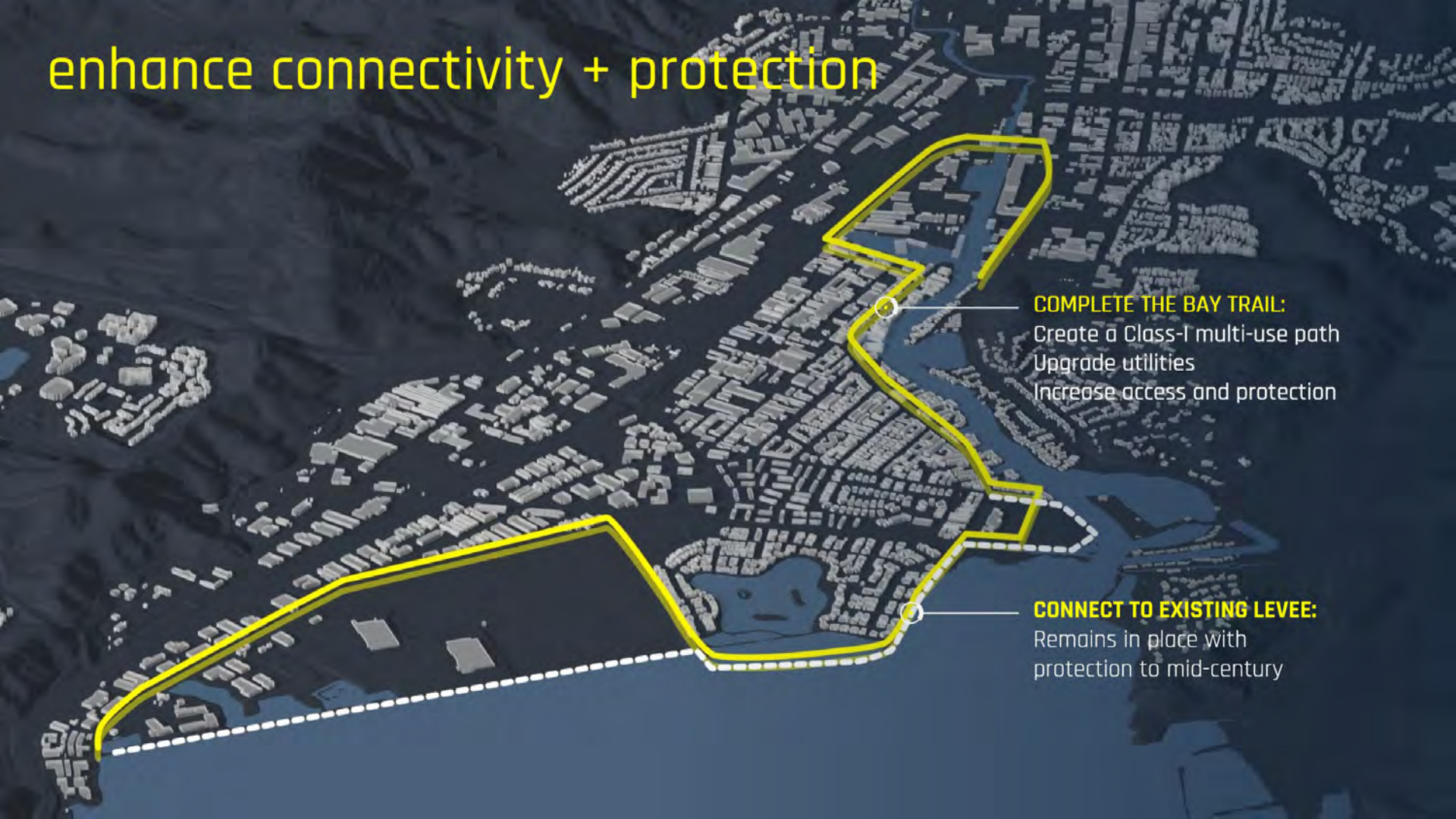
community event space



emergency response center

catalyst project 2 //
BUY TIME

enhance connectivity + protection



COMPLETE THE BAY TRAIL:

- Create a Class-I multi-use path
- Upgrade utilities
- Increase access and protection

CONNECT TO EXISTING LEVEE:

- Remains in place with protection to mid-century

canal street today

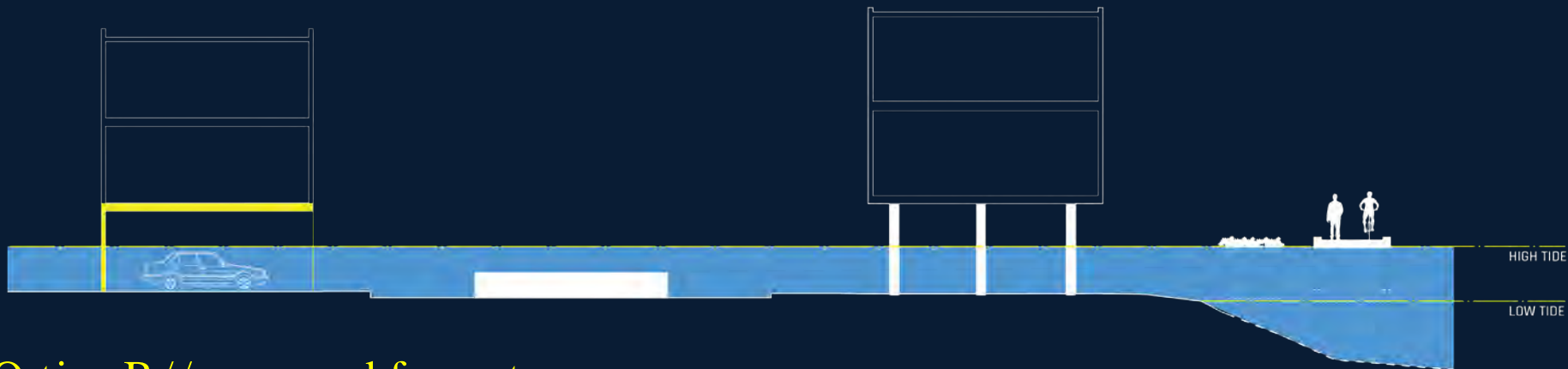


←..... Existing corroding
corrugated metal pipes



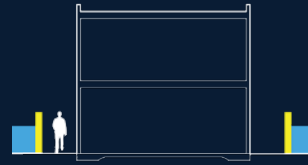
- Flood Gate
- Raised Class-I multi-use path
- Upgraded + elevated utilities

options

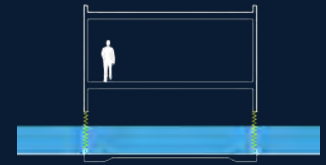


Option B // prepared for water

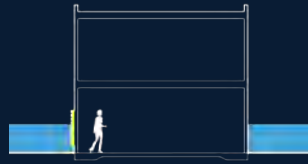
single property retrofit + upgrade



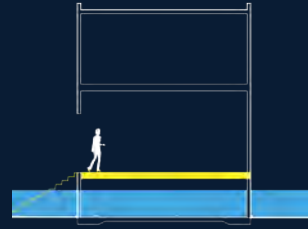
Wall



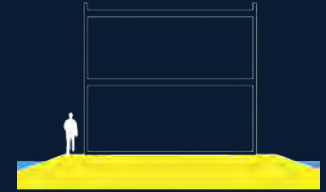
Wet Flood Proofing



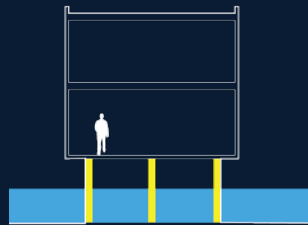
Flood Proofing



Raised Ground Floor



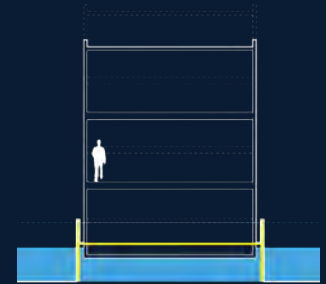
Mound



Raised



Floodable Ground Floor



Floating

catalyst project 3 //
new forms of living

2018



2060

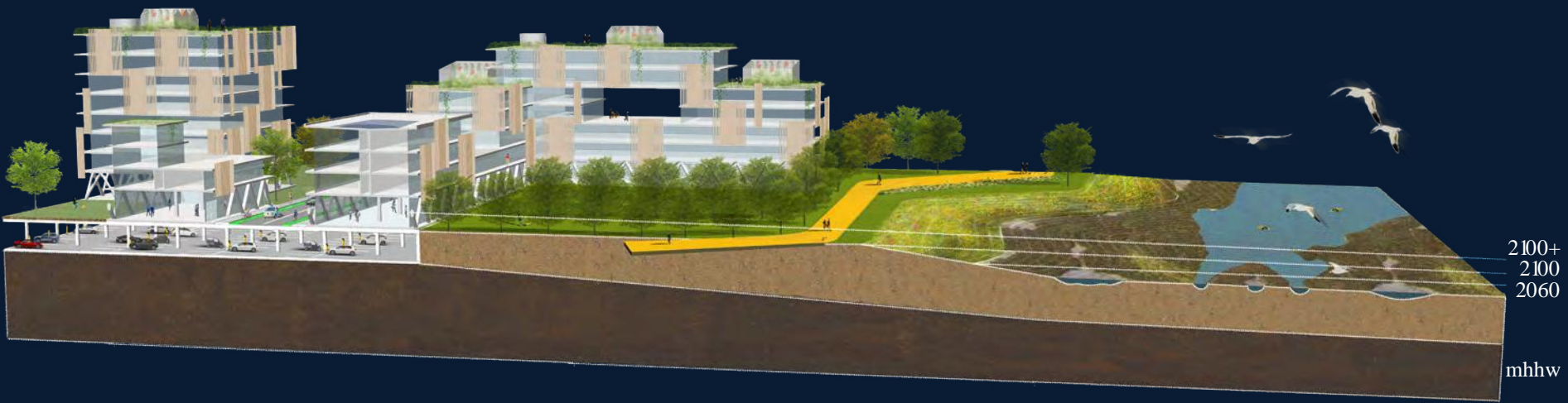


NEW HOUSING + BUSINESSES

On underutilized adjacent site
Connect high ground for protection

HIGH GROUND

new housing + businesses



parking & protection

community spaces



new neighborhood + marsh



the marsh



catalyst project 4 //
the canal

canal ecology //
floating wetlands



canal ecology //
floating wetlands



canal ecology //
floating wetlands



canal //
new perception



catalyst project 5 //
the reef

MARIN ISLANDS
NATIONAL WILDLIFE
REFUGE

EXISTING MARSHES

TISCORNIA MARSH
CONCEPT PROPOSAL
(IN PROGRESS)

SPINNAKER LAGOON
TIDAL MARSH PROPOSAL

LIVING SHORELINE PILOT
PROJECT

EXISTING BRACKISH
MARSH

existing ecology





future edge

multiply ecological diversity



reef ecology



reef research lab



stewardship + recreation



elevating: the long term



RETAIL

SMALLER FORMAT



**HIGHER
PERFORMING
LAND USES**

The image shows the front interior of a car, looking out through the windshield at a cityscape at sunset. The dashboard is dark with a central infotainment screen displaying a car icon. The seats are dark leather. The text 'MOBILITY' is overlaid in large yellow letters at the top.

MOBILITY

DECREASE IN OWNERSHIP
NEW SALES & SERVICE MODELS

TECHNOLOGY

A yellow DHL drone is shown in flight against a blue sky. The drone is carrying a yellow parcel with a large white 'M' and the word 'PACKSAT' on it. The drone has 'DHL' and 'microdrones.com' written on its arms. The parcel has 'DHL' and 'PACKSAT' written on it. The drone is flying towards the right.

NEW LOGISTICS
MODELS & PATTERNS

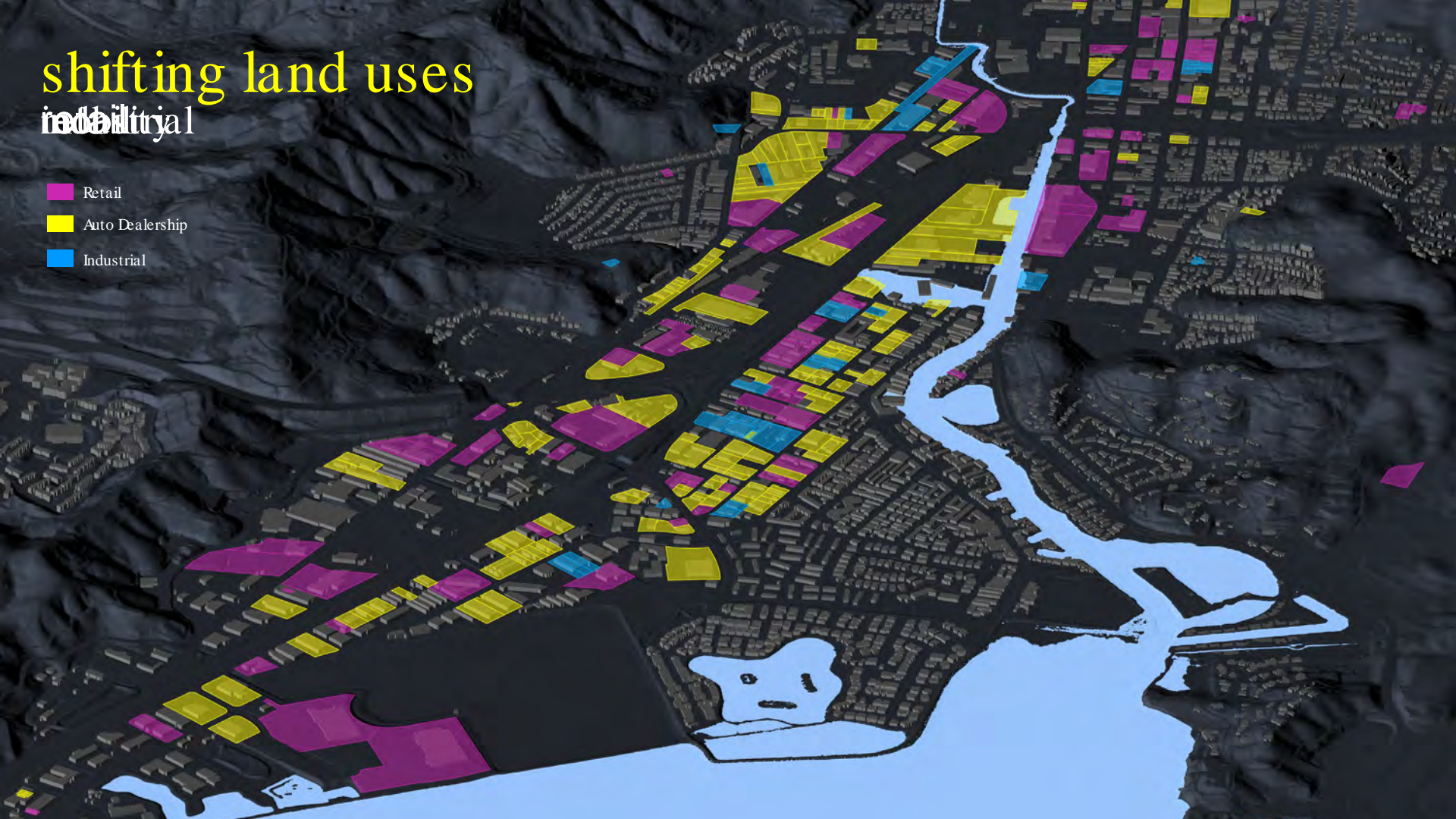
An aerial photograph of a multi-lane highway that has been severely flooded. The water is murky brown and reaches up to the shoulders and surrounding areas. Several pieces of construction equipment, including orange excavators and trucks, are positioned along the road, with workers in high-visibility vests nearby. In the foreground, there are several billboards, including one with a '50% OFF' sign and another for 'Q1'. The background shows a residential or commercial area with houses and trees under a grey, overcast sky.

INSURANCE

NEW INCENTIVES
PROGRAMS MARKETS

shifting land uses in downtown

- Retail
- Auto Dealership
- Industrial





SMART RAIL LINE EXTENSION

EXISTING 101 & 580 FREEWAYS

existing infrastructure

2018

An aerial photograph of a city, likely San Francisco, showing a dense urban grid and a winding river. The image is rendered in a dark, monochromatic blue color scheme. The buildings are represented as light-colored, rectangular shapes, and the river is a darker blue. The overall scene is viewed from a high angle, looking down on the city.

acquisition + evolution

2100



COMPLETE THE BAY TRAIL

Near term protection

LONG TERM SPINE

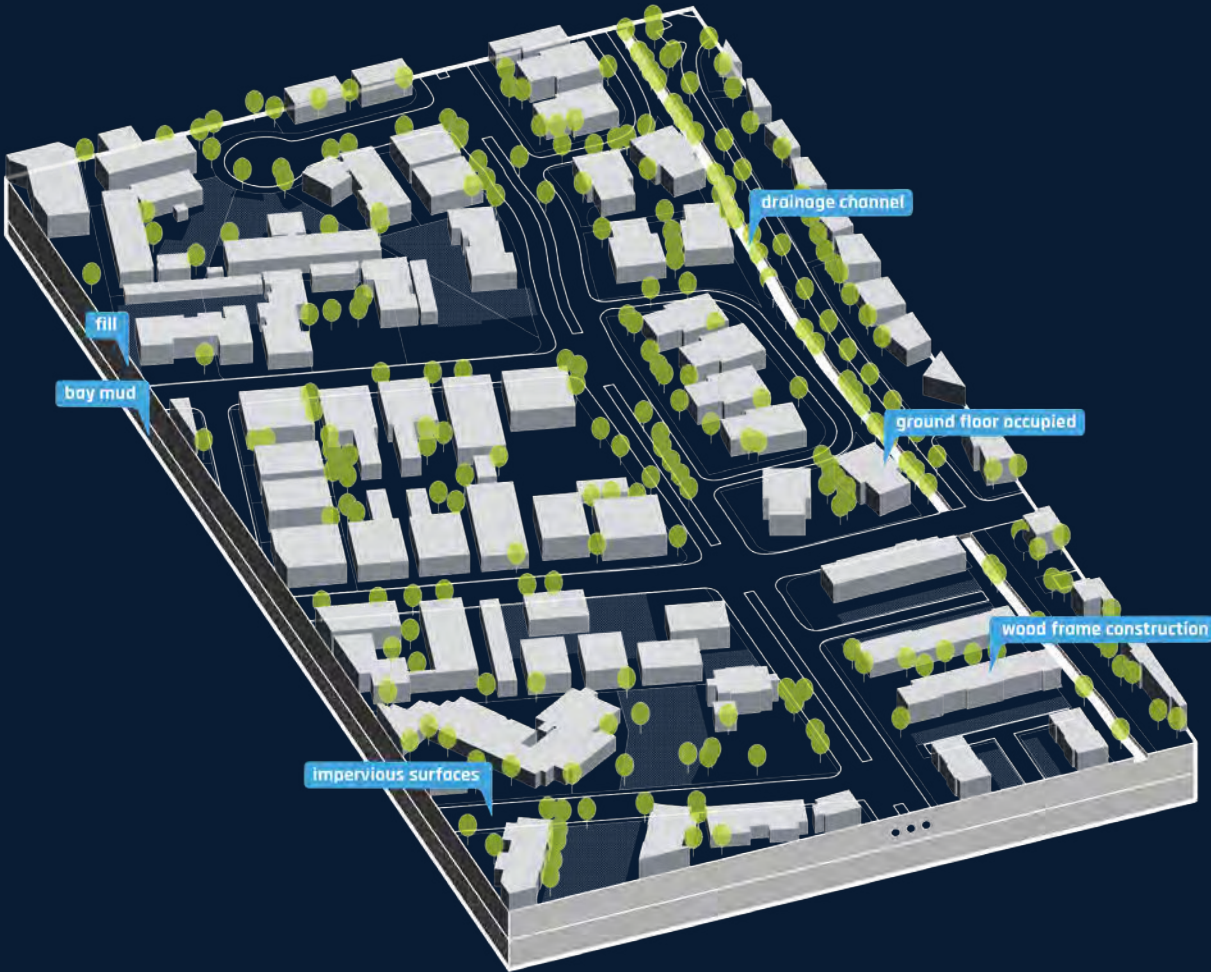
- Primary roads as critical infrastructure
- Provides safe access and utilities
- Acquire properties along these roads for future-proofing

HIGH GROUND

acquisition + evolution

Kerner Blvd

today // residential



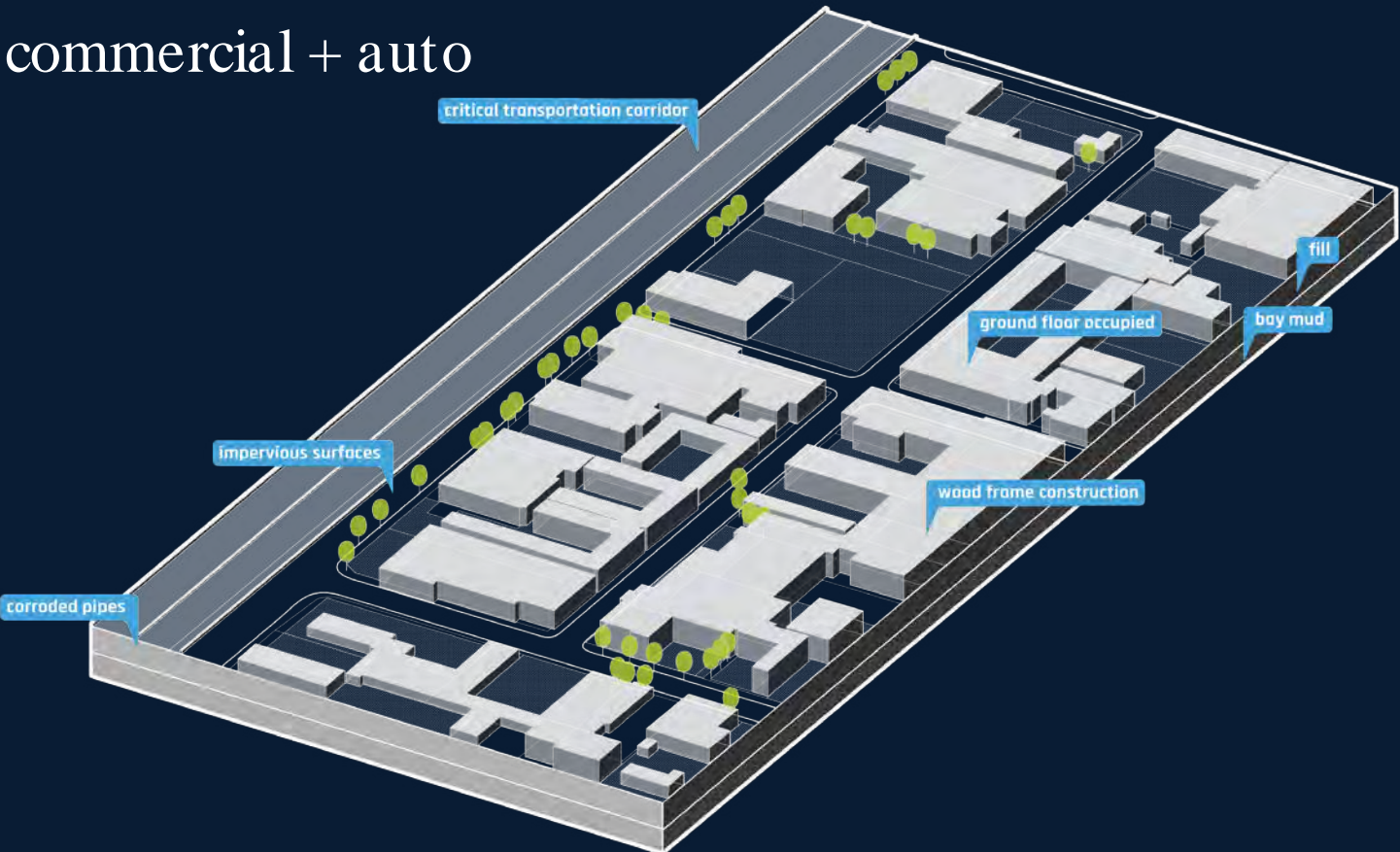
Kerner Blvd

new infrastructure



Francisco Blvd

today // commercial + auto



Francisco Blvd

new infrastructure

- 1 New Fill
- 2 Bay Mud
- 3 Existing Ground
- 4 Existing Fill
- 5 Linear Cistern



San Rafael +
the metropolis



NEXT STEPS

Identify

San Rafael is a nexus of the bay area economy.

Lead

To advance planning, policy, and financing efforts

Prioritize

Planning and infrastructure for the watershed and the waterfront

Organize

- All people of San Rafael
- Policy mechanisms
- A new process

Start



bionic

PennDesign

WXY architecture + urban design

Studio for Urban Projects

Enterprise Partners

M Yame

SF State University

Keyser Marston Associates

WRA Environmental

RAD Urban

Moffatt & Nichol

SAN RAFAEL
ELEVAT

A large, bright yellow arrow points diagonally upwards and to the right, starting from the bottom right of the word 'ELEVAT' and extending towards the top right of the image. The arrow is solid and has a simple, clean design.



South End Living Shorelines Project

Kate Bimrose

Bolinas Lagoon Project Manager

March 21, 2019

SLR Adaptation Workshop



PROJECT NEED: Communities surrounding the South End of Bolinas Lagoon face frequent flooding that is likely to worsen with sea level rise and increased storm intensity. If habitat in this area is not restored, flooding will all but eliminate important refugia for plant and wildlife species and undermine access/safety of surrounding trails and roads.

PROJECT AREA: The South End project encompasses the eastern span of Dipsea Road in the Seadrift community and Calle del Arroyo Road in Stinson Beach.

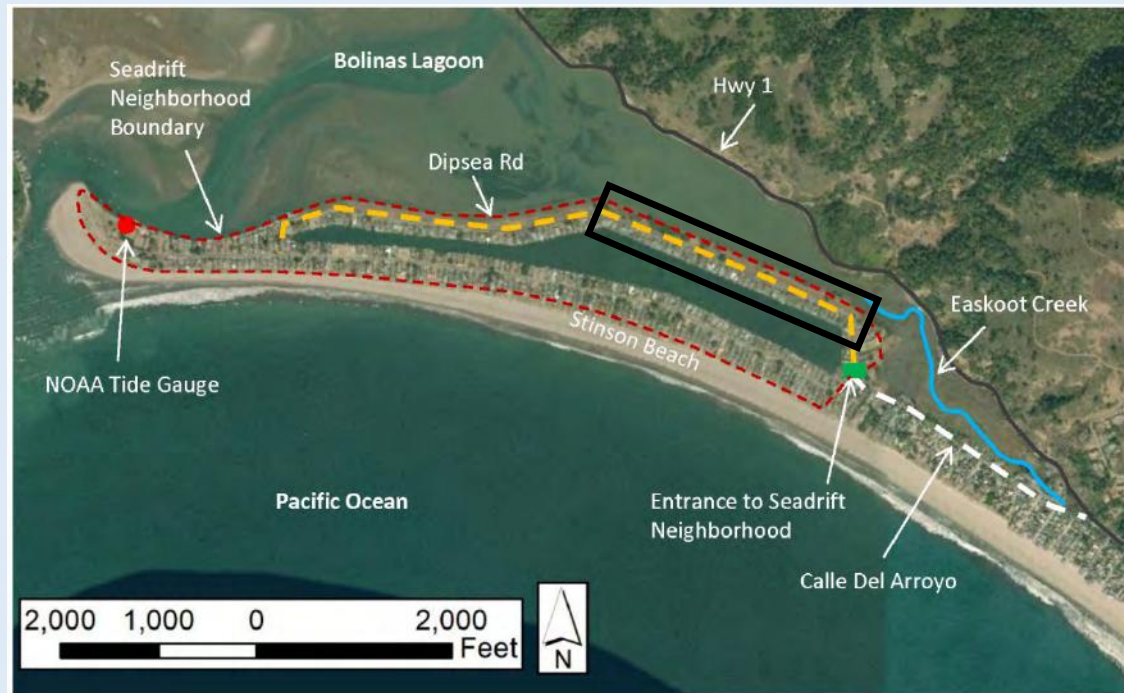


Dipsea Road



Shoreline along the eastern section of Dipsea Road is eroding, causing a steep scarp that drops upwards of 10 ft to the lagoon. Continued erosion will:

- Limit habitat refugia for plants and animals as water levels rise
- Contribute increased sedimentation/fill into the lagoon
- Eventually undermine the local walking path, and eventually Dipsea Road, and nearby homes





Calle del Arroyo



Calle del Arroyo frequently floods during storms and high tide events, particularly at a ~500ft section that dips as low as 7.5ft NAVD88.

Past 5 years = 29 events with water levels >7ft NAVD88 and 6 events with water levels >7.5ft NAVD88 in Bolinas Lagoon

Continued high water events:

- Flood the only access road in and out of Stinson Beach patios/calles and Seadrift community
- Turn marsh/intertidal habitat into subtidal habitat, drowning important wetlands that could act as a buffer to protect to the road
- Threaten nearby homes and utilities





NEW CULVERT

LEWIS GULCH CREEK

RECONFIGURED INTERSECTION

NEW BRIDGE

WILLOW / ALDER FOREST

FLOODPLAIN

WILKINS RANCH

WILKINS GULCH CREEK

DECOMMISSIONED ROAD

RAISED ROADWAY

BOLINÁS FAIRFAX ROAD

NEW CAUSEWAY

SALT CREEK

LATE CENTURY SLR (11.1')

MID CENTURY SLR (7.6')

DECOMMISSIONED ROAD

ALKALI BRUSH

RAISED ROADWAY

BIKE LANE

SALT MARSH

OLEMA BOLINÁS ROAD

TIDAL BRACKISH MARSH TRANSITION ZONE

MHHW (5.6')

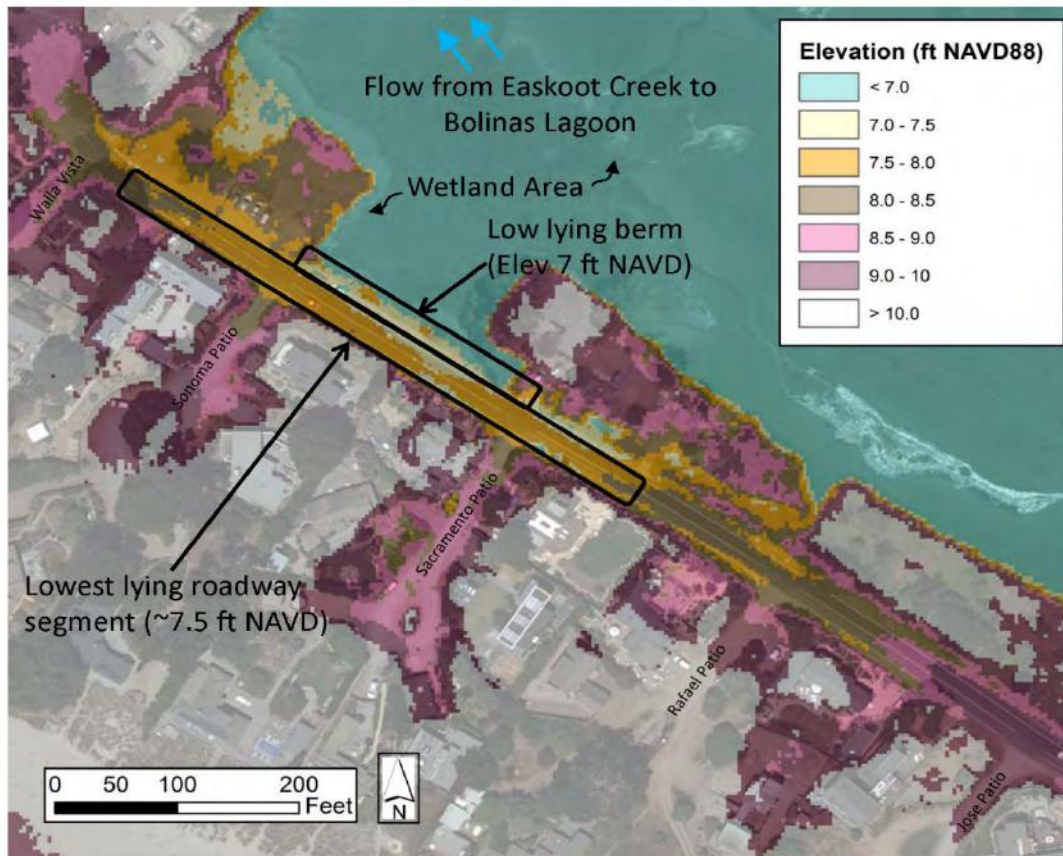
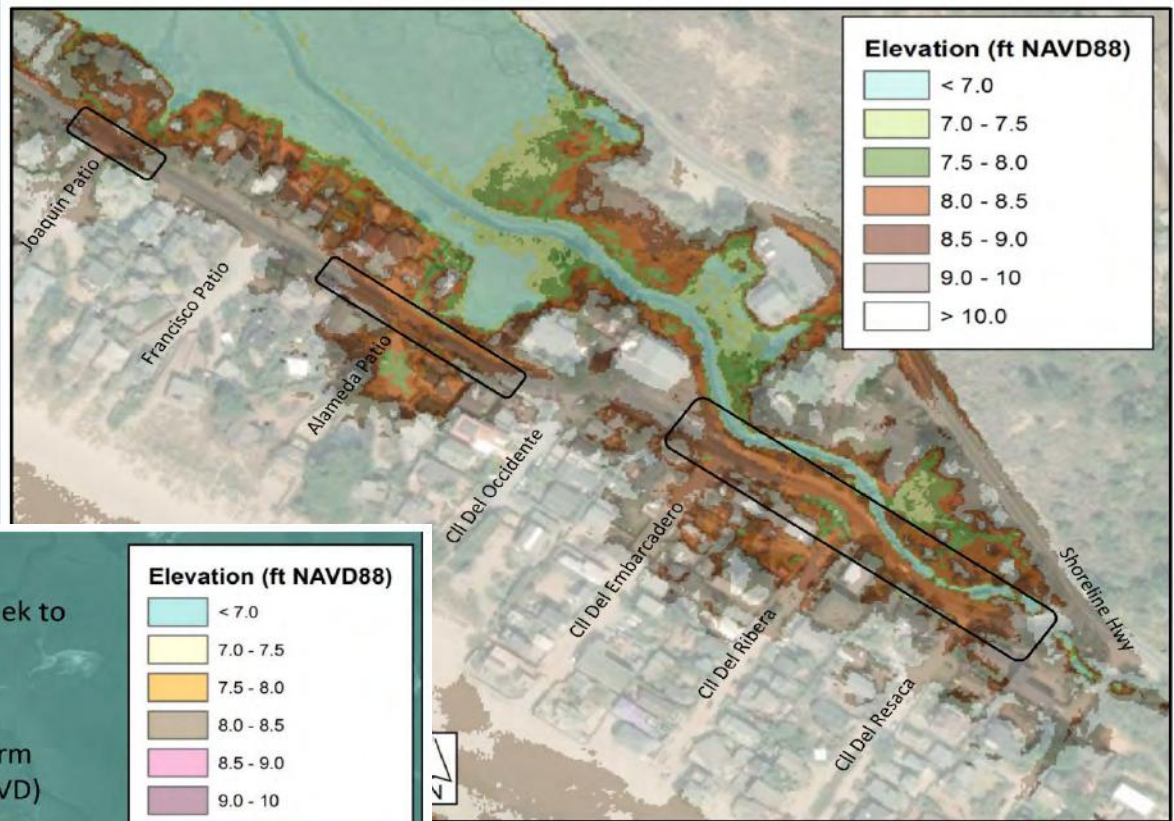
BOLINÁS LAGOON

An aerial photograph of a coastal town built on a narrow peninsula. The town is surrounded by clear, turquoise water. In the background, there are large, forested mountains. The sky is clear and blue. The text "Thank you!" is overlaid in white on the right side of the image.

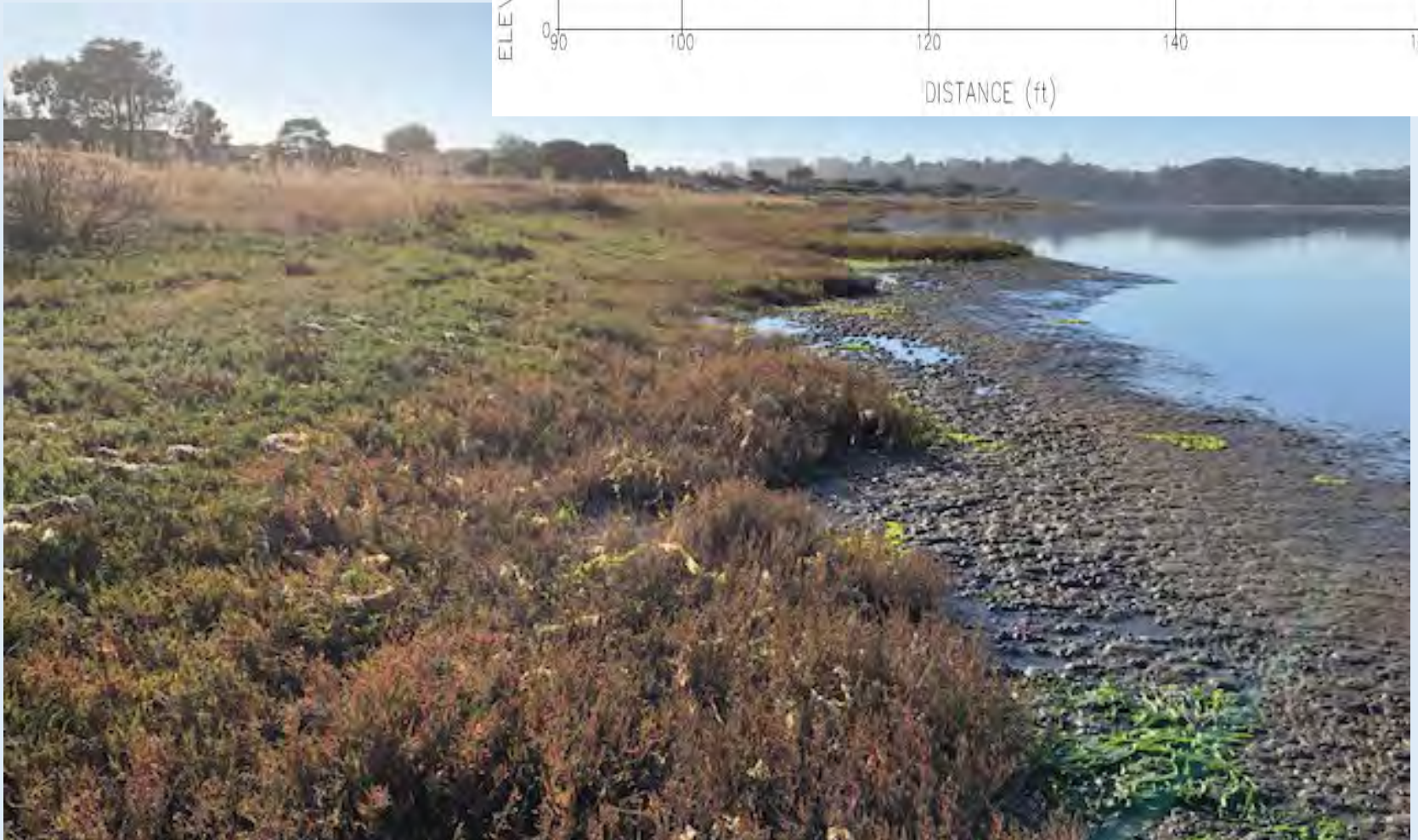
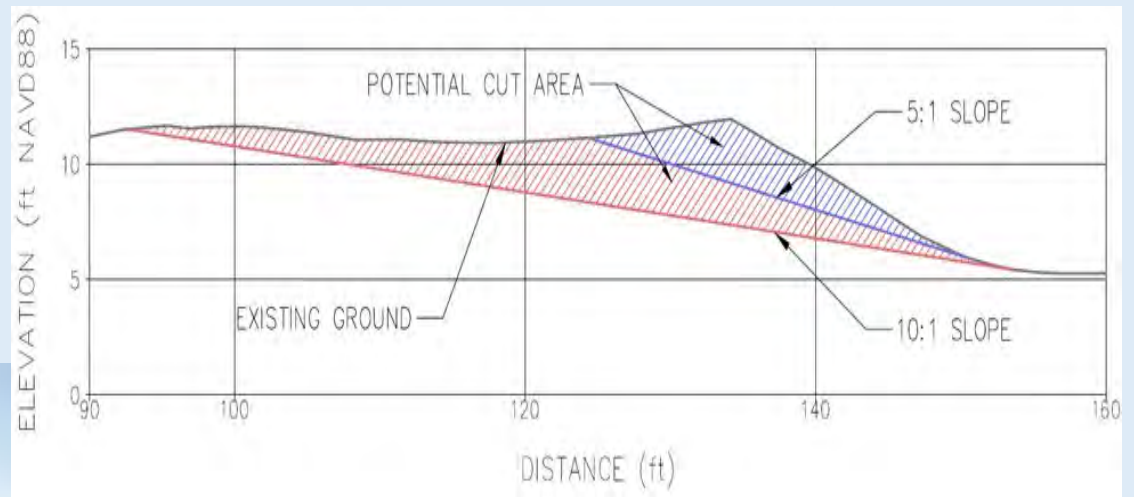
Thank you!

kbimrose@farallones.org
Greater Farallones Association

Calle del Arroyo



Dipsea Road



Dunphy Park Nature-Based Wave Attenuator

Conservation Corps North Bay



Existing Eelgrass and Oyster beds Proposed Sheet Pile Breakwater



SOURCE: Google Earth, WB Clausen Structural Engineers 2014, SF Bay Subtidal Goals 2014

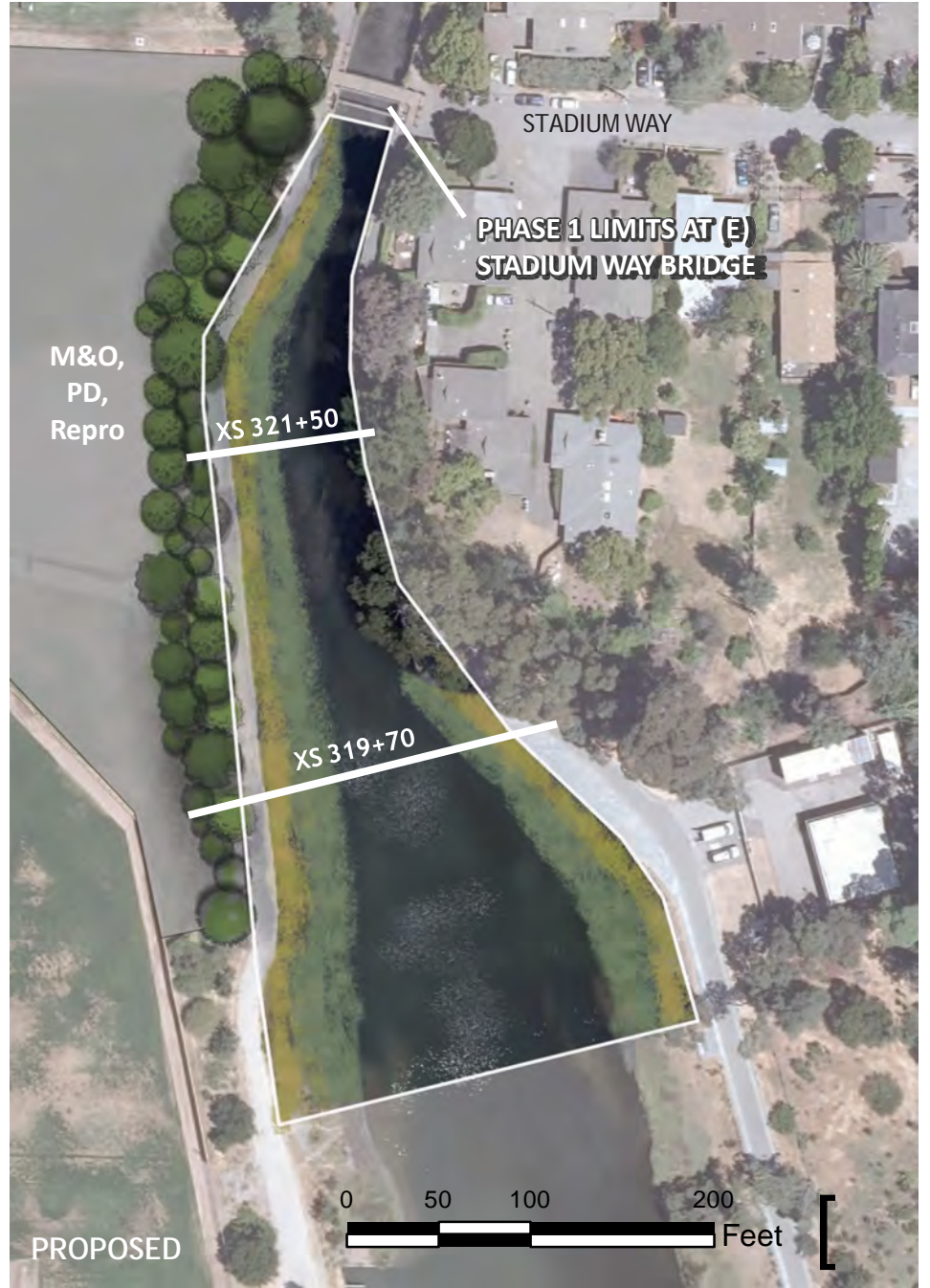
Sausalito Nature-Based Wave Attenuator

Responding to SLR in Corte Madera Creek

Two Project Cameos



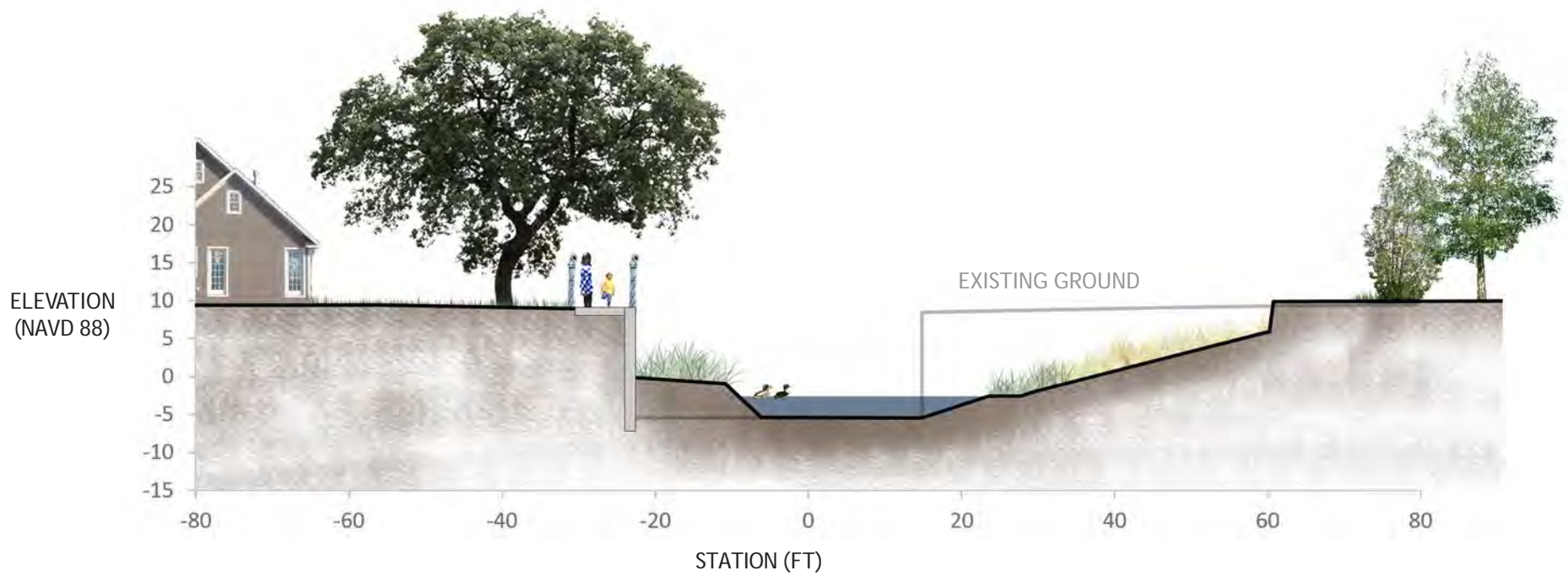
Sandy Guldman
March 21, 2019



PHASE 1 - EXISTING AND PROPOSED CONDITIONS

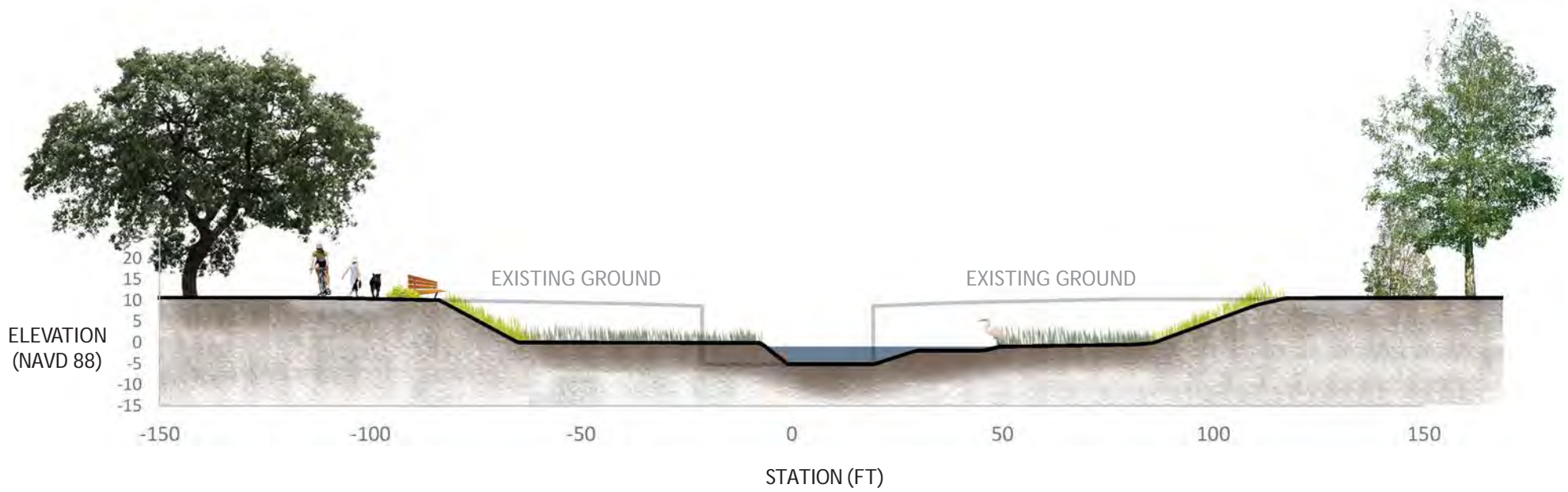


walls land+water, llc



PHASE 1 - CROSS SECTION 321+50 (FACING DOWNSTREAM)





PHASE 1 - CROSS SECTION 391+70 (FACING DOWNSTREAM)



walls land+water, llc



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MILLER AVENUE

By the numbers....

18 Month Construction Period

18 Million Dollars

2 Miles Bike Lanes with Buffers

160 Trees

31 Painted Crosswalks

8 Raingardens

63 Bike Friendly Back-in Diagonal Parking Spaces



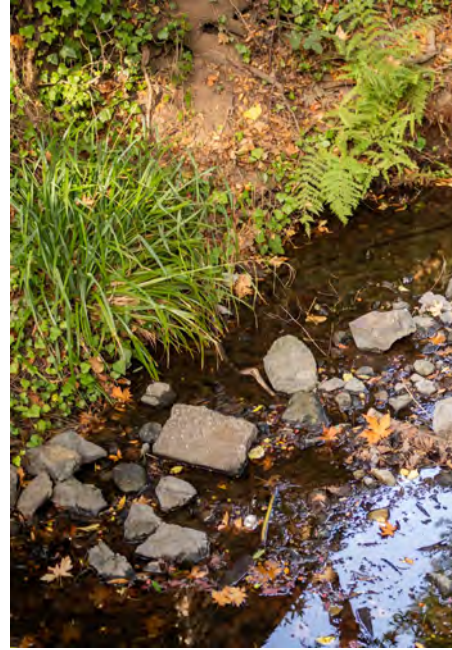
Bike Lanes
with Buffer



Sidewalks &
Accessibility



Drainage &
Stormwater
Treatment



Creek
Celebration &
Protection



Public Safety



COMMUNITY CENTER

DOWNTOWN
MILL VALLEY

BOTHIN
MARSH

Passage

Parkway

Main Street

Gateway

Marsh

MILLER AVENUE | SLR & ADAPTATION





MILLER AVENUE | SLR & ADAPTATION





MILLER AVENUE | SLR & ADAPTATION



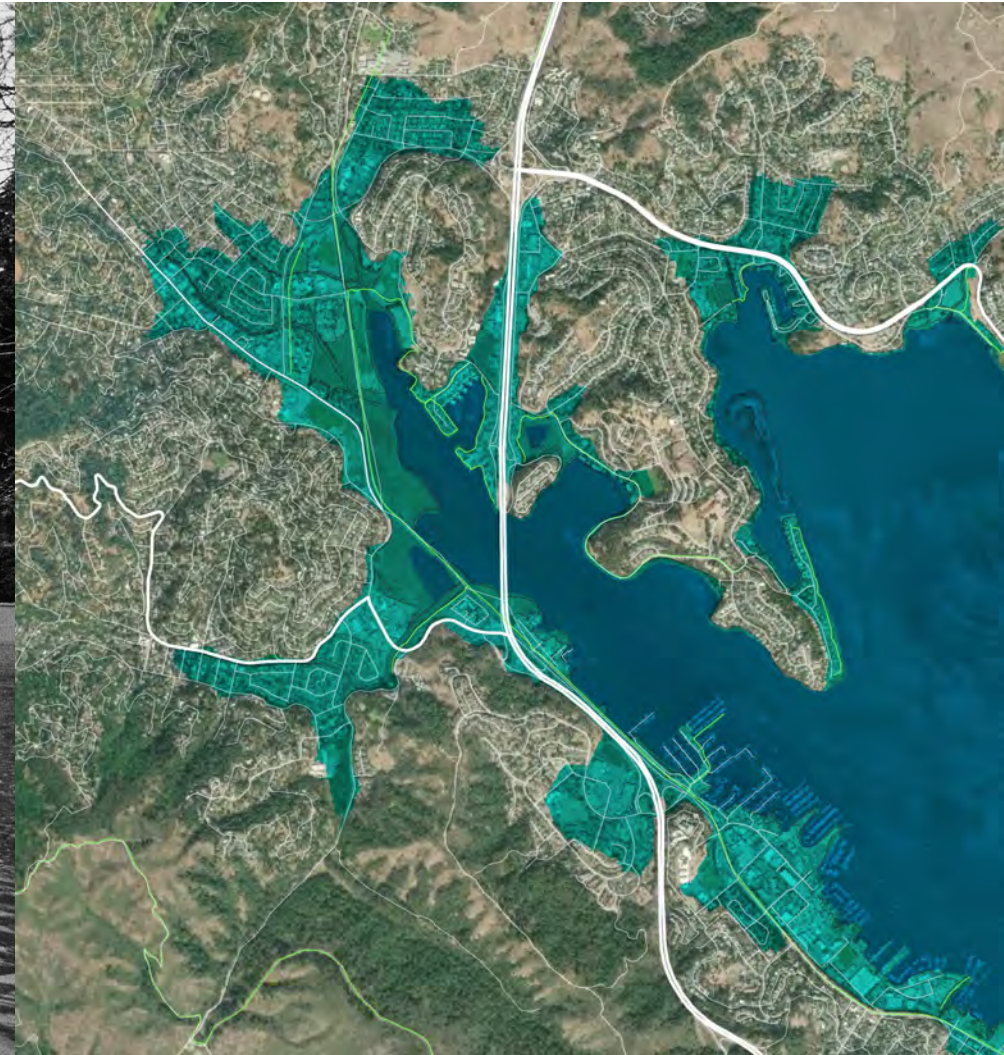


MILLER AVENUE | SLR & ADAPTATION





Storm Flooding



Sea Level Rise
100yr storm + 3m SLR

MILLER AVENUE | SLR & ADAPTATION



MILLER AVENUE | SLR & ADAPTATION





MILLER AVENUE | SLR & ADAPTATION





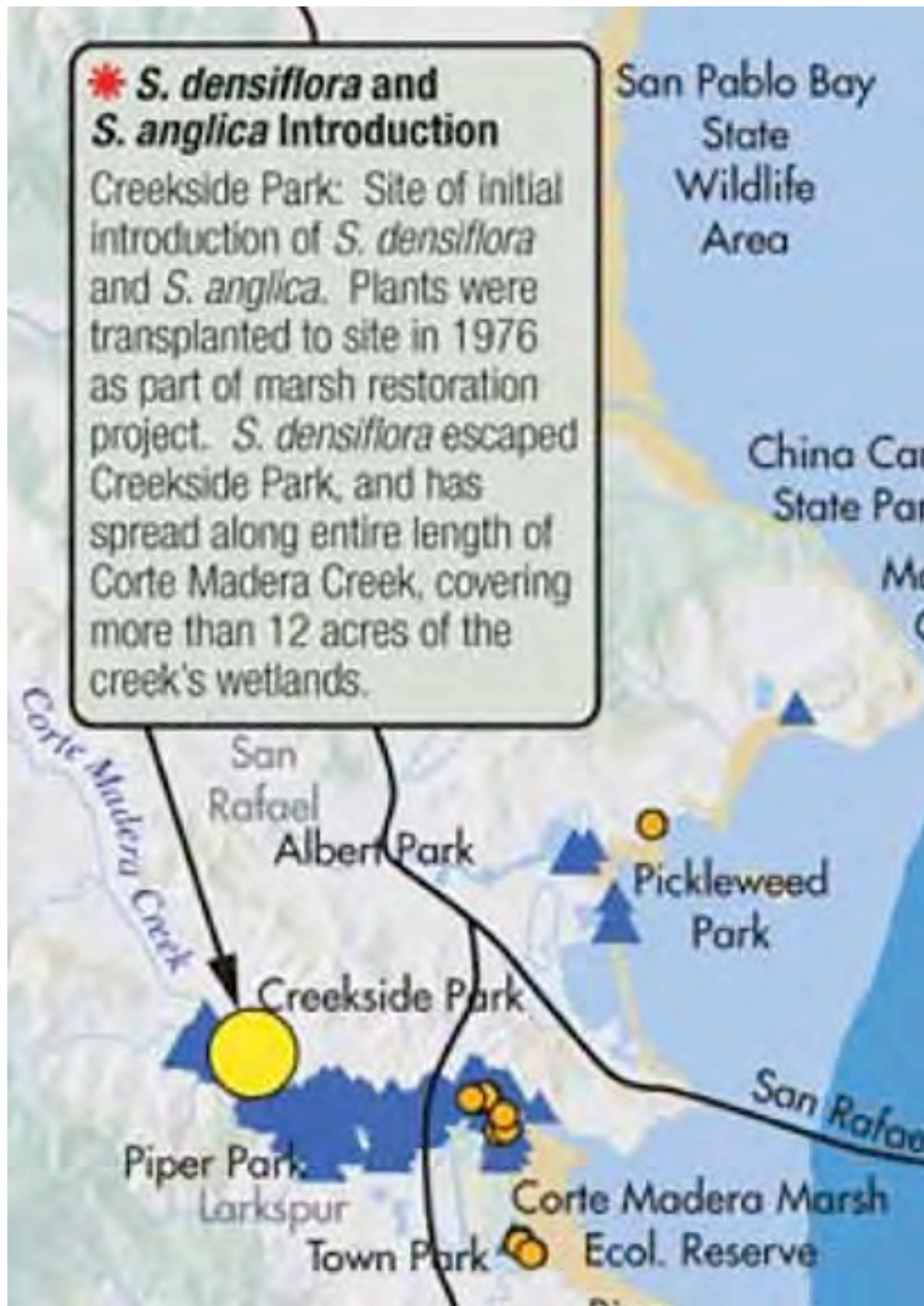
MILLER AVENUE | SLR & ADAPTATION





MILLER AVENUE | SLR & ADAPTATION





Invasive Spartina Project

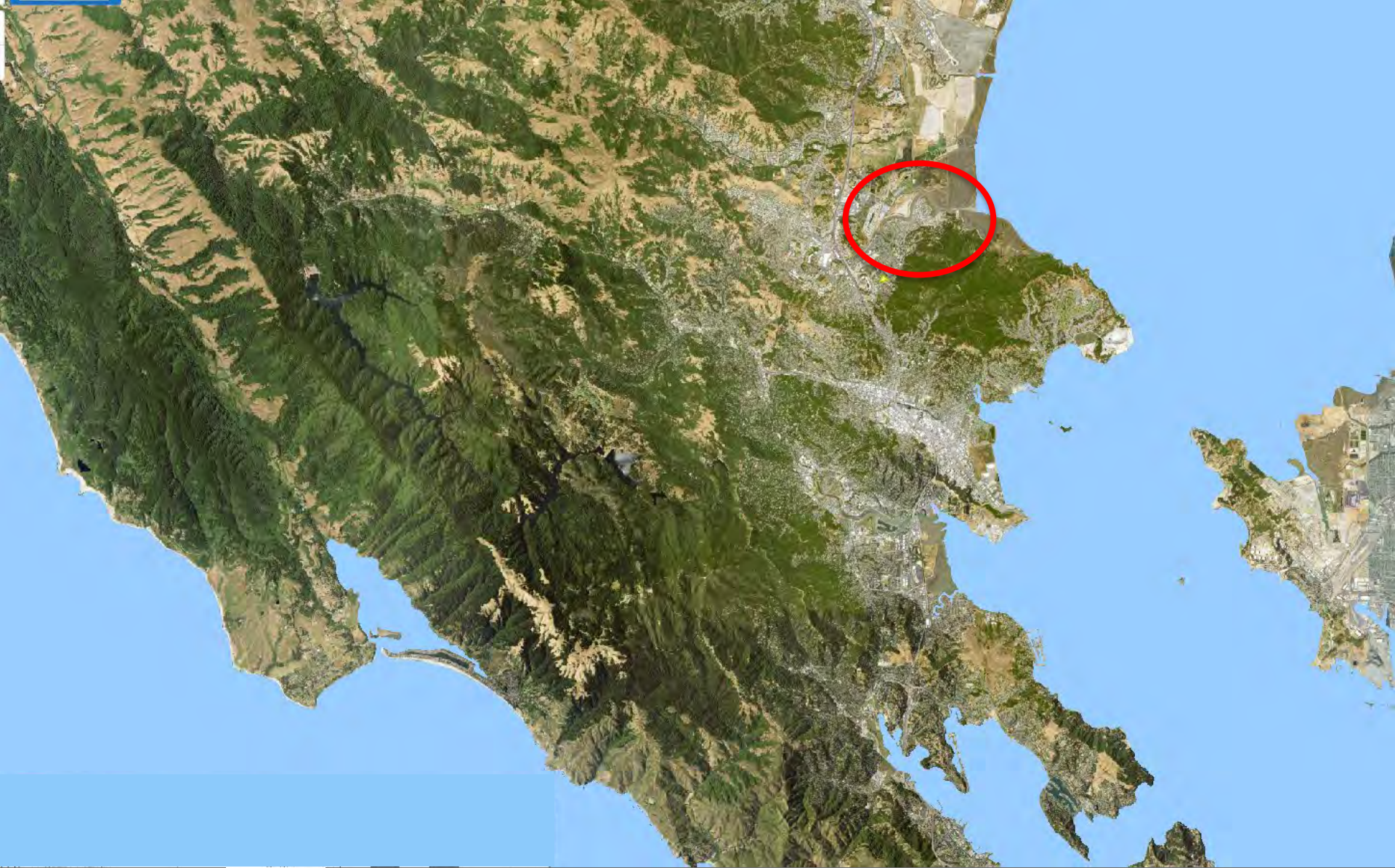
- Bay-wide project of Coastal Conservancy
- Work began in Corte Madera Creek in 2003
- 12 acres of invasive cordgrass
- Four invasive species, one native
- More than 95% eliminated by 2018

Fragment of map from EIR published in 2003



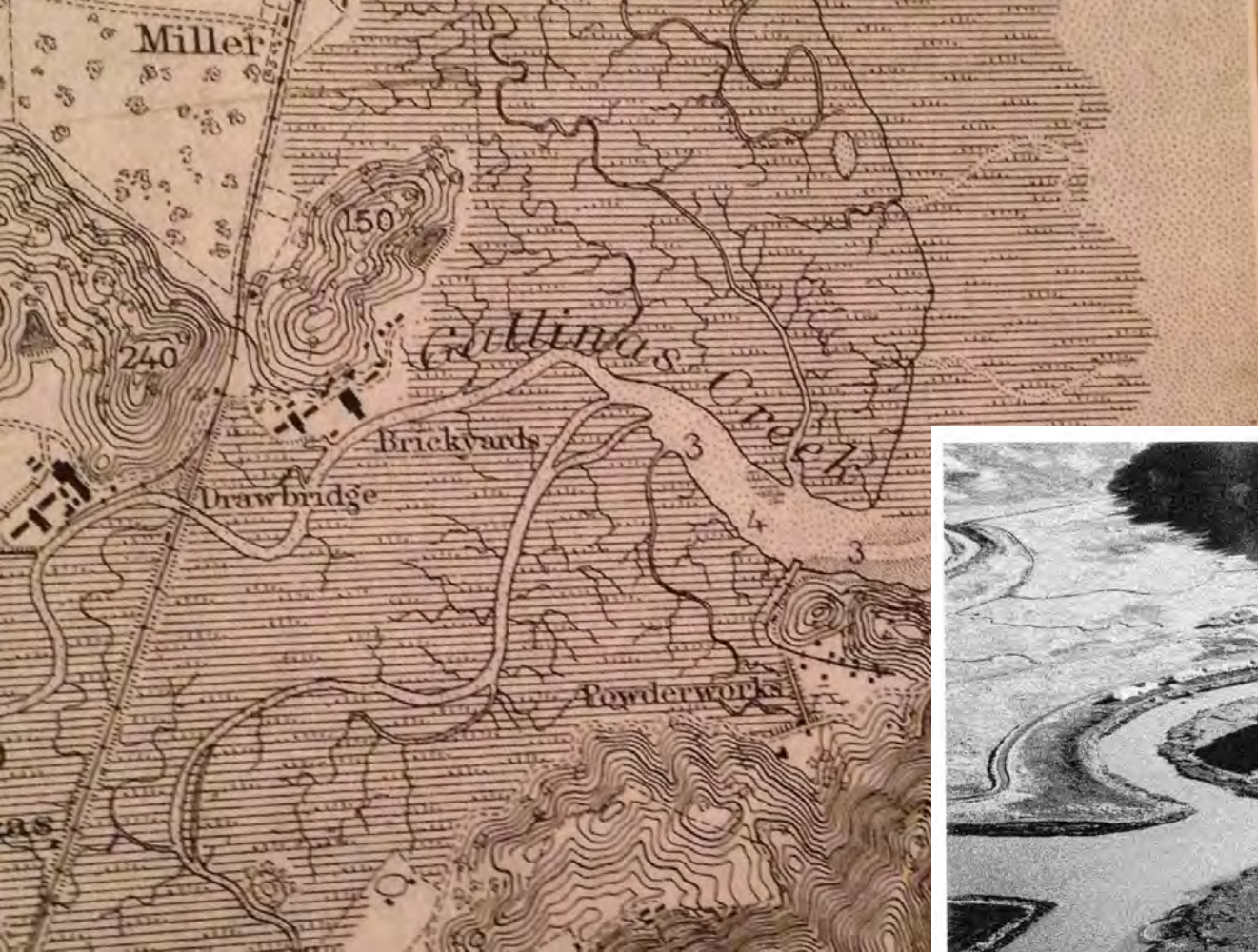
Santa Venetia Flood Control Zone #7

TIMBER REINFORCED BERM IMPROVEMENT PROJECT
GERHARD EPKE



Santa Venetia – Gallinas Watershed

WWW.MARINWATERSHEDS.ORG



Development 1930s - 1970s



WWW.MARINWATERSHEDS.ORG



Santa Venetia Today

WWW.MARINWATERSHEDS.ORG





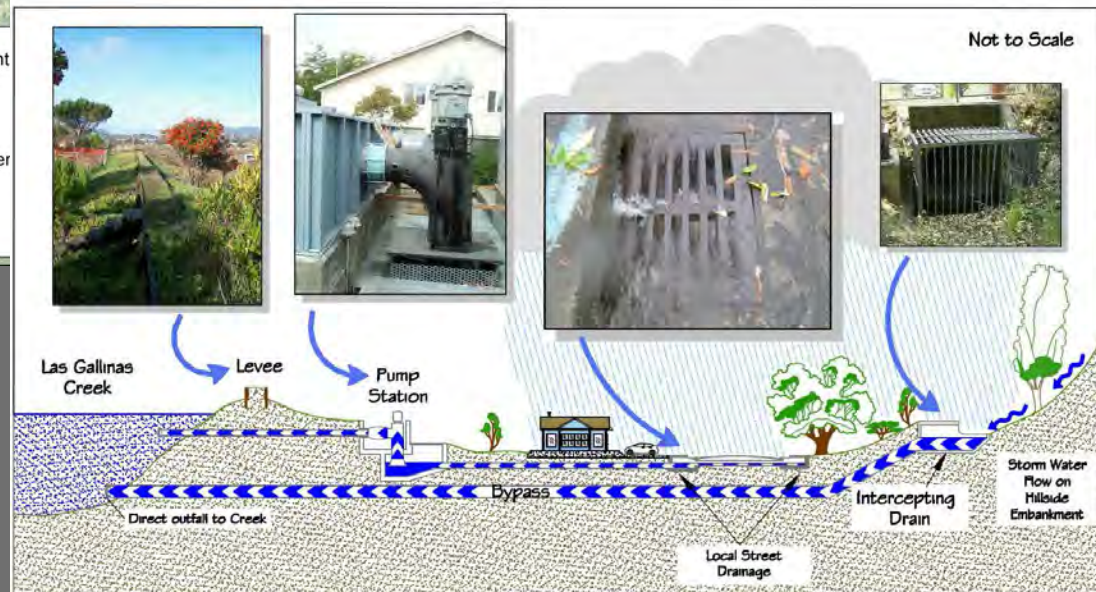
Chronic Flooding until 1984



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- Pump Station - Permanent
- Pump Station - Portable
- Earthen Levee
- Earthen Levee with Timber
- Maintenance Ditch
- Bypass Pipe



Pump Stations, Bypass Drainage, Levee

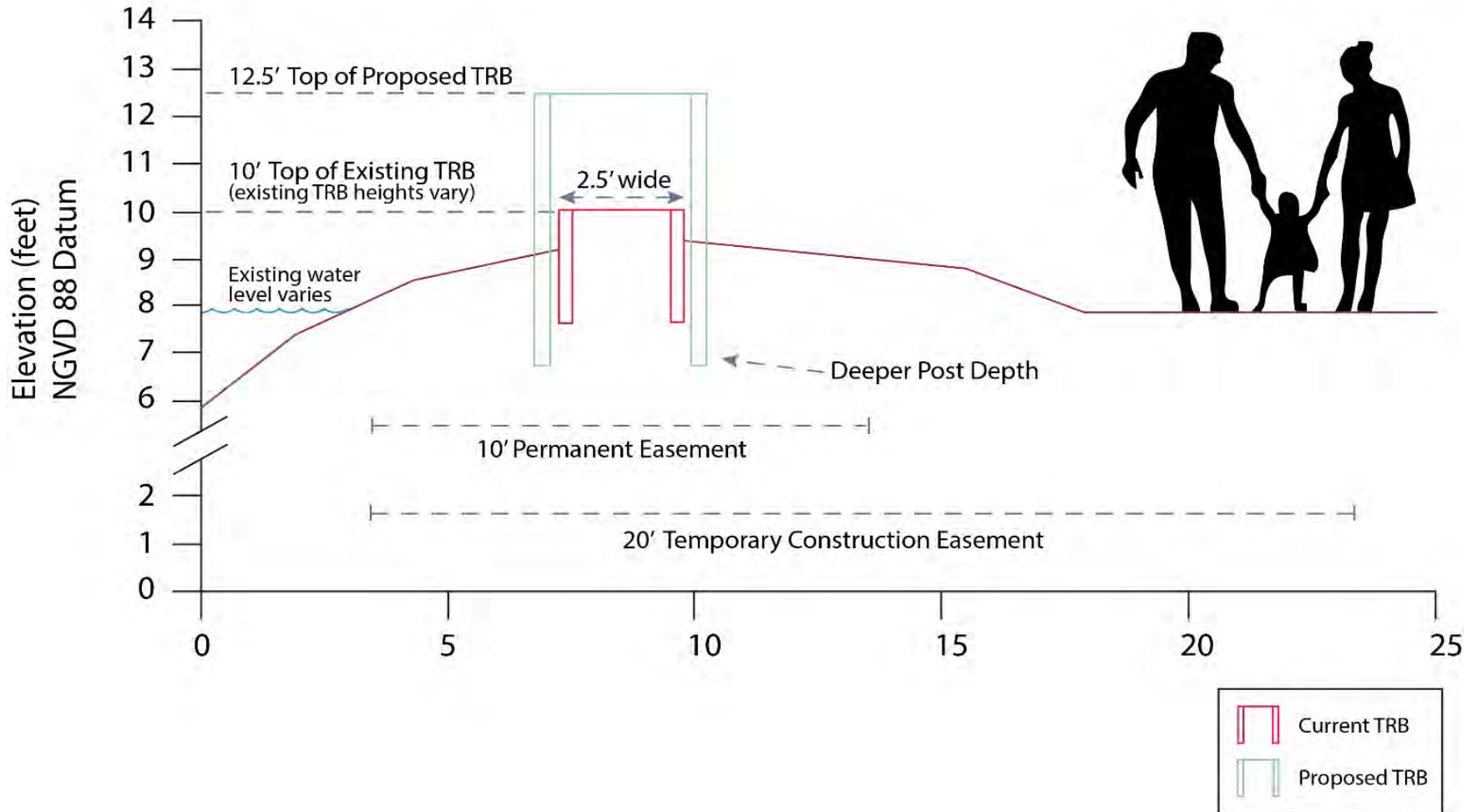


1983 Timber Berm through 115 yards



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Comparison between Current and Proposed Timber-Reinforced Berm (TRB) and Proposed Easements





Proposed TRB Improvement

114 Parcels - New TRB
22 Parcels - Currently w/o TRB
92 Parcels - Current TRB w upgrade

Inner Levee

0 260 520
Feet





Thank You!

TIMBER REINFORCED BERM IMPROVEMENT PROJECT
GERHARD EPKE