

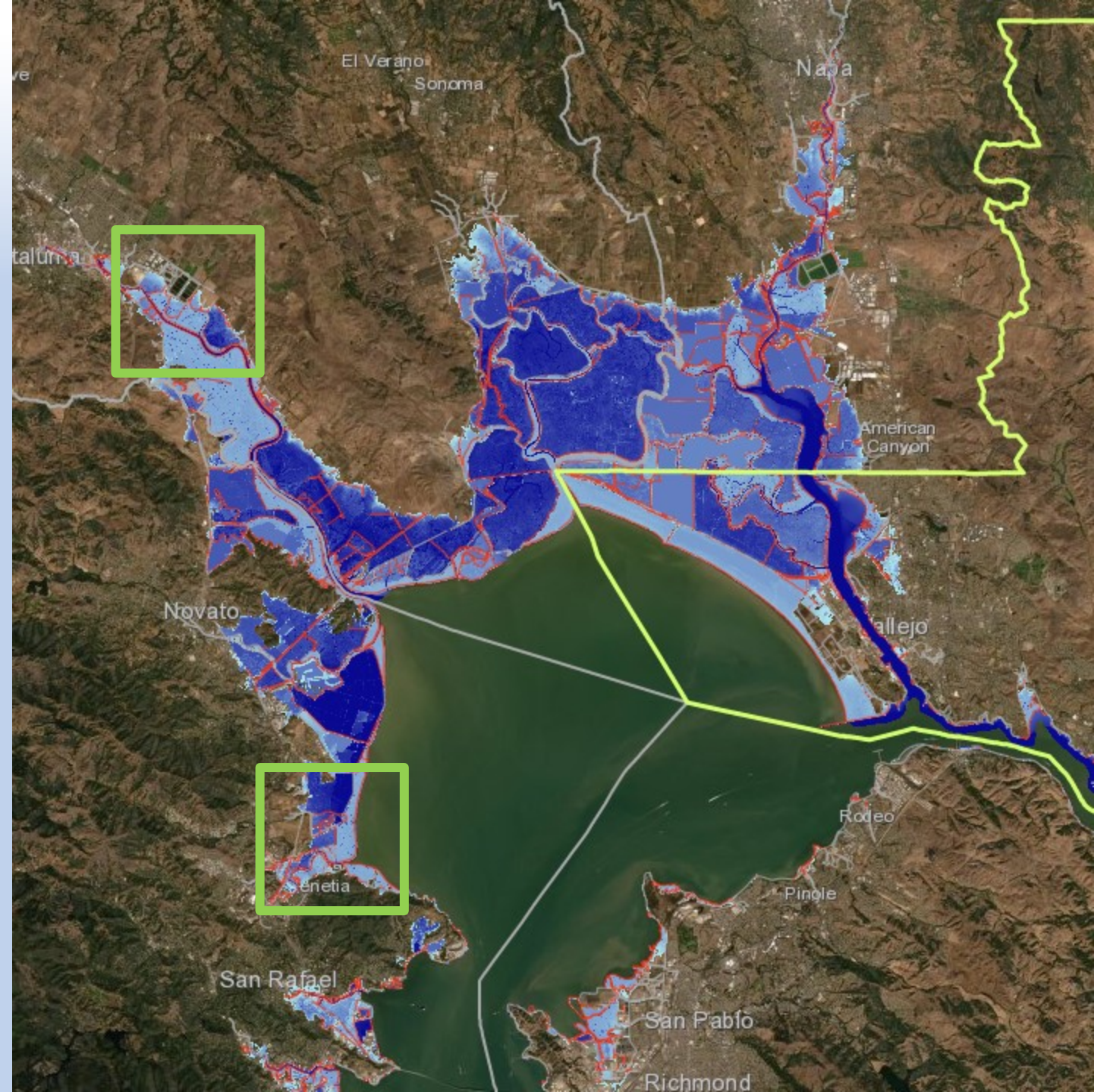


NBWRA SLR Adaptation Plan: LGVSD Board Update

March 6, 2025



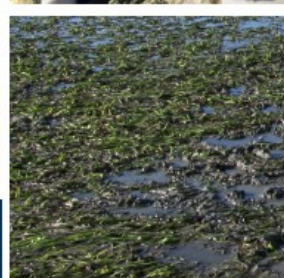
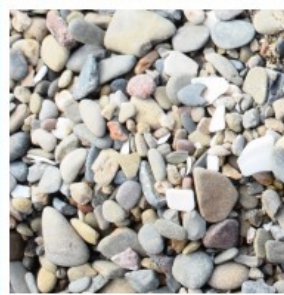
Sea Level Rise at NBWRA Participating Agencies



SEA LEVEL RISE

Adaptation Framework

A user guide to planning with nature,
as demonstrated in Marin County



SAN FRANCISCO BAY SHORELINE Adaptation Atlas

Working with Nature to Plan for Sea Level Rise
Using Operational Landscape Units



SFEI San Francisco Estuary Institute
SPUR



SFEI

AQUATIC
SCIENCE
CENTER



NORTH BAY WATER REUSE PROGRAM
Water Supply Reliability through Regional Reuse

GENERAL PROCESS:

Develop Vision(s), Goals and the Outcome Desired



Develop Strategy(ies) to Achieve the Goals of that Vision



Evaluate Trade Offs of Visions against criteria to prioritize or select



Potential Criteria

100-year SLR + 100-year
flood protection

Implementation Cost

Funding Strategy

Institution
Arrangements

Right of Way

Permitting

Number of
Implementing
Agencies/Agreements




NORTH BAY WATER REUSE PROGRAM
Water Supply Reliability through Regional Reuse

OVERVIEW OF THE ADAPTATION FRAMEWORK


The Adaptation Framework is an iterative process intended to support planners and other coastal decision makers in identifying, evaluating, and prioritizing adaptation strategies in a way that transparently considers multiple benefits. The five steps are summarized here, elaborated on in the following pages, and illustrated with two case study examples located in Marin County.

This chapter walks through the steps linearly to demonstrate how the framework could be applied to a real place, but the order of the steps can be adapted to fit the needs of the users or incorporate lessons learned. In particular, we acknowledge that practitioners could implement Step 3 before Step 2, resulting in a filter that narrows the number of measures that need to be considered. Individual steps may also need to be revisited with the availability of new data, changes in stakeholder goals, or other considerations that change the inputs driving the outcomes.




STEP 1
Assess vulnerability to sea level rise by OLU

- In this step, stakeholders determine what assets are vulnerable by assessing exposure and risk, documenting where assets are located, and identifying hazards (e.g., coastal flooding, riverine flooding, erosion from waves)
- The goal of the vulnerability assessment is to understand which assets are vulnerable to flooding in different sea level rise scenarios.
- It is difficult, although critical, to assess the root cause of vulnerability (e.g., coastal vs. riverine flooding, combined flooding, erosion from waves) in order to identify the most effective adaptation options.




STEP 2
Identify adaptation approaches with a focus on natural and nature-based measures

- Identify adaptation measures that are suitable within each OLU.
- Understand which vulnerabilities are addressed by different adaptation measures.
- Determine what physical configuration would maximize the effectiveness of a particular adaptation approach.




STEP 3
Envision desired futures

- Define a vision or alternate visions, goals, and the outcomes desired by communities within the OLU to guide development of adaptation strategies.
- Determine what the OLU strategy needs to achieve based on the needs and desires of the communities and stakeholders projected to be impacted by sea level rise and future flooding (e.g., maintain function or service X and Y at location Z up to 2070).



STEP 4
Develop adaptation strategies

- Develop a strategy for each vision. There may be one or more strategies for each vision.
- Determine what combination of measures could be used where and when to achieve the goals of each vision.
- Discuss the co-benefits of each strategy.



STEP 5
Evaluate trade-offs and prioritize strategies

- Once strategies have been drafted, they can be compared or evaluated for trade-offs, including cost and ecosystem services. These can include benefits to people and wildlife, such as carbon storage, wave attenuation, recreation, and impacts to regional transportation.
- Estimate how long the strategy will last, how much it costs, and what are potential adverse impacts of each measure within a strategy.
- The process is iterative. Once there is a sense of benefits and trade-offs among strategies, elements of strategies may be combined into a final strategy, or the goals and visions revisited and the strategies redefined.

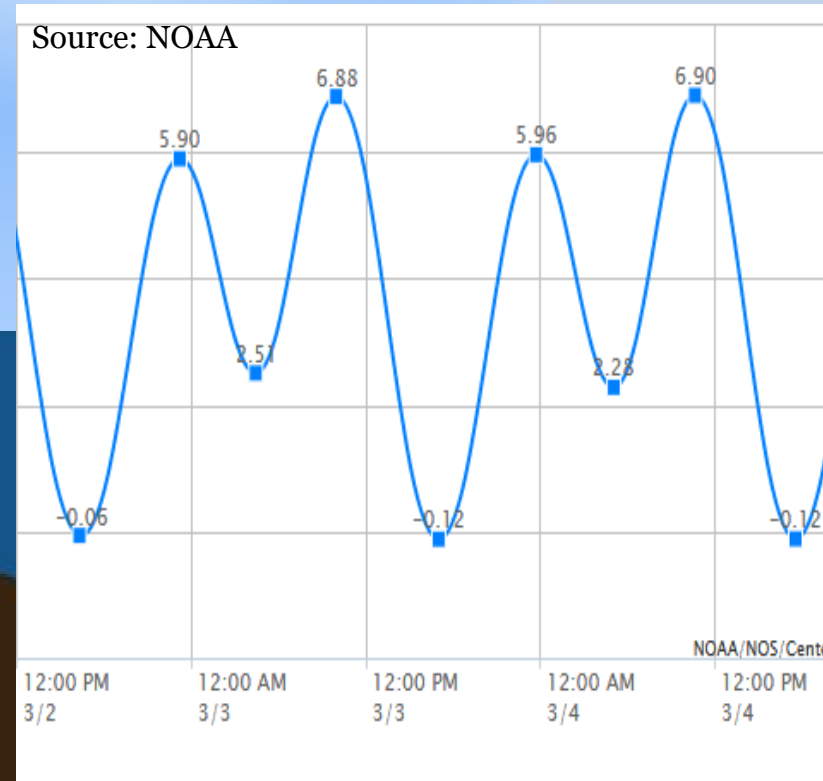
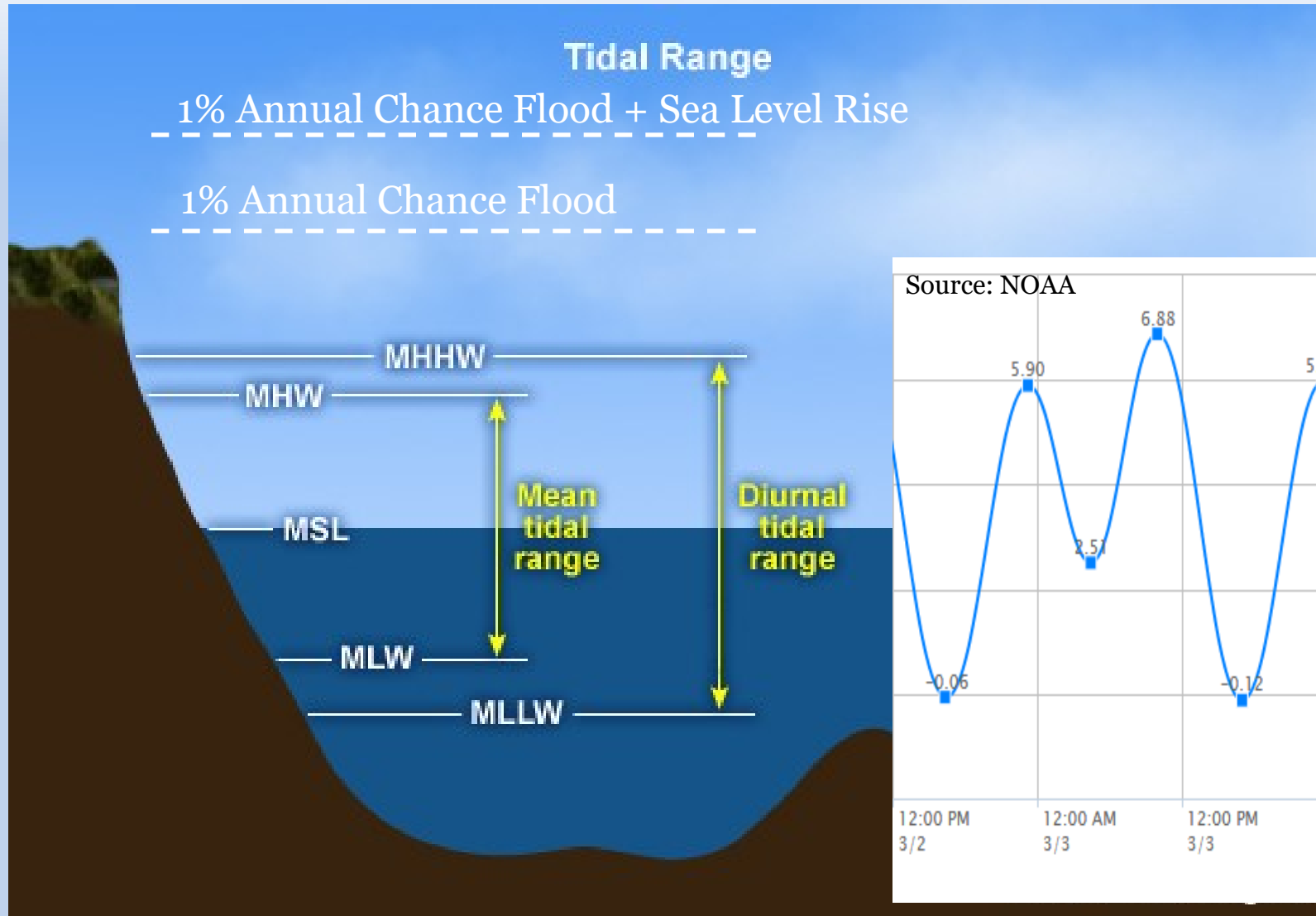
Framework steps to plan adaptation efforts (modified from SFEI and SPUR 2019)

Sea Level Rise Vision, Goals and Objectives

**TABLE 1
NBWRA SEA LEVEL RISE VISION, GOALS, AND OBJECTIVES**

Vision	Goals	Objectives
<p>NBWRA: <i>Cooperate with public and private entities in <u>the North Bay</u> to identify, fund, and implement sea level rise adaptation in a collaborative and cost-effective manner.</i></p> <p>Member Agencies: <i>Identify adaptation strategies to protect wastewater, recreational and other infrastructure, maintain service, and be eligible for state and federal funding.</i></p>	<p>1. Reduce risk to critical infrastructure and built environments</p>	<p>1a. Reduce risk and maintain the viability of regional critical utilities from sea level rise, groundwater intrusion and flood events</p> <p>1b. Reduce risk to recreational assets such as McGinnis Park, Schellenberger Park and the Bay Trail</p> <p>1c. Reduce risk of flood to built and underserved environments</p>
	<p>2. Align longer-term adaptation with regional efforts to improve resilience</p>	<p>2a. Coordinate, align and partner with agencies to implement integrated adaptation</p> <p>2b. Provide framework for public agency and private landowner cooperation for adaptive response to sea level rise</p>
	<p>3. Build Capacity for Current and Future Generations to Adapt to Climate Change</p>	<p>3a. Provide for education, interpretation and understanding of sea level rise impacts to the shoreline and adjacent uplands</p> <p>3b. Promote regional vision for adapting to sea level rise and climate change</p>
	<p>4. Create a Resilient Shoreline Environment for People and Ecology</p>	<p>4a. Enhance the shorelines ecological value and adapt to sea level rise</p> <p>4b. Enhance recreational opportunities and adapt to sea level rise</p> <p>4c. Identify funding sources and position entities in the NBWRA region to apply for and meet federal and state funding requirements.</p>

Causes of Flooding



Planning Scenario

TABLE 2
FUTURE WATER LEVELS WITH SEA-LEVEL RISE NEAR LGVSD, IN FEET NAVD88

Annual Chance (Return Interval)	0 ft SLR	1 ft SLR	2 ft SLR	3 ft SLR	5 ft SLR
(Daily MHHW)	6.1	7.1	8.1	9.1	11.1
99% annual chance (1-year)	7.3	8.3	9.3	10.3	12.3
10% annual chance (10-year)	8.3	9.3	10.3	11.3	13.3
1% annual chance (100-year)	9.5	10.5	11.5	12.5	14.5

Source: NOAA Richmond Station 9414863 and OPC (2018)

TABLE 4
FUTURE WATER LEVELS WITH SEA-LEVEL RISE AT PETALUMA RIVER, IN FEET NAVD88

Annual Chance (Return Interval)	0 ft SLR	1 ft SLR	2 ft SLR	3 ft SLR	5 ft SLR
(Daily MHHW)	6.3	7.3	8.3	9.3	11.3
99% annual chance (1-year)	7.6	8.6	9.6	10.6	12.6
10% annual chance (10-year)	8.6	9.6	10.6	11.6	13.6
1% annual chance (100-year)	9.9	10.9	11.9	12.9	14.9

Source: AECOM (2016)

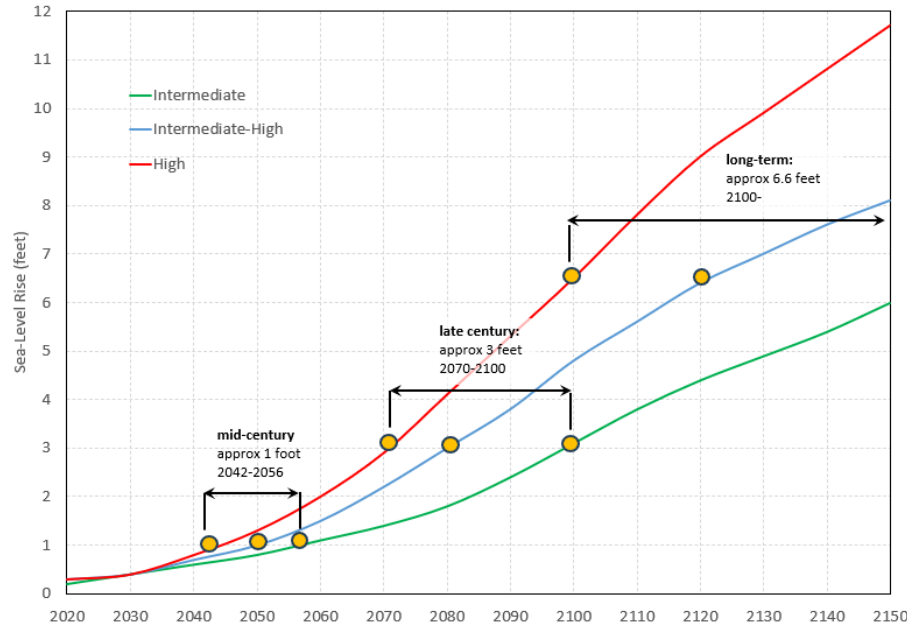


Figure 1
Sea-level rise projections for San Francisco through 2100 and two selected time horizons



Gallinas Study Area

- Hamilton South to Gallinas Watershed
- Engaging the Following Key Stakeholders:
 - SMART
 - St. Vincent's, Silveira
 - Bay Trail, PGE
 - Santa Venetia HOA:
 - Next Phase

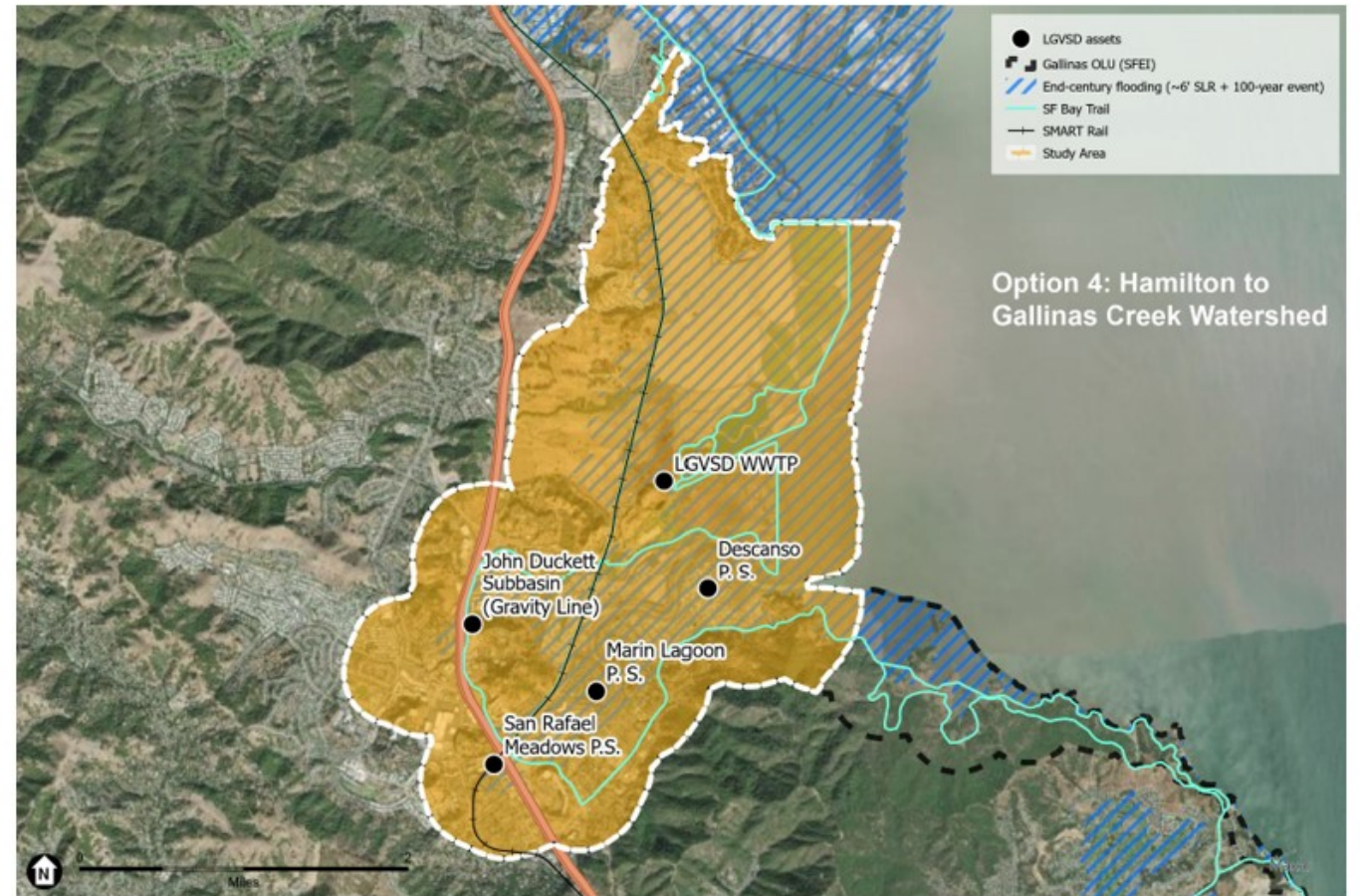


Figure 2

Recommended Study Area: Hamilton to Gallinas Watershed



Petaluma Study Area

- WWTP North to U.S. 101
- Modified to Include South of Petaluma River Main Channel
- Engaging the Following Key Stakeholders:
 - SMART, Sonoma PRMD

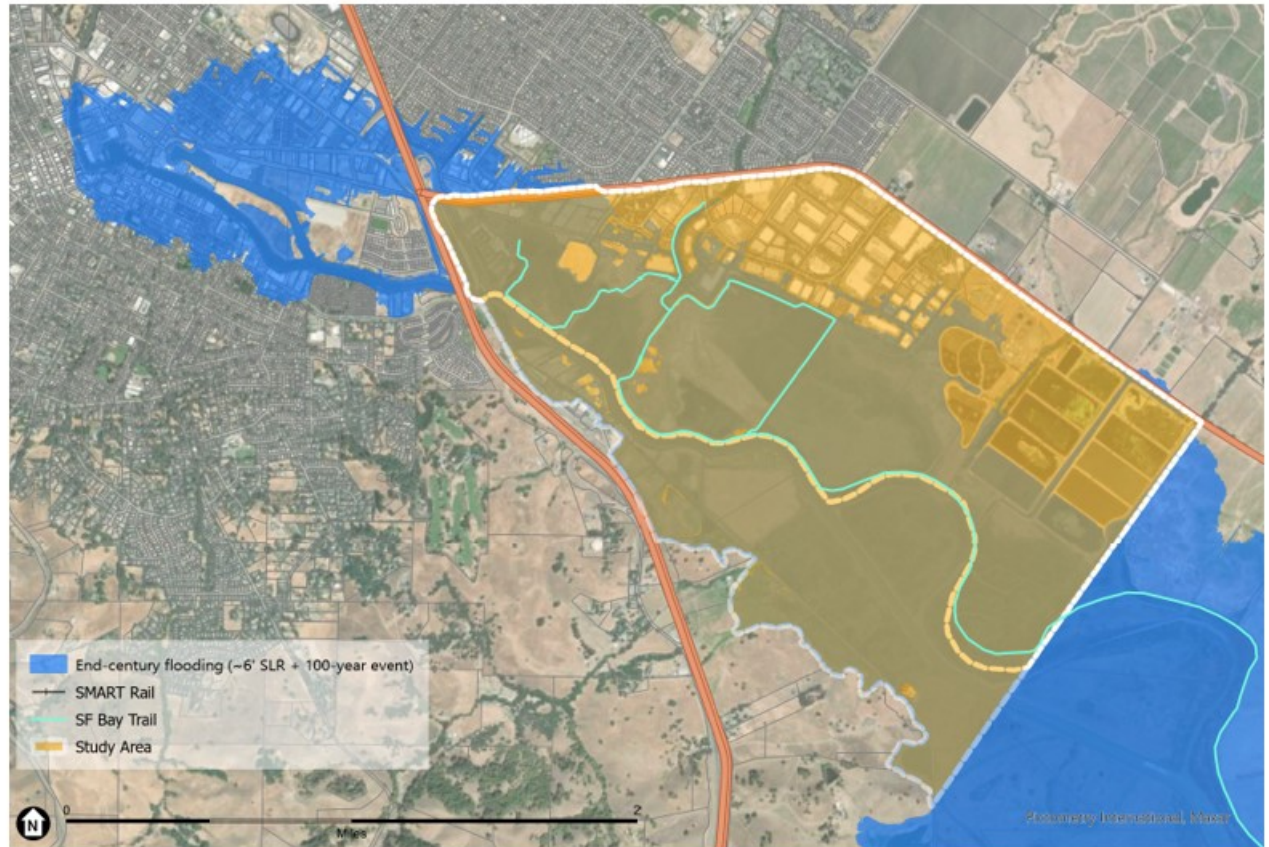


Figure 3

Recommended Study Area: Petaluma WWTP to US 101



Vulnerability Analysis

- Compiled Available Data
- Building Elevation Data: Cal OES Building Layer
- Generate flood inundation layers
 - Integrate Petaluma City Hydraulic Model
 - Coastal Flood: BCDC Adapting for Rising Tides
- GIS Analysis of Affected Buildings
- LIDAR Data for Railroad Elevations



Las Gallinas Study Area

- 💧 2 ft - Short Term Vulnerability: Red
- 💧 4 ft - Medium Term Vulnerability: Yellow
- 💧 7 ft - Long Term Vulnerability: Blue
- 💧 Elevation Comparison and Coding
- 💧 Linear Features: Smart Rail, Bay Trail, US 101

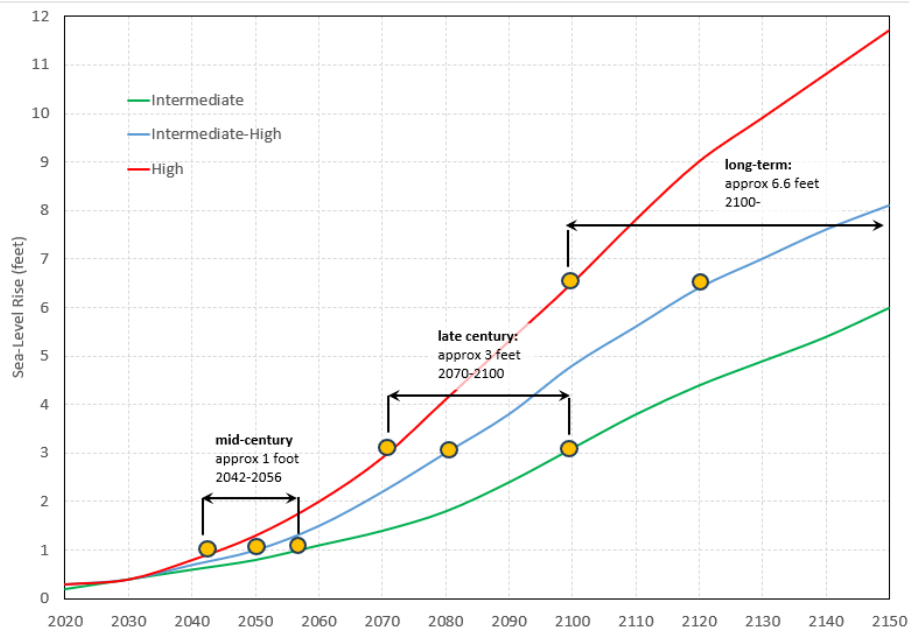


Figure 1
Sea-level rise projections for San Francisco through 2100 and two selected time horizons

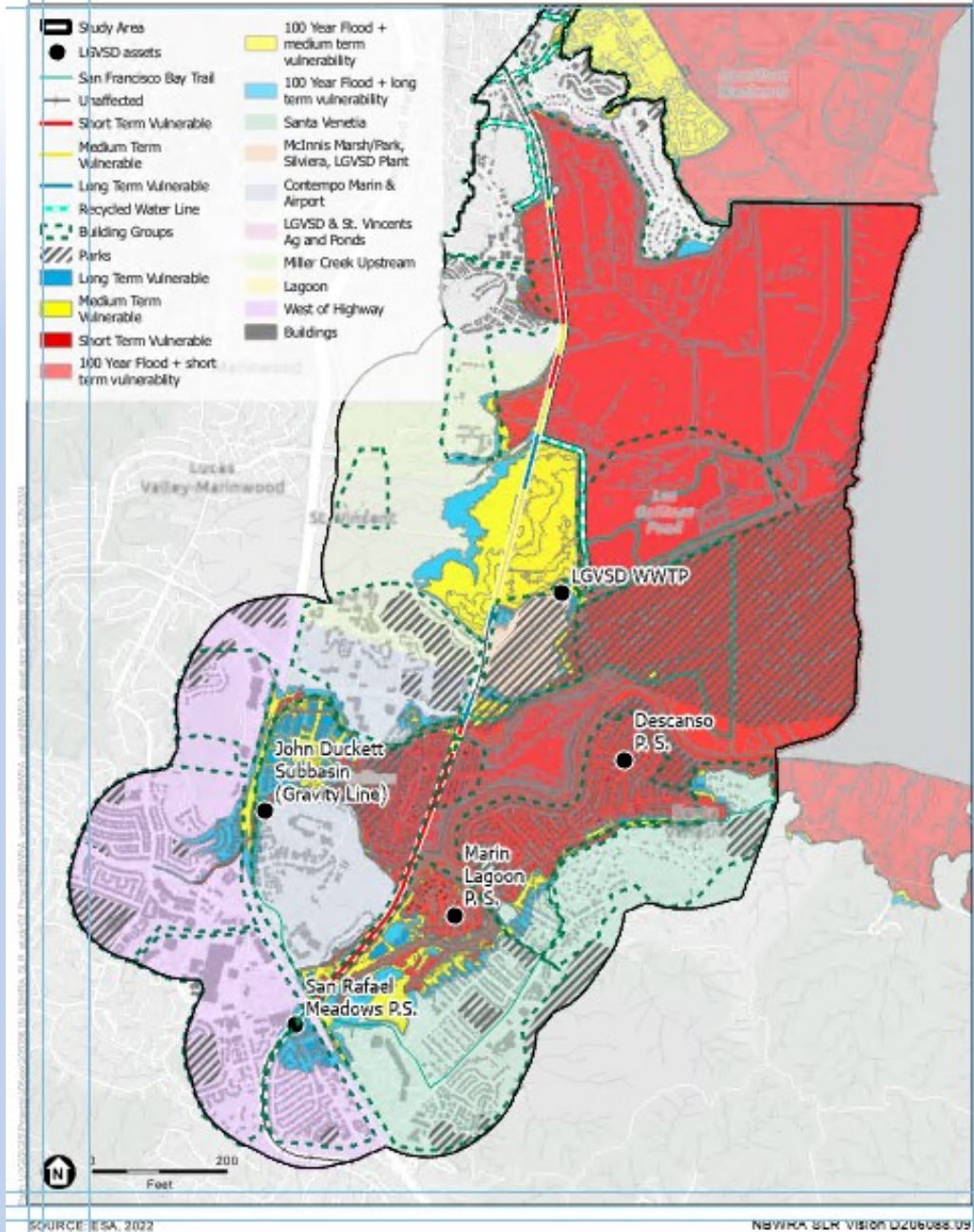


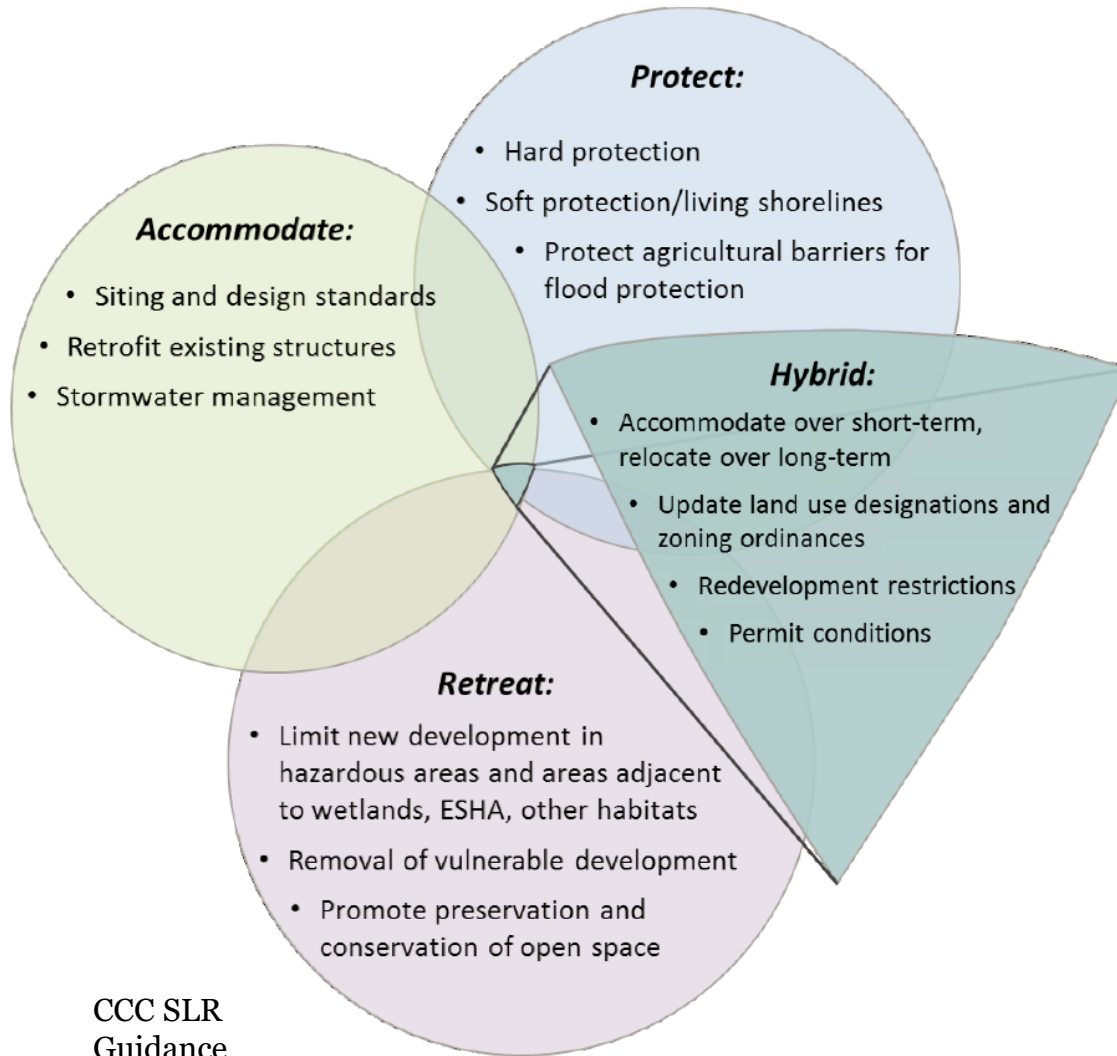
Figure X
Las Gallinas Study Area Asset Map
100 Year short, medium, and long-term flooding



ESA

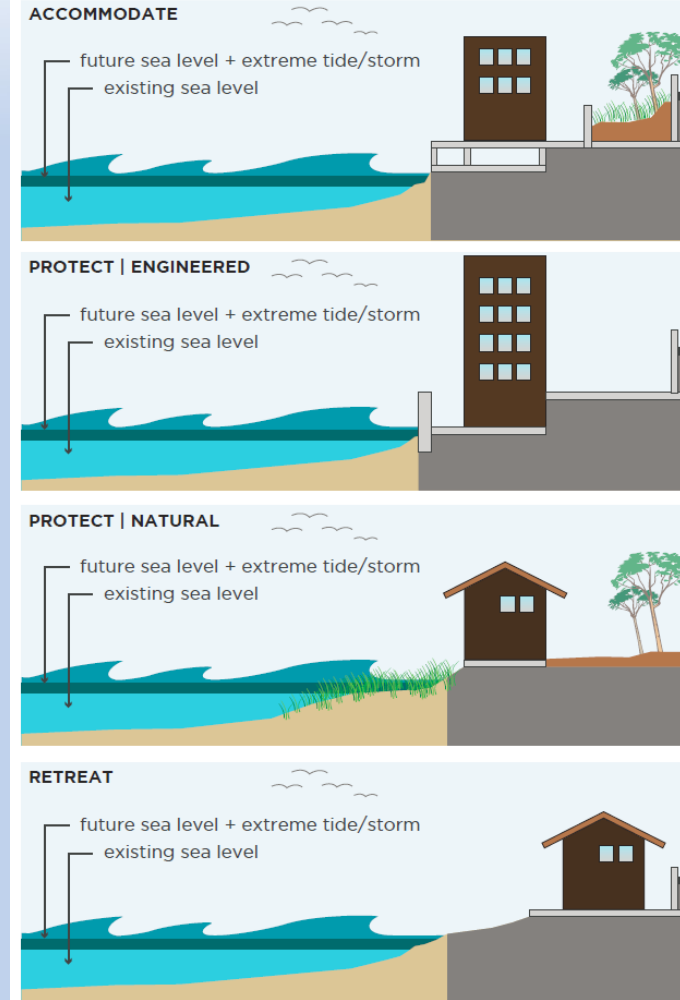


Approaches to Adaptation



CCC SLR
Guidance

INTERVENTION OPTIONS



SAN FRANCISCO SEA LEVEL RISE ACTION PLAN



NORTH BAY WATER REUSE PROGRAM
Water Supply Reliability through Regional Reuse

Vision Alternatives

Hold the Line

Protect all existing developed and agricultural land

- Maintain existing embankment and levee alignments.
- New levees installed where needed.

Managed Retreat

Install new flood protection only for priority areas, while allowing tidal habitat restoration elsewhere

- Levee alignments adjusted to support habitat migration
- Some managed retreat

Restore / Retreat

Install new flood protection only for critical transportation and utility infrastructure.

- Managed retreat from all non-critical infrastructure (including commercial and residential parcels)
- Habitat restoration in areas where retreat occurs

These preliminary draft scenarios are presented to inform the ongoing adaptation visioning process. ESA invites input and discussion. ESA expects that these preliminary drafts will be revised and updated as the underlying assumptions and planning priorities are confirmed and refined.



Adaptation Strategies: Summary

Strategy	Cost/Unit	Uncertainties
Flood Walls	\$37,300/LF	Access, Habitat Loss, Visual, Wave/Sediment Interaction,
Sheet Pile Wall/Bulkhead	\$11,900/LF	Seepage, landward property costs, not a flood barrier
Flood Protection Levee	\$11,900/LF	Geotech, stormwater/groundwater management, fill source/haul costs
Ecotone Levee	\$24,900/LF	Higher cost, greater ecological benefit; cost/benefit compared to FPL is site specific
Tide Gate and Pumps	\$25M Tide Gate \$5.1M Pumps	Habitat impacts, water quality, sediment transport
Retention Basin	\$500K-\$2M/acre	ROW, geotechnical, volume to affect peak flow, pumps
Tidal Marsh/Mudflat Restoration	\$30K- \$300K/acre	Elevations and active vs passive sediment deposition affect cost
Managed Retreat/Buy-Out	\$1M/Parcel	Actual parcel cost, community/political support



Criteria Summary

Public Benefit

Environmental Impacts

Cost

Flood Protection

Acceptability

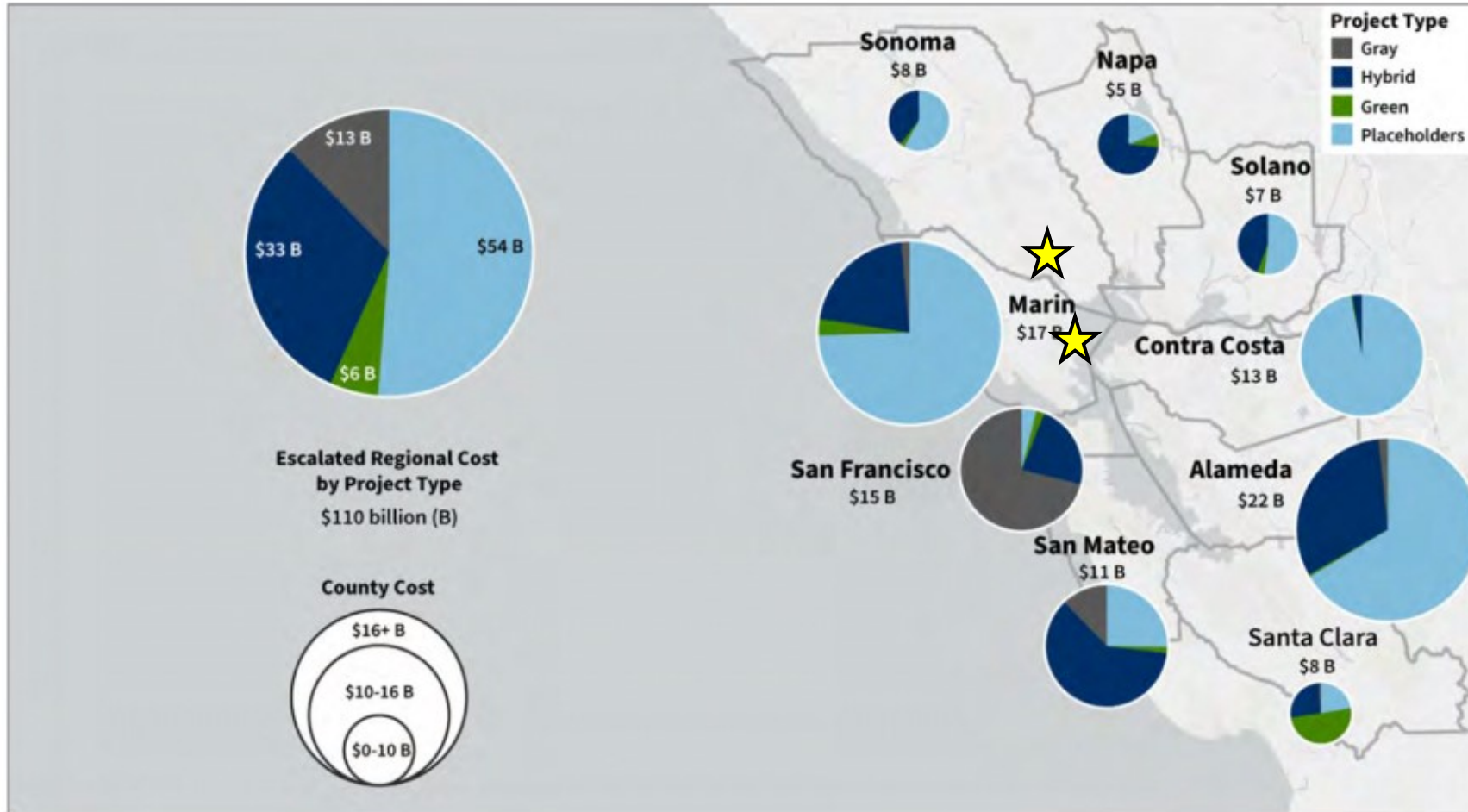
- Legal
- Political
- Community



Vision Concepts	Criteria	Comparison
Hold the Line	Typical Concept	Protect all existing developed and agricultural lands. Major Upgrade and Installation of Levees along shoreline and Gallinas Creek, installation of tide gate and pump station.
	Public Benefit	High: Maintains current shoreline, protects residences
	Environmental Impacts	High: High Regulatory Permitting due to loss of Steelhead habitat
	Cost	High, approaching \$500M to \$1B
	Flood Protection	FEMA 100-year
	Acceptability (Legal, Political, Community)	Legal: Acceptable, but high ROW; Political: Highly Acceptable; Community: Acceptable, but ROW
Managed Retreat	Typical Concept	New Flood Protection for critical infrastructure and developed areas, with some managed retreat and restoration.
	Public Benefit	High: enhances shoreline and restoration
	Environmental Impacts	Moderate: Restoration Offset
	Cost	Lower infrastructure, but potential enhancement and private property cost Approaching \$600M to \$1.5B
	Flood Protection	FEMA 100-year, but less area protected
	Acceptability (Legal, Political, Community)	Legal: Acceptable, but high ROW; Political: Moderate; Community: Likely Low: Includes Residential Buy Out (178 parcels)
Restore/Retreat	Typical Concept	Flood protection for critical infrastructure only; managed retreat and buy out for developed areas.
	Public Benefit	Low
	Environmental Impacts	Lower
	Cost	Lowest Infrastructure, highest private property acquisition; \$400M to \$3.3B
	Flood Protection	Less than 100-year
	Acceptability (Legal, Political, Community)	Legal: Acceptable, but high ROW; Political: Low; Community: Low. Includes Residential Buy Out at scale (2500 parcels)

1.4 Additional Findings

Figure 4. County Need Estimates by Project Type



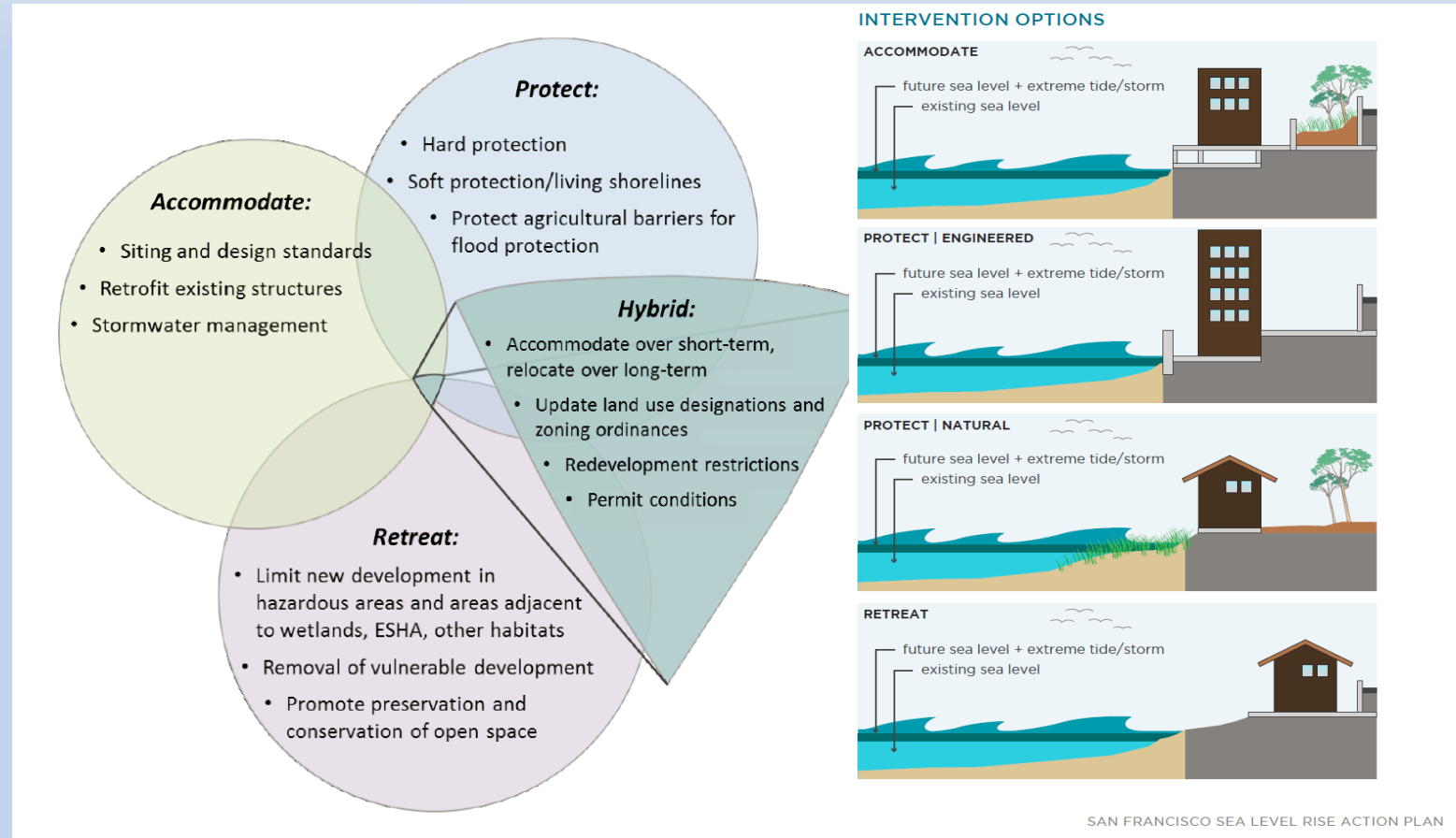
Funding Opportunities

- Largest Funding Pools for Implementation will be FEMA and USACOE
- Several Planning Level Funding Opportunities for Next Phase of Work
- Ocean Policy Council SB-1 Application
 - Rolling planning grant program for community based planning
 - Focused on community outreach, a next logical step following our NBWRA SLR Visioning Process.
 - Recommend Application in March/June
 - Allow for Completion of SLR Vision Process and review by LGVSD/Petaluma Boards.
 - Allow for Discussion with OPC regarding consistency with SB-272 and use of “OLU” approach.



Next Steps

- Complete SLR Adaptation Vision Process: May
- Review with Member Agency Boards
- Apply for OPC Grants: Spring 2024
- Integrate SLR Adaptation Planning Process into 2025/26 Budget





Discussion





EXTRA SLIDES



Gallinas Summary

Hold the Line

Type	Cost	
Levees and Infrastructure	\$979,100,000	
Environmental Benefits	Low	\$23,500,000
	High	\$141,000,000
Managed Retreat	\$0	
TOTAL	Low	\$1,003,000,000
	High	\$1,120,000,000
Net Acres of Habitat Restored	410	

Managed Retreat

Type	Cost	
Levees and Infrastructure	\$860,000,000	
Environmental Benefits	Low	\$90,000,000
	High	\$540,000,000
Managed Retreat	High Uncertainty	\$178,000,000
TOTAL	Low	\$950,000,000
	High	\$1,578,000,000
Net Acres of Habitat Restored	1800	

Restore / Retreat

Type	Cost	
Levees and Infrastructure	\$324,000,000	
Environmental Benefits	Low	\$90,000,000
	High	540,000,000
Managed Retreat	High Uncertainty	\$2,495,000,000
TOTAL	Low	\$414,000,000
	High	\$3,359,000,000
Net Acres of Habitat Restored	1800	

These preliminary draft scenarios are presented to inform the ongoing adaptation visioning process. ESA invites input and discussion. ESA expects that these preliminary drafts will be revised and updated as the underlying assumptions and planning priorities are confirmed and refined.



Hold the Line

Under this scenario all existing developed and agricultural land would be protected.

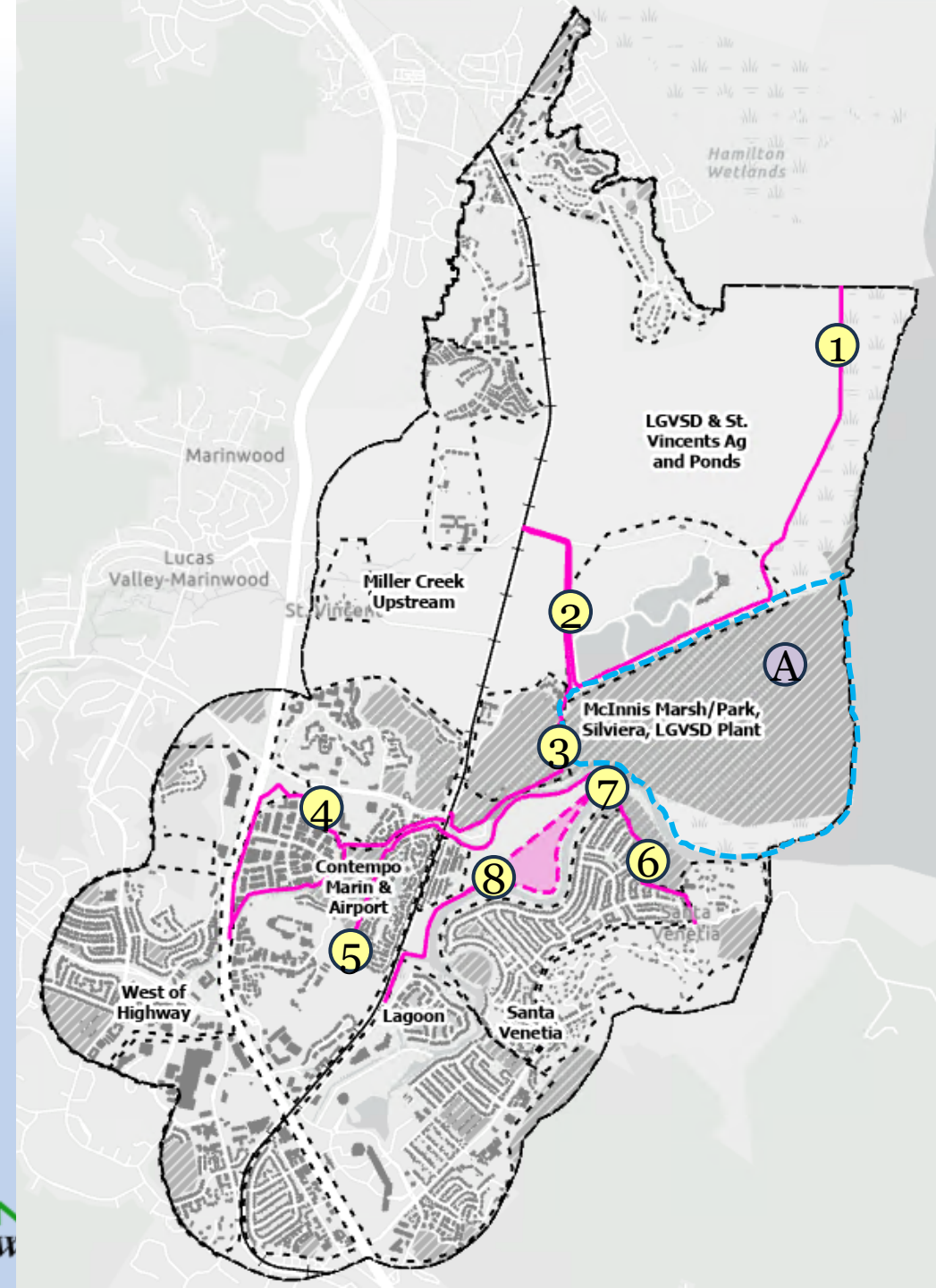
Flood Protection

1. Maintain existing bayfront levee
2. Maintain existing creek levees
3. New levee at McInnis Park and Golf Course
4. Improve levees along north fork Gallinas Creek
5. Improve levees at Contempo Marin
6. Improve levee at Santa Venetia northeast
7. New tide gate structure and pump station at south fork Gallinas Creek
8. New retention basin at airport

Retreat and Restoration

- A. Potential tidal marsh and mudflat restoration at McInnis Marsh

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Managed Retreat

Under this scenario new flood protection would be installed for critical transportation and utility infrastructure and residential areas.

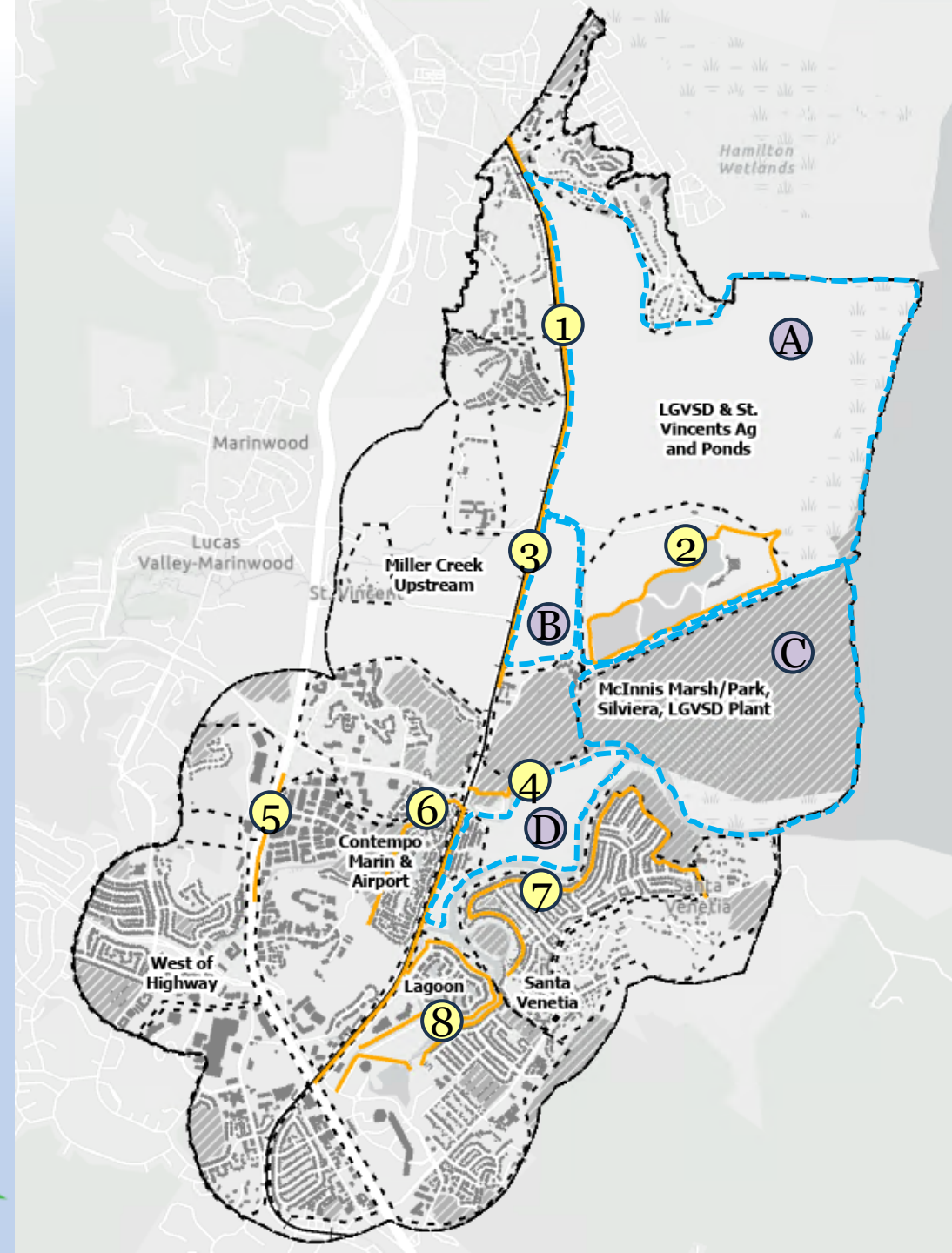
Flood Protection

1. New flood protection levee aligned with SMART embankment (north of Miller Creek)
2. Improve existing berms around LGVSD Ponds
3. New flood protection levee aligned with SMART embankment (south of Miller Creek)
4. Improve berm at McInnis Park fields and into parking area
5. New flood wall along Highway 101
6. Improve levee around Contempo Marin neighborhood
7. New levee or flood wall around Santa Venetia neighborhood with potential setback onto first row of parcels along creek bank
8. New levee or flood wall around Marin Lagoon neighborhood with potential setback onto first row of parcels along creek bank

Retreat and Restoration

- A. Potential tidal marsh and mudflat restoration at St. Vincent's and LGVSD fields
- B. Potential tidal marsh and mudflat restoration at Silveira
- C. Potential tidal marsh and mudflat restoration at McInnis Marsh
- D. Potential tidal marsh and mudflat restoration at airport

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Restore / Retreat

Under this scenario no new flood protection would be created for residential or commercial areas, flood protection is limited to critical transportation and utility infrastructure. Establishes a new flood protection line.

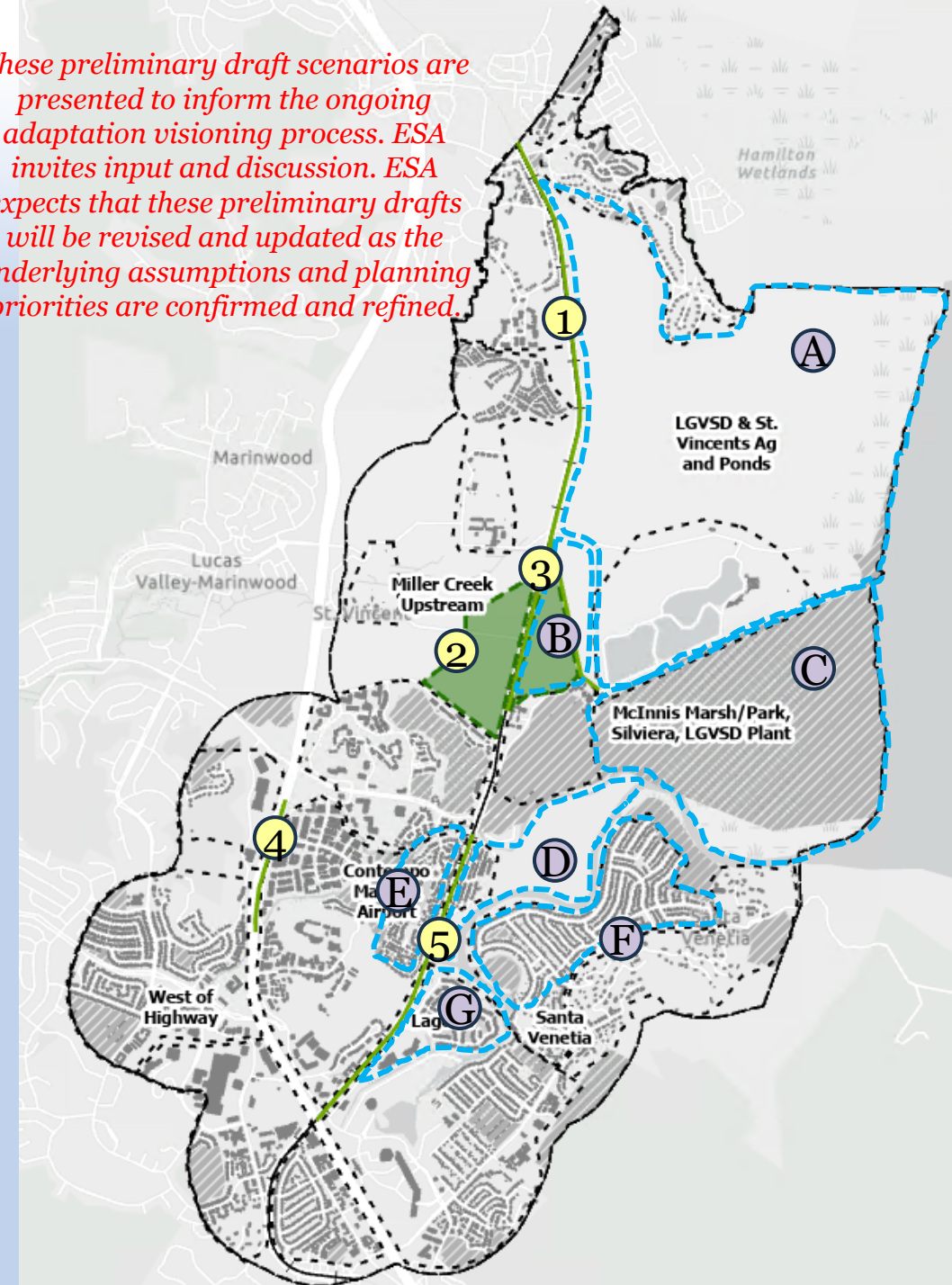
Flood Protection

1. New flood protection levee aligned with SMART embankment (north of Miller Creek)
2. Relocate LGVSD Ponds to Silveira or St. Vincent's parcels
3. Raise SMART rail embankment (south of Miller Creek)
4. New flood wall along Highway 101
5. Raise SMART rail embankment

Retreat and Restoration

- A. Potential tidal marsh and mudflat restoration at St. Vincent's and LGVSD fields
- B. Potential tidal marsh and mudflat restoration at Silveira
- C. Potential tidal marsh and mudflat restoration at McInnis Marsh
- D. Potential tidal marsh and mudflat restoration at airport
- E. Managed retreat at Contempo Marin neighborhood
- F. Managed retreat at Santa Venetia neighborhood
- G. Managed retreat at Lagoon neighborhood

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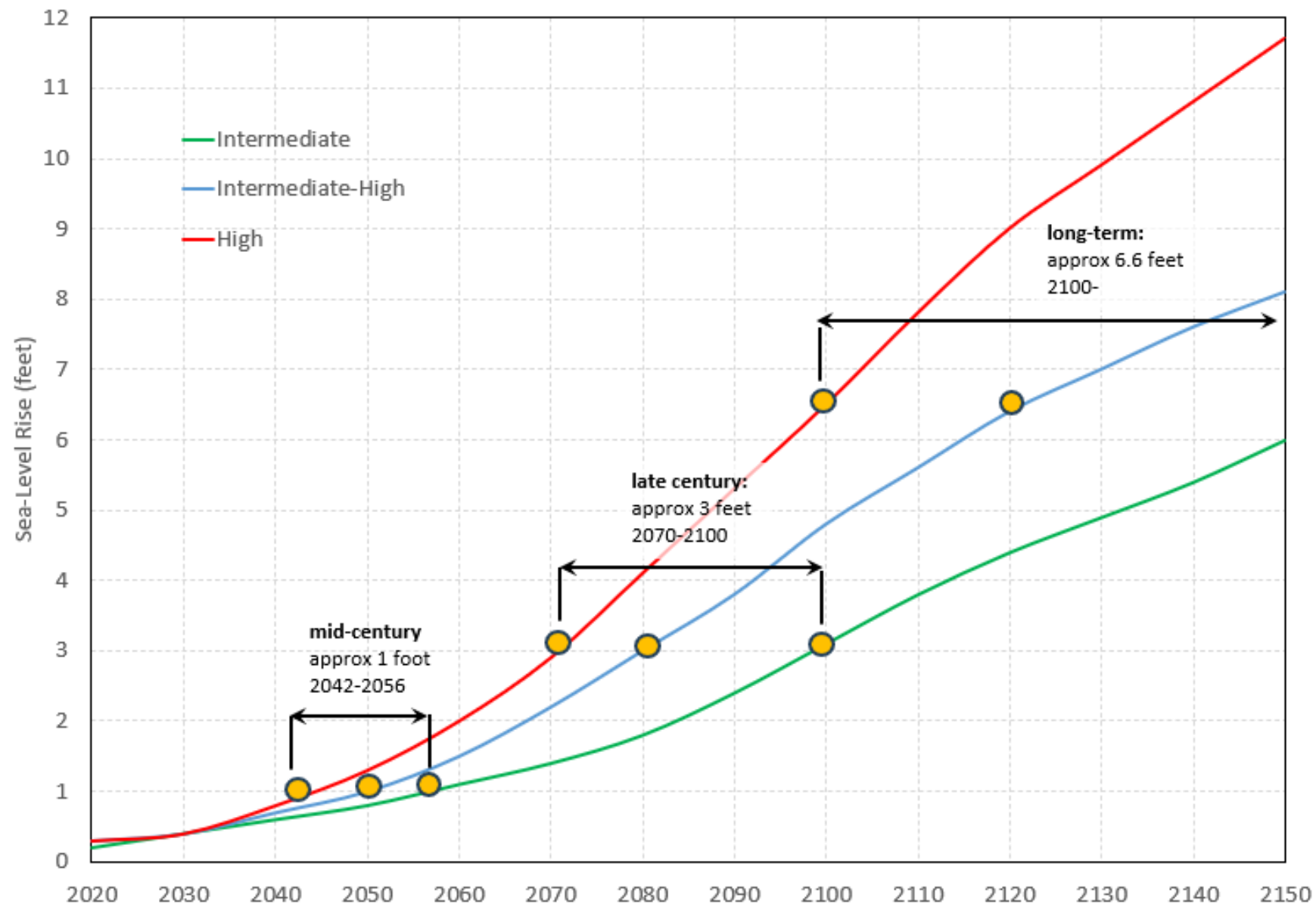


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