



# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay

Hank Seemann, Deputy-Director  
Humboldt County Department of Public Works  
April 11, 2019

## Project Team:

- GHD Inc.
- Northern Hydrology & Engineering
- Environmental Science Associates
- GMA Hydrology, Inc.
- Trinity Associates (Aldaron Laird)
- Philip King, San Francisco State University

## Funding Sources:

- Caltrans Adaptation Planning Grant Program
  - City of Eureka
  - Humboldt County Association of Governments
  - County of Humboldt
- (Total Budget = \$480,000)



City of Arcata

City of Eureka

Project Area

255

101

101

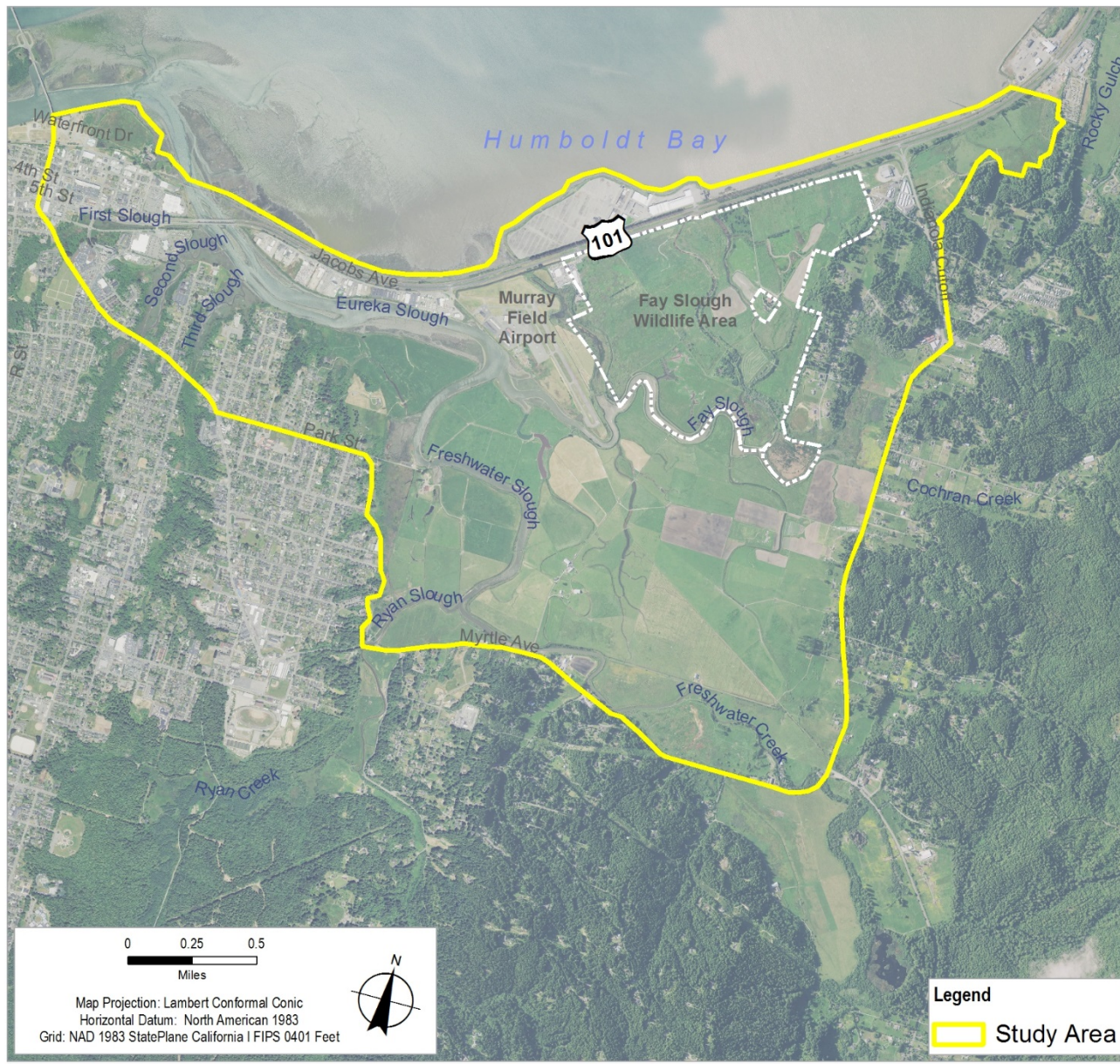
101

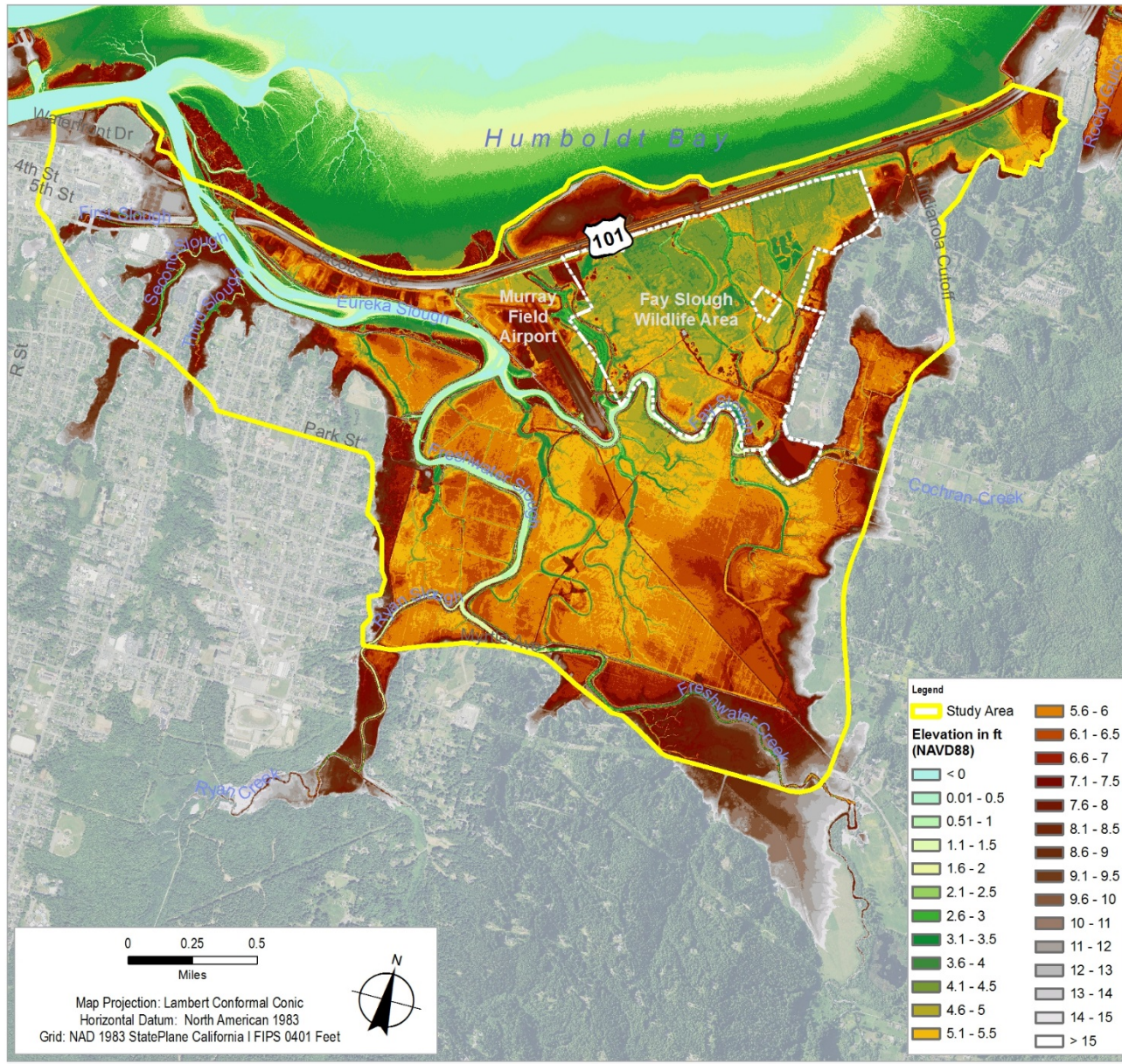
# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay



## Question #1: What are the most significant risks?

- 1) Understand the geomorphic setting (water bodies and landforms)
- 2) Understand shoreline conditions and the most likely failure modes
- 3) Account for total water level (stillwater plus wind and waves)
- 4) Develop useful hazard scenarios for evaluating potential impacts
- 5) Assess sensitivity to impacts and range of consequences
- 6) Synthesize

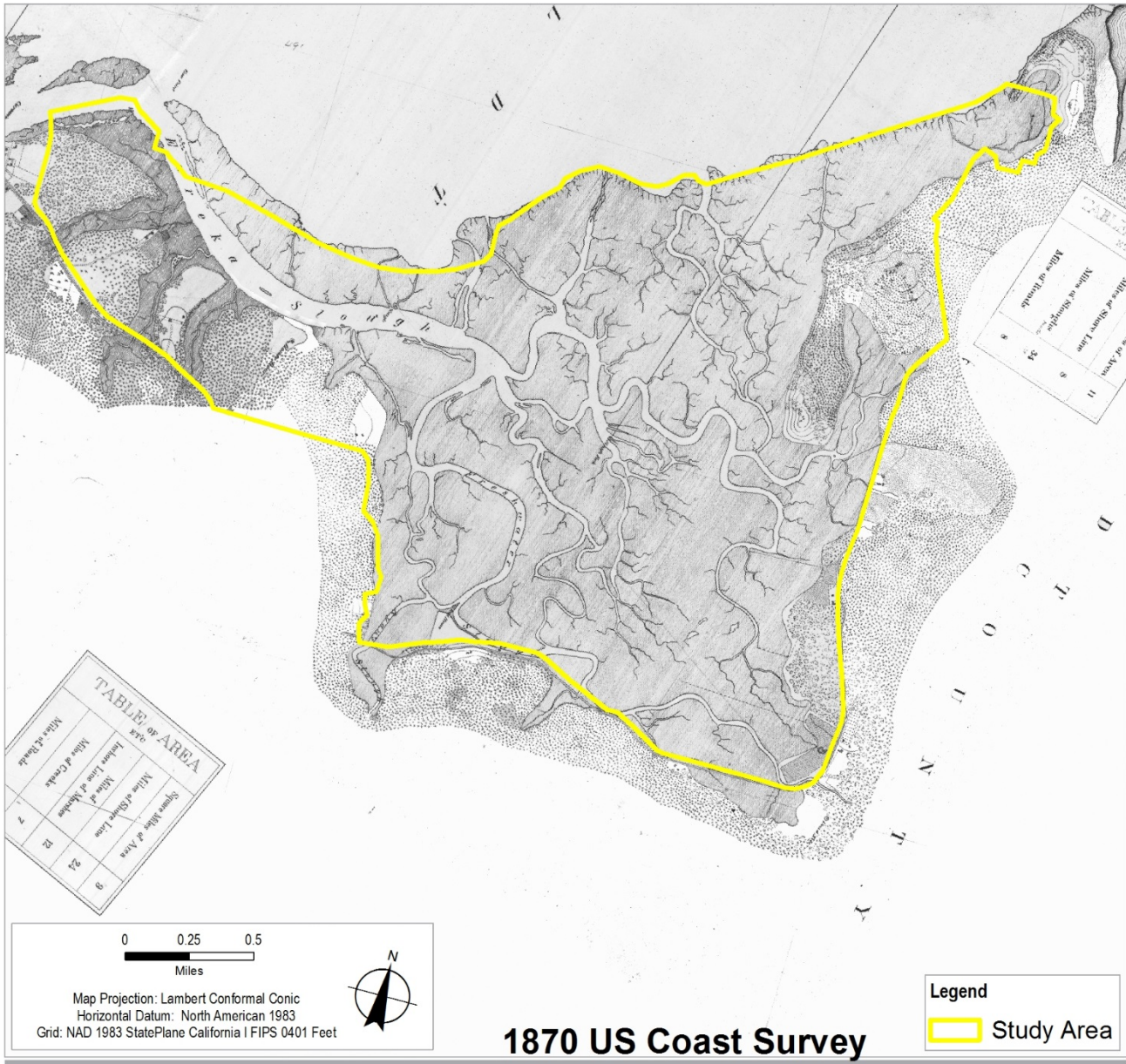


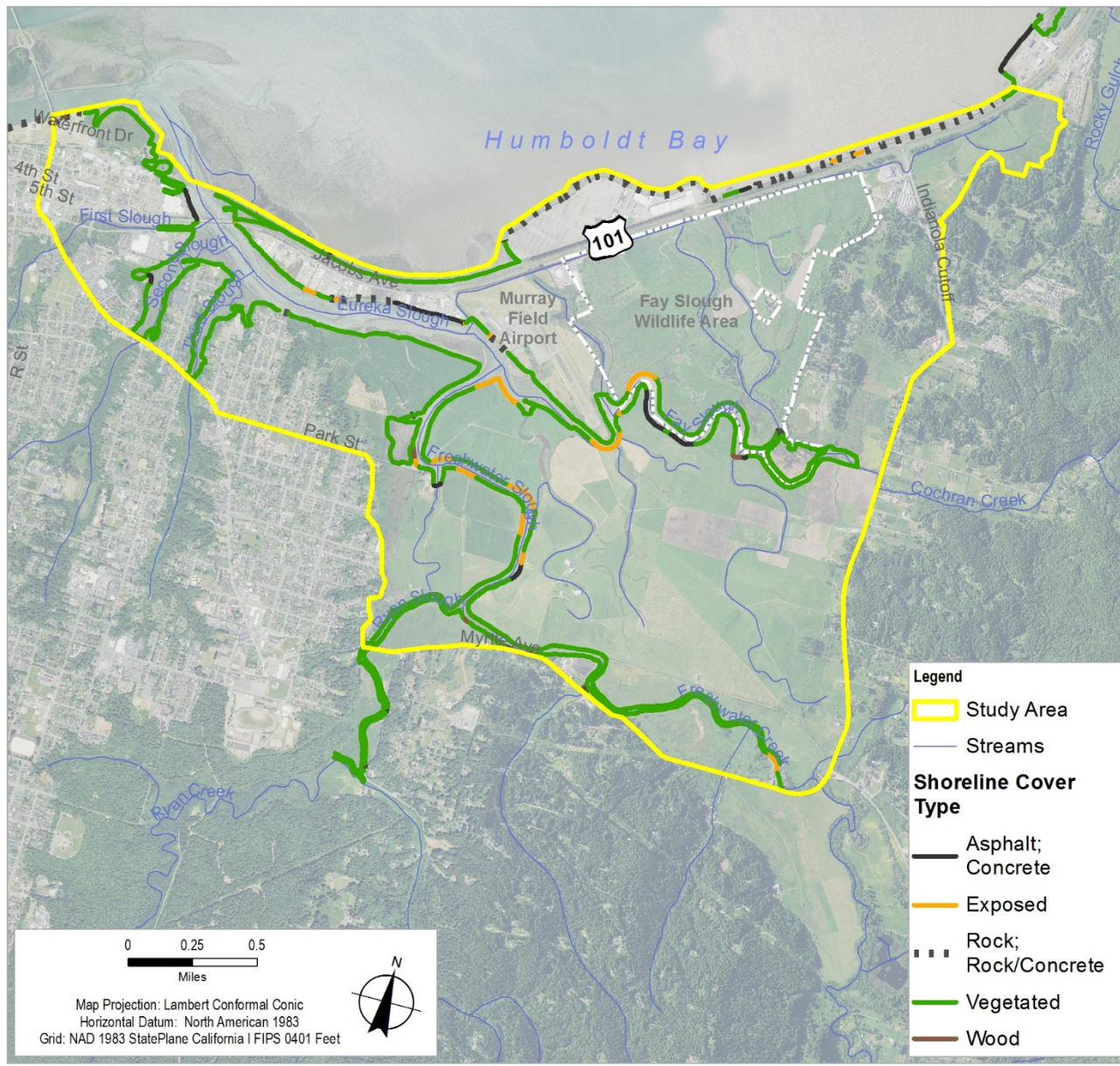


G:\56111191743\GIS\Maps\Deliverables\EC\_HumBaySymp\11191743\_002\_Elevation.mxd

Data source: Study Area boundary, Humboldt County, DEM 2010, NOAA, Roads data, TIGER, Orthoimagery 2016, NAIP, Created by: ashows





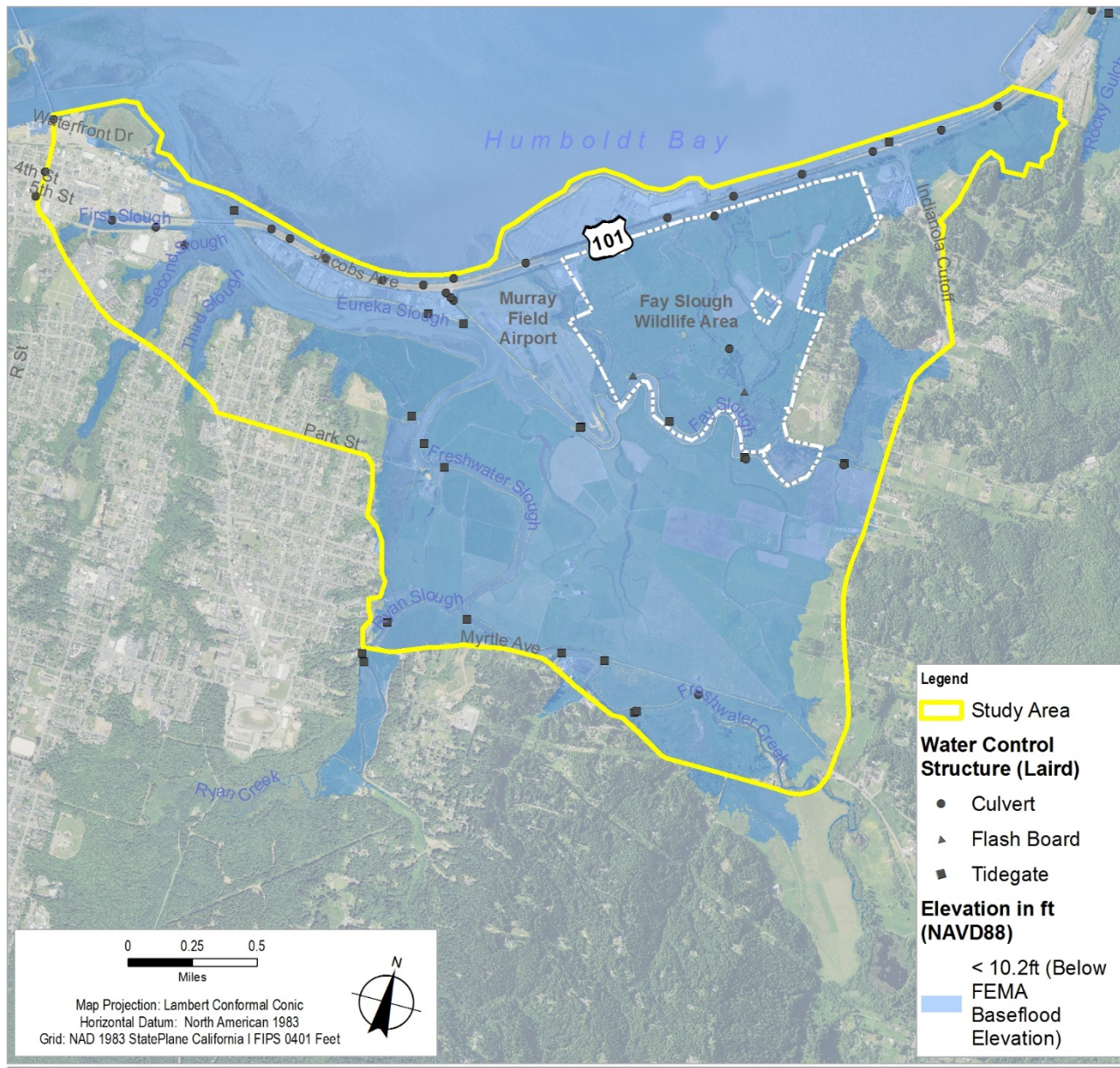


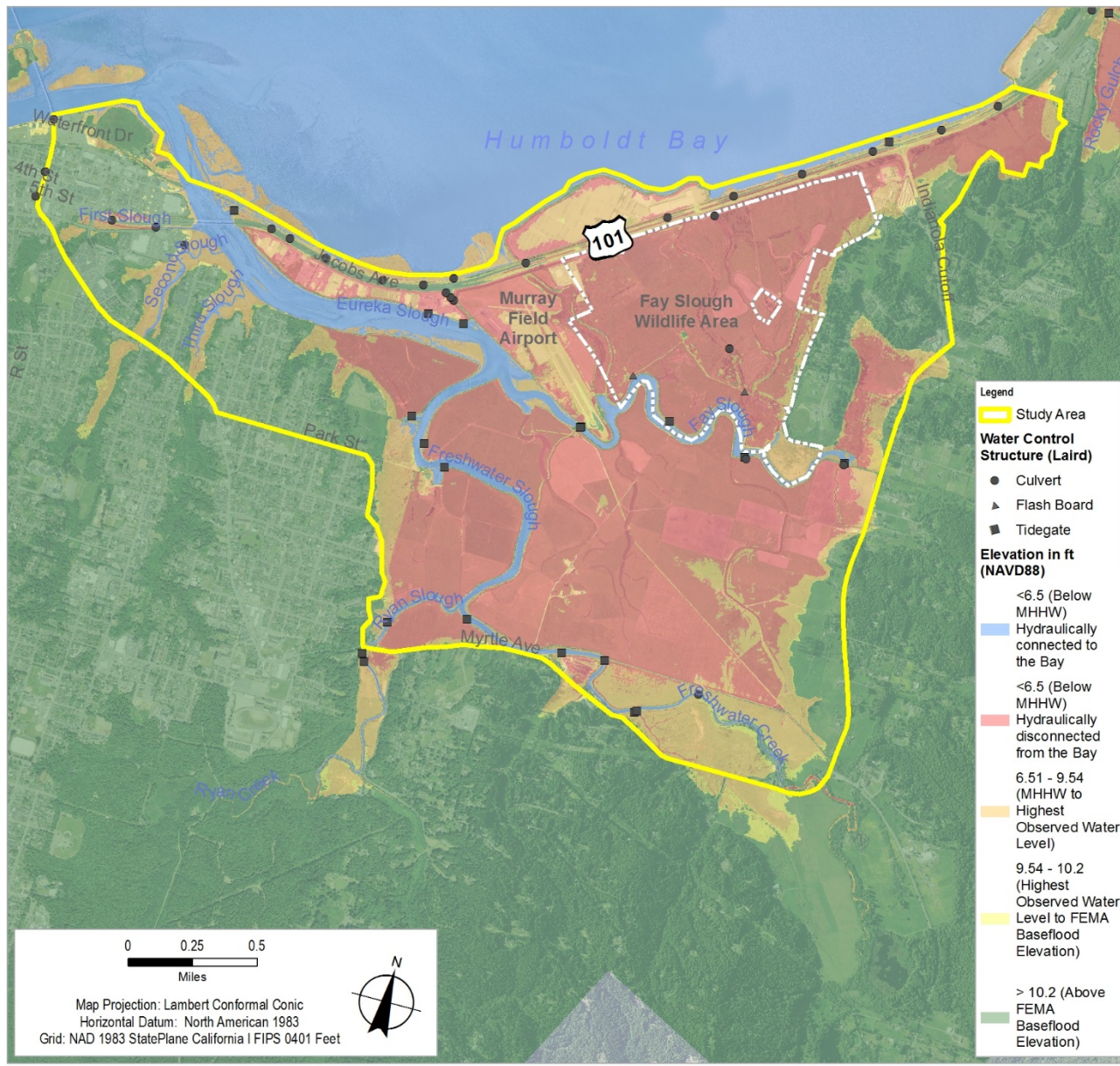
# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay



## Question #1: What are the most significant risks?

- 1) Understand the geomorphic setting (water bodies and landforms)
- 2) Understand shoreline conditions and the most likely failure modes
- 3) Account for total water level (stillwater plus waves)
- 4) Develop useful hazard scenarios for evaluating potential impacts
- 5) Assess sensitivity to impacts and range of consequences
- 6) Synthesize







# SLR Report for Humboldt Bay Trail South



Final

## HUMBOLDT BAY TRAIL SOUTH

Sea-Level Rise Vulnerability and Adaptation Report

Prepared for  
County of Humboldt, under contract with  
GHD

June 2018



Photo by GHD, 2017

[www.humboldttrail.info](http://www.humboldttrail.info)

# SLR Report for Humboldt Bay Trail South



# SLR Report for Humboldt Bay Trail South

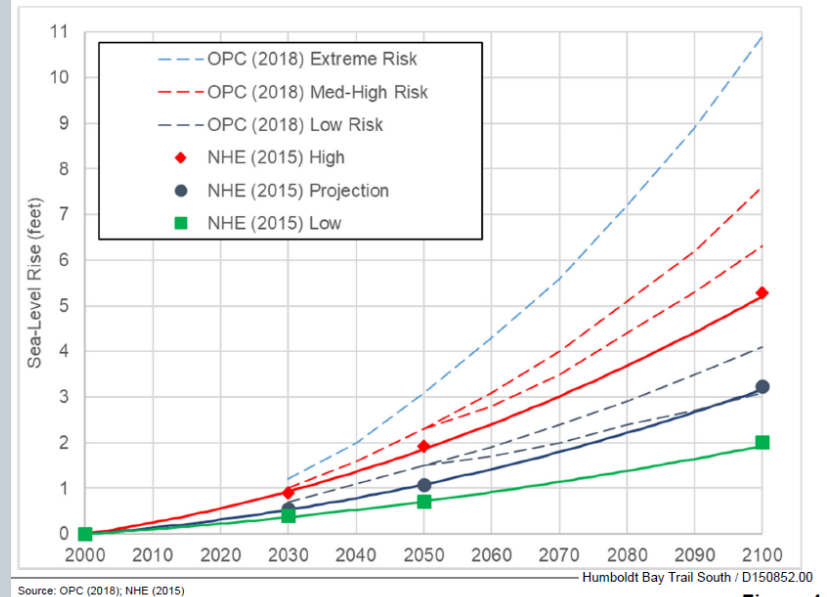


**TABLE 2**  
**OPC (2018) STATE GUIDANCE: PROJECTED SEA-LEVEL RISE FOR THE HUMBOLDT BAY NORTH SPIT IN FEET**

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...	5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
			Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.6	0.5 - 0.7	0.8	1	1.2
	2040	0.9	0.7 - 1.1	1.2	1.6	2.0
	2050	1.2	0.9 - 1.5	1.7	2.3	3.1
Low emissions	2060	1.3	1.0 - 1.7	2	2.8	
High emissions	2060	1.5	1.2 - 1.9	2.2	3.1	4.3
Low emissions	2070	1.6	1.2 - 2	2.4	3.5	
High emissions	2070	1.9	1.4 - 2.4	2.9	4	5.6
Low emissions	2080	1.8	1.4 - 2.4	2.9	4.4	
High emissions	2080	2.3	1.7 - 2.9	3.5	5.1	7.2
Low emissions	2090	2.1	1.5 - 2.7	3.4	5.3	
High emissions	2090	2.7	2.0 - 3.5	4.3	6.2	8.9
Low emissions	2100	2.3	1.7 - 3.1	3.9	6.3	
High emissions	2100	3.1	2.3 - 4.1	5.1	7.6	10.9
Low emissions	2110*	2.5	1.9 - 3.3	4.2	7.1	
High emissions	2110*	3.3	2.6 - 4.3	5.2	8	12.7
Low emissions	2120	2.7	2.0 - 3.7	4.8	8.2	
High emissions	2120	3.7	2.9 - 4.9	6.1	9.4	15.0
Low emissions	2130	3	2.1 - 4	5.3	9.4	
High emissions	2130	4.2	3.1 - 5.5	6.9	10.9	17.4
Low emissions	2140	3.2	2.3 - 4.4	5.9	10.7	
High emissions	2140	4.6	3.4 - 6.2	7.8	12.5	20.1
Low emissions	2150	3.4	2.3 - 4.8	6.6	12.1	
High emissions	2150	5	3.7 - 6.8	8.7	14.1	23.0

\*Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.

Source: OPC (2018)



Source: OPC (2018); NHE (2015)

**Figure 4**  
 Comparison of new OPC (2018) Sea-Level Rise Guidance for the Humboldt Bay North Spit to NHE (2015) Projections

**TABLE 3**  
**SEA-LEVEL RISE SCENARIOS USED FOR HUMBOLDT BAY TRAIL ASSESSMENT**

Time Horizon	2040-2050	2060-2070	2080-2100
Sea-Level Rise Amount (feet)	1 foot	2 feet	3 feet

# SLR Report for Humboldt Bay Trail South



Final

## HUMBOLDT BAY TRAIL SOUTH

Sea-Level Rise Vulnerability and Adaptation Report

Prepared for  
County of Humboldt, under contract with  
GHD

June 2018



Photo by GHD, 2017

<b>4</b>	<b>Coastal Hazards Analysis</b> .....	<b>19</b>
4.1	Terminology & Definitions .....	19
4.2	Coastal Hydrology and Shore Parameters .....	22
4.2.1	Tidal Water Levels and Datums .....	22
4.2.2	Extreme Still Water Levels .....	23
4.2.3	Wave Climate and Design Wave Height .....	23
4.2.4	Site Topography .....	24
4.3	Physical Site Hazards and Evaluation Criteria .....	27
4.3.1	Potential Hazards and Impacts to the Site and Users .....	27
4.3.2	Evaluation Criteria .....	28
4.4	Wave Runup, Overtopping, and Tidal Flooding Assessment .....	29
4.4.1	Total Water Level Analysis .....	29
4.4.2	Wave Overtopping .....	35
4.4.3	Tidal Flooding with Sea-Level Rise .....	39
4.5	Assessment of Historic Extreme Event .....	42
4.6	Summary of Trail Vulnerability to Coastal Hazards and Sea-Level Rise .....	44

[www.humboldttrail.info](http://www.humboldttrail.info)

# Hazard Impact Evaluation Criteria



- 1) Trail Usability (Stillwater Flooding) >0.5 feet inundation
- 2) Trail Usability (Wave Overtopping) >0.22 cfs/linear foot
- 3) Trail Damage from Wave Overtopping >0.54 cfs/linear foot



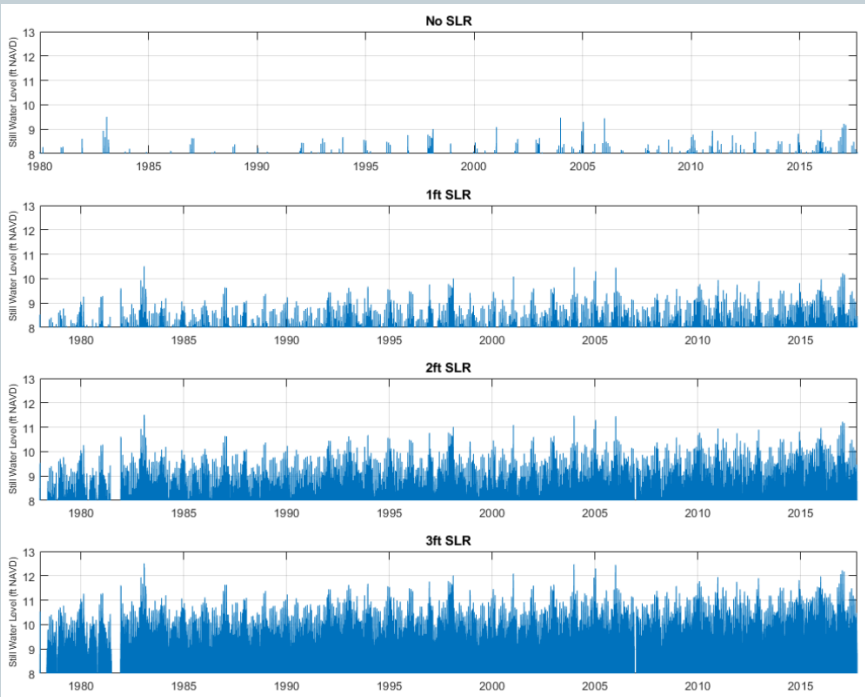
# Total Water Level Cases



**TABLE 6  
TWL CASES**

	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>
<b>SWL</b>	6.5 feet NAVD	8.5 feet NAVD	9.34 feet NAVD	9.97 feet NAVD
<b>SWL Basis</b>	MHHW (NOAA 2017)	Highest Astronomical Tide (HAT) (NOAA 2017)	2-year SWL (NHE 2016)	10-year SWL (NHE 2016)
<b>Wind+Wave Setup</b>	1 foot	No setup	1 foot	1 foot
<b>Reference Water Level</b>	7.5 feet NAVD	8.5 feet NAVD	10.34 feet NAVD	10.97 feet NAVD
<b>Wind Waves</b>	50-year wind wave (FEMA 2014)	No wind waves	50-year wind wave (FEMA 2014)	50-year wind wave (FEMA 2014)
<b>Range of TWL Along Trail</b>	7.5-12 feet NAVD	8.5 feet NAVD	12-15 feet NAVD	14-15.5 feet NAVD
<b>Approximate TWL Return Period (and % Annual Exceedance)</b>	2-year (50%)	1- to 2-year (50% to 99.9%)	5- to 10-year (10% to 20%)	40- to 50-year (2% to 2.5%)

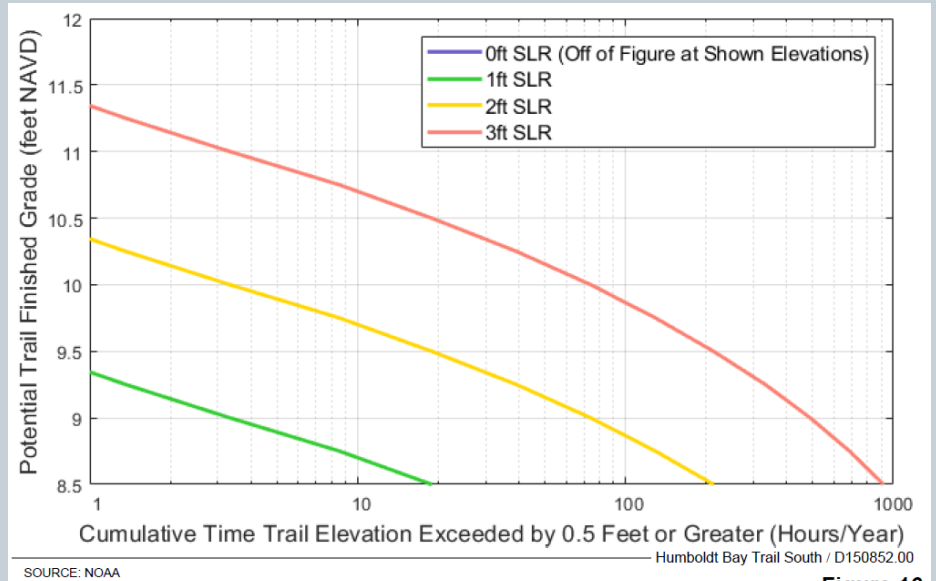
# Frequency Analysis



SOURCE: NOAA

Humboldt Bay Trail South / D150852.00

**Figure 15**  
Tidal Still Water Level Time Series with Sea-Level Rise



SOURCE: NOAA

Humboldt Bay Trail South / D150852.00

**Figure 16**  
Cumulative amount of time that trail is inundated by 0.5 foot

# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay



## Question #2: What designs for adaptation projects could be feasible and effective?

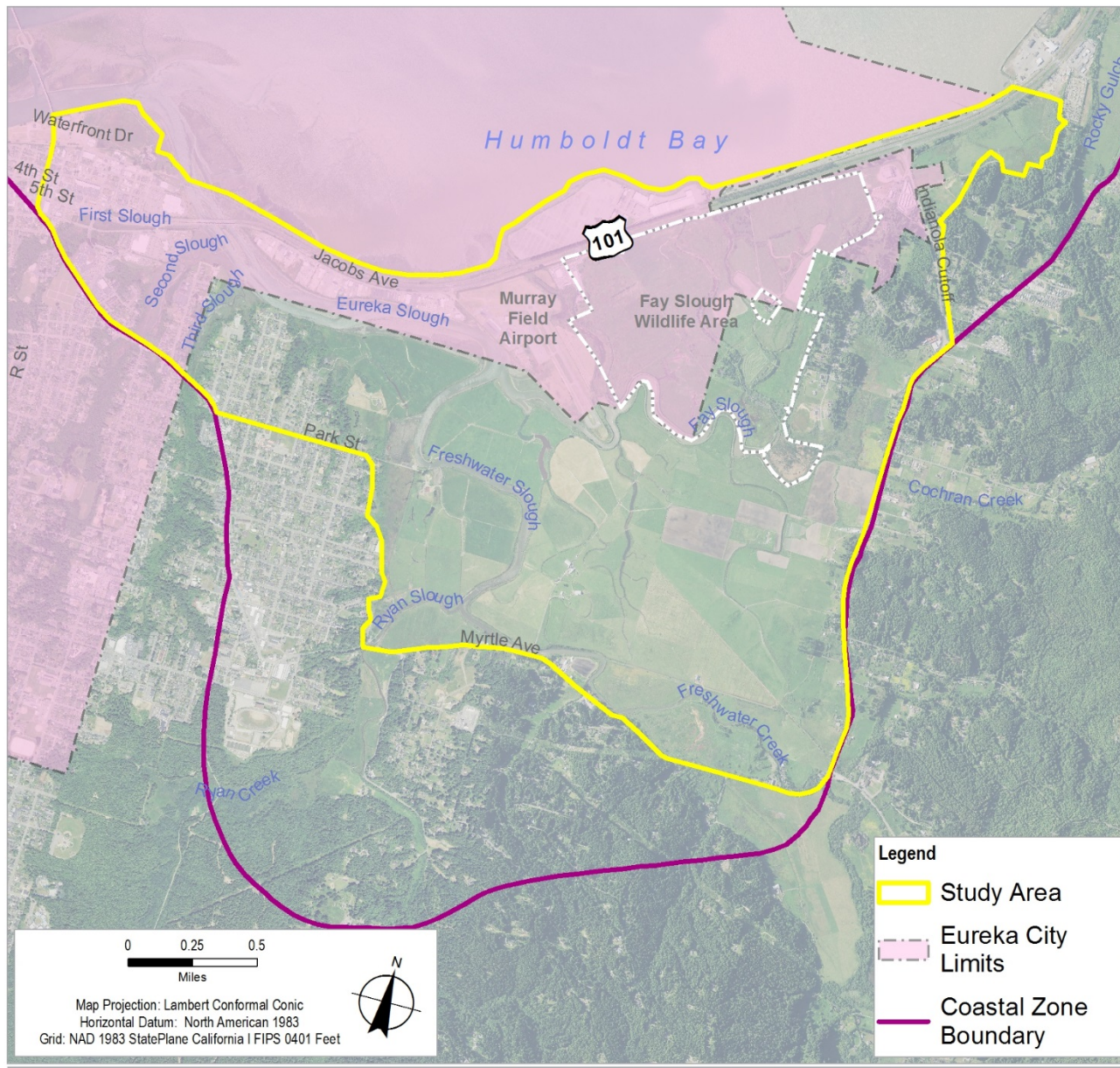
- 1) Develop conceptual designs for at least four adaptation projects
- 2) Consider innovative approaches (natural infrastructure, multi-objective projects, short-term/long-term transitions)
- 3) Develop order of magnitude budgetary costs
- 4) Develop a framework for Benefit-Cost Analysis (account for avoided costs, co-benefits, benefits to disadvantaged communities)

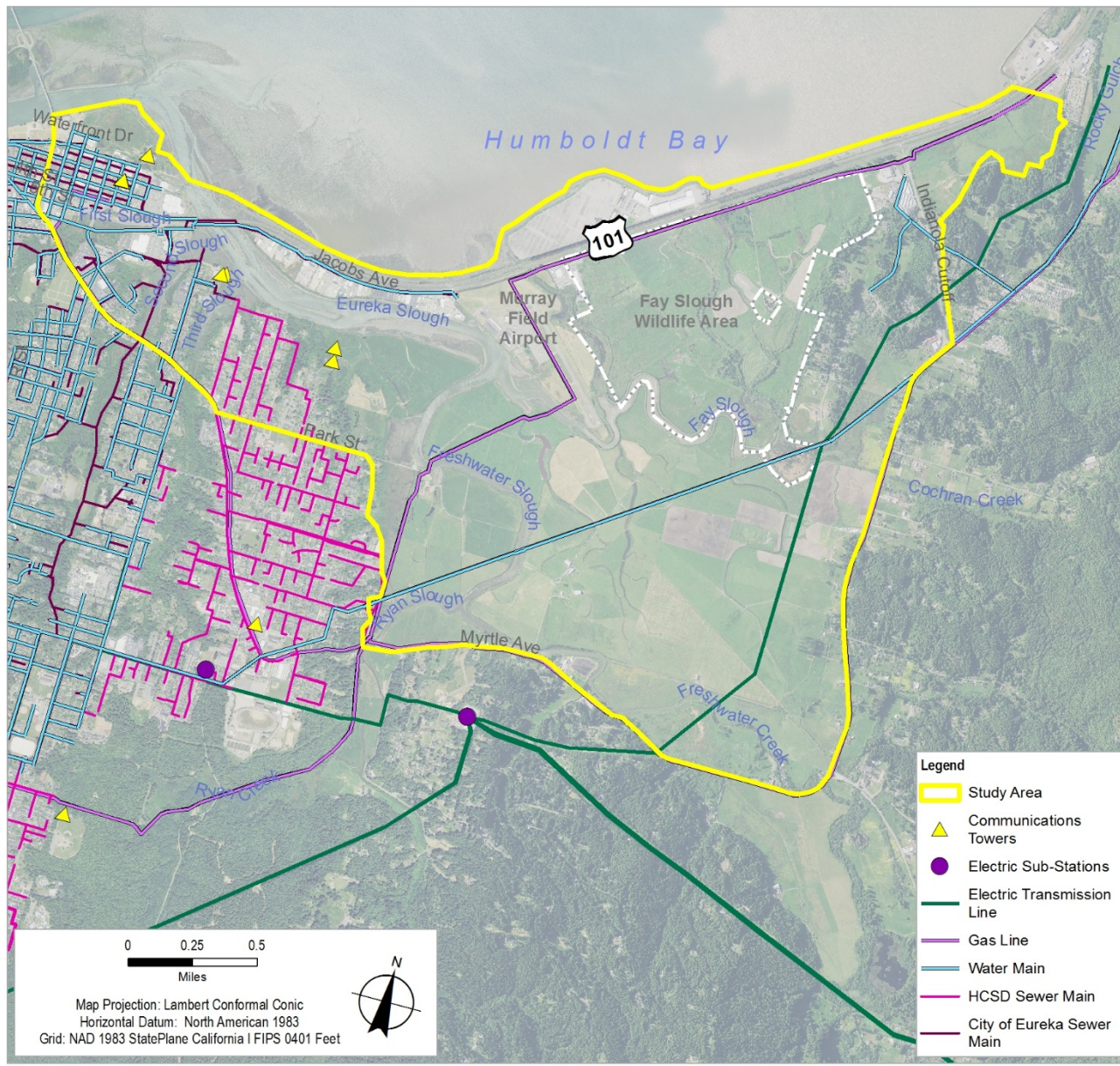
# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay

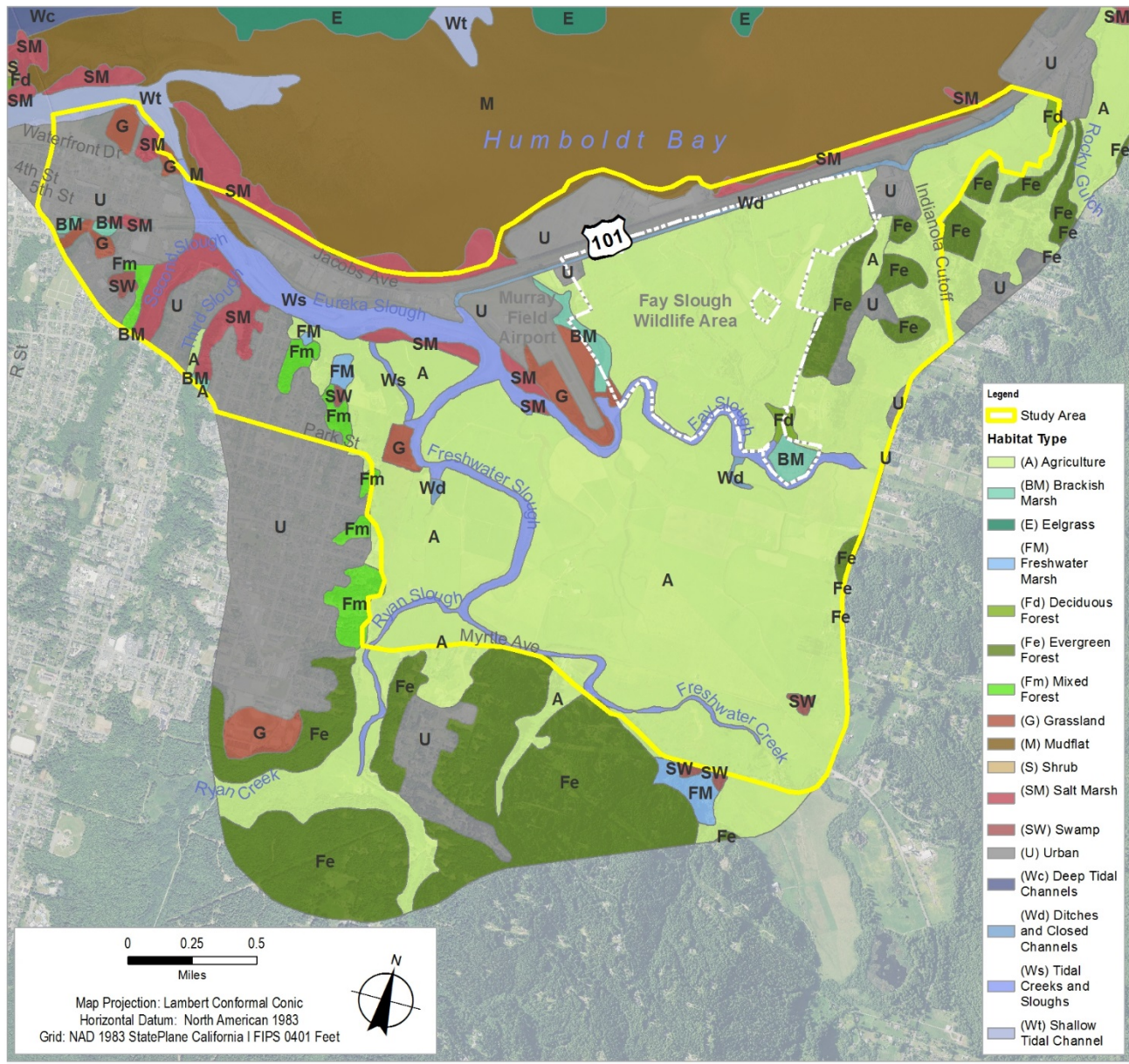


## Question #3: How do we collaborate?

- 1) **Emphasis on building relationships and an organizing framework for advancing collaborative efforts among public and private landowners**
- 2) **Emphasis on interdisciplinary work**
- 3) **Understand barriers and obstacles**
- 4) **Develop an implementation strategy for priority projects**







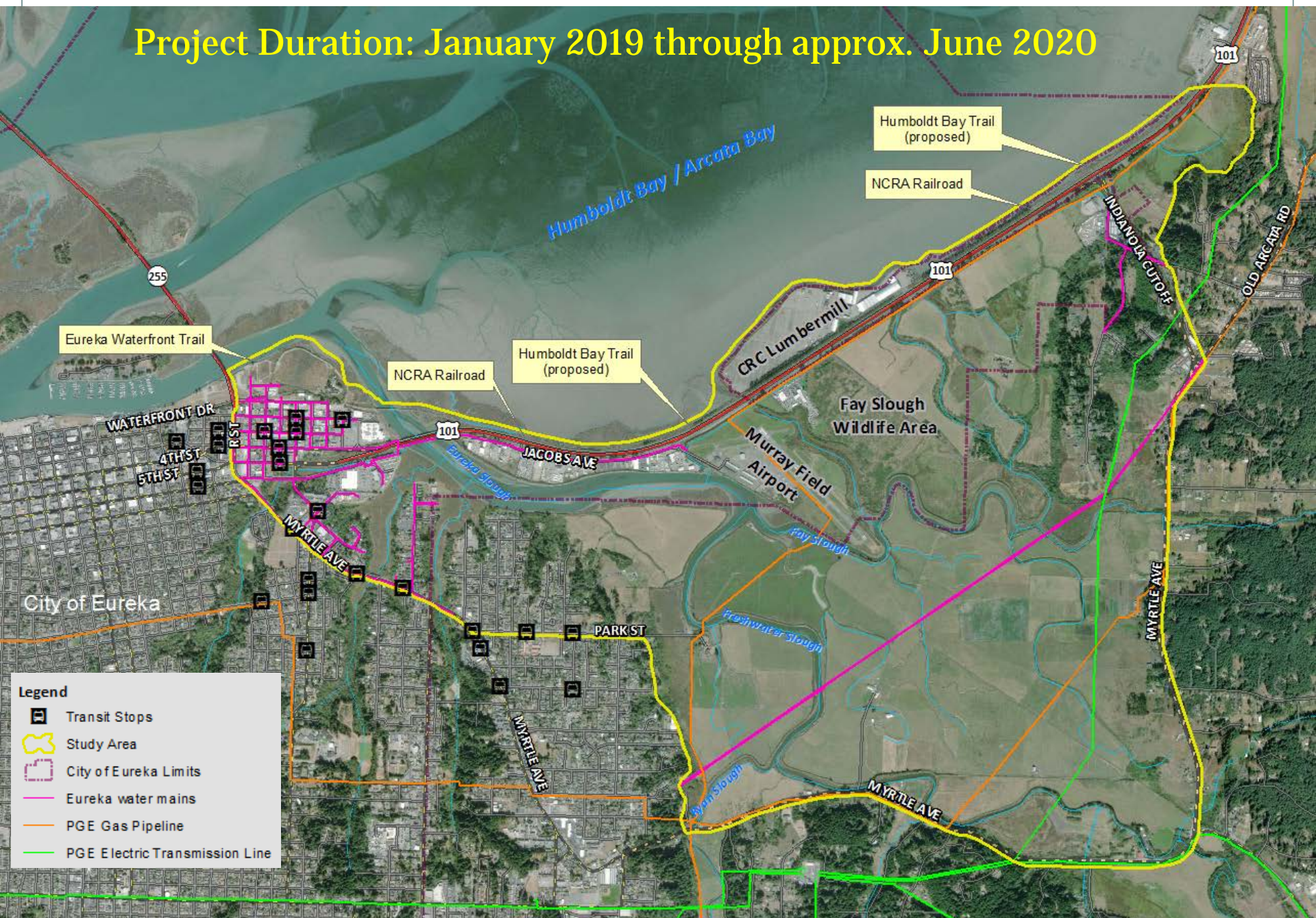
# Sea Level Rise Adaptation Plan for Eureka Slough Hydrographic Area, Humboldt Bay



## Question #3: How do we collaborate?

- 1) **Emphasis on building relationships and an organizing framework for advancing collaborative efforts among public and private landowners**
- 2) **Emphasis on interdisciplinary work**
- 3) **Understand barriers and obstacles**
- 4) **Develop an implementation strategy for priority projects**

# Project Duration: January 2019 through approx. June 2020



**Legend**

- Transit Stops
- Study Area
- City of Eureka Limits
- Eureka water mains
- PGE Gas Pipeline
- PGE Electric Transmission Line