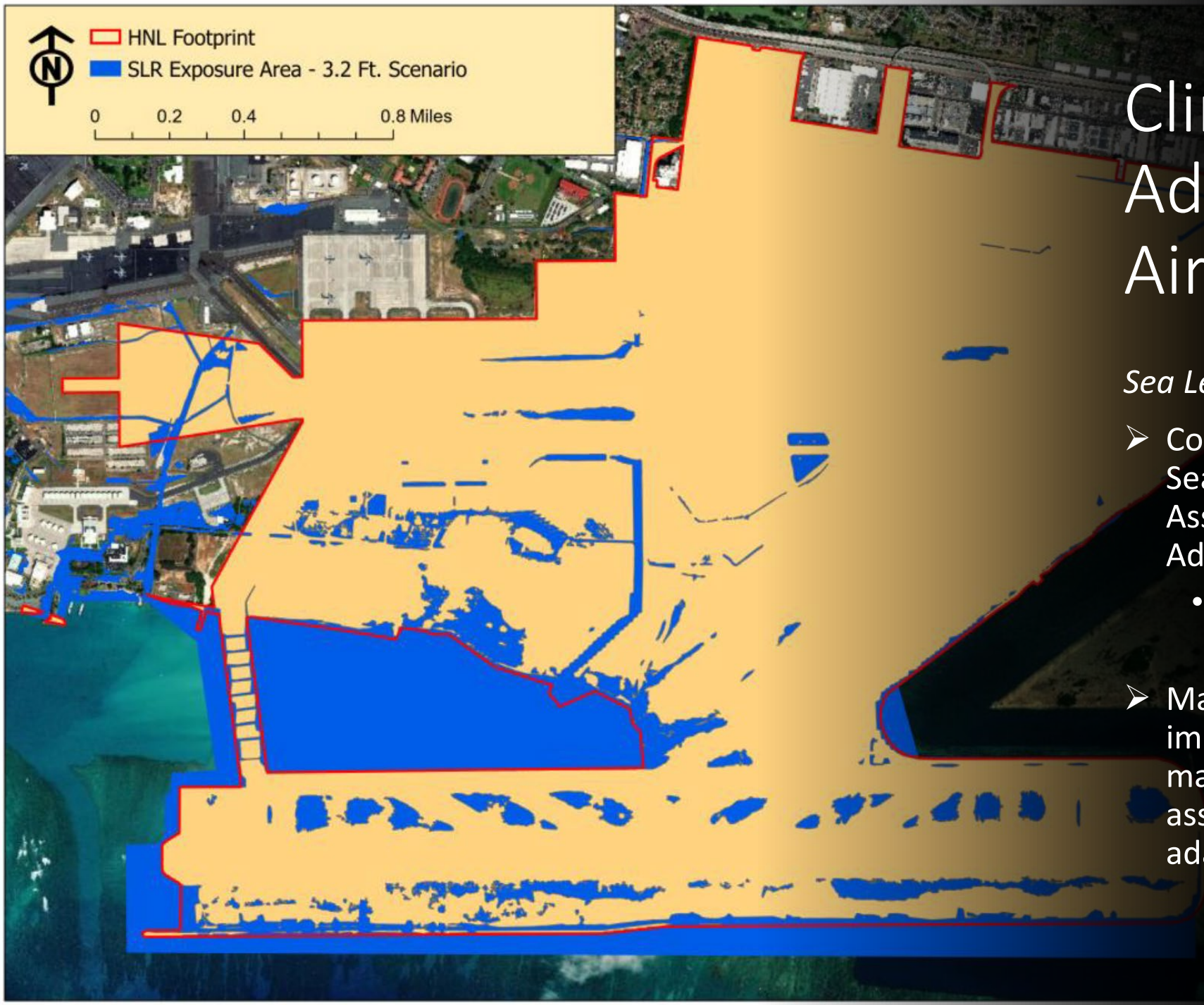
Infrastructure Climate Stressors

Current and expected impacts to airports, ports, and highways

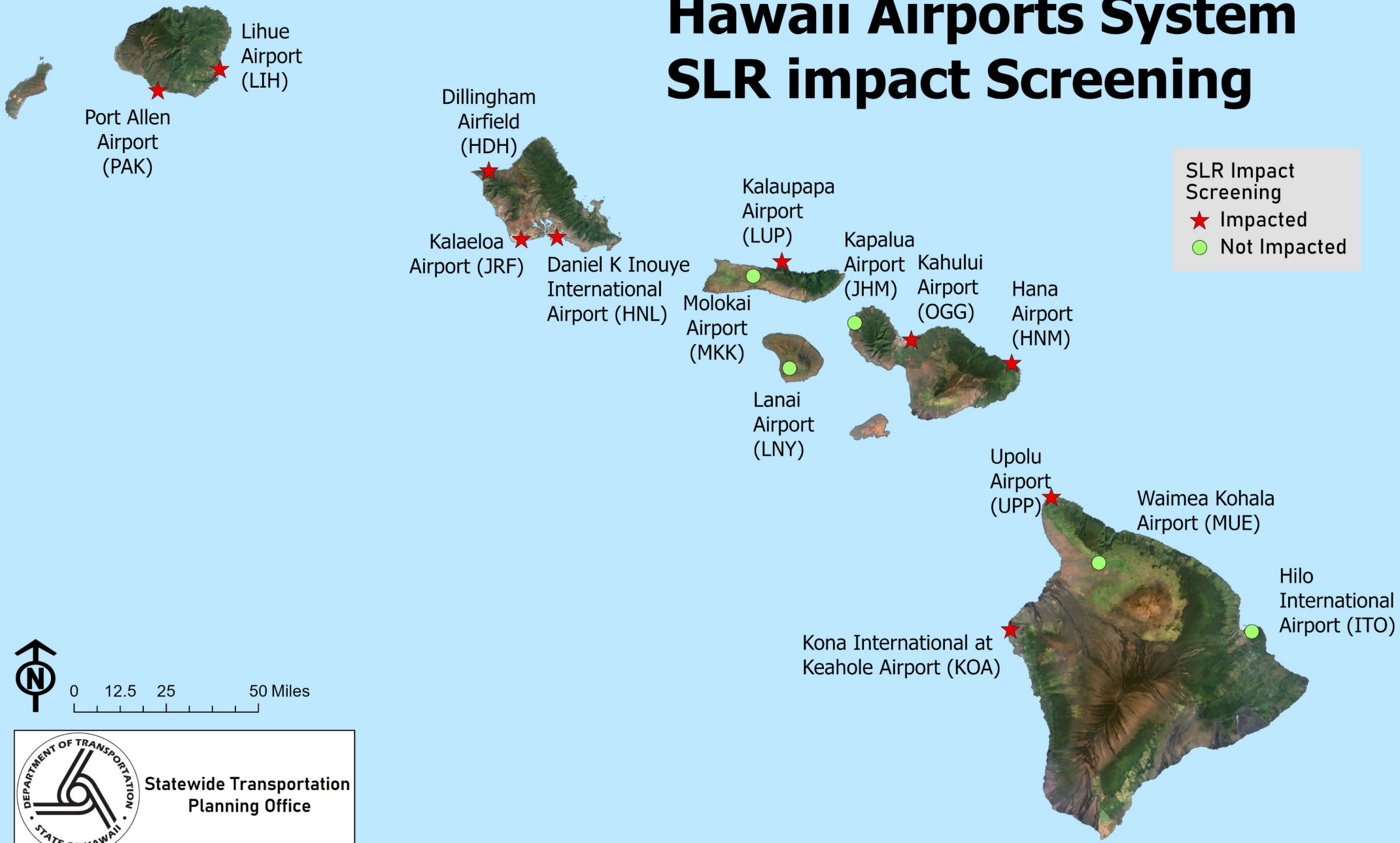


Climate Adaptation - Airports

Sea Level Rise

- Completed "Climate Change & Sea Level Rise: Preliminary Assessment for Mitigation and Adaptation" Report
  - Evaluating recommendations for mitigation measures
- Mapping anticipated sea level rise impacts and developing GIS managed inventory of airport assets for future climate adaptation planning.

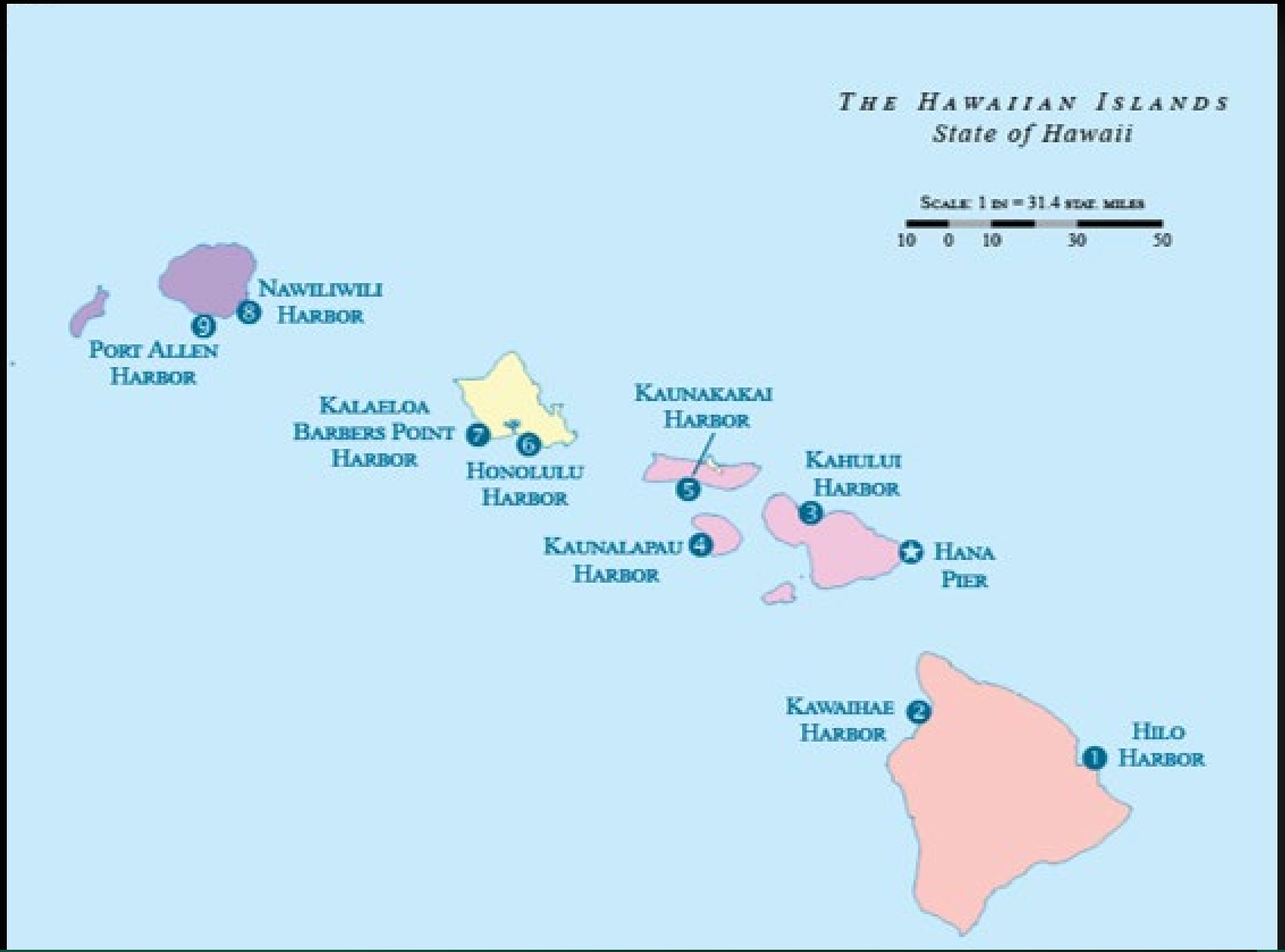
Hawaii Airports System SLR impact Screening



Projected Impact of SLR on Hawaii Airports

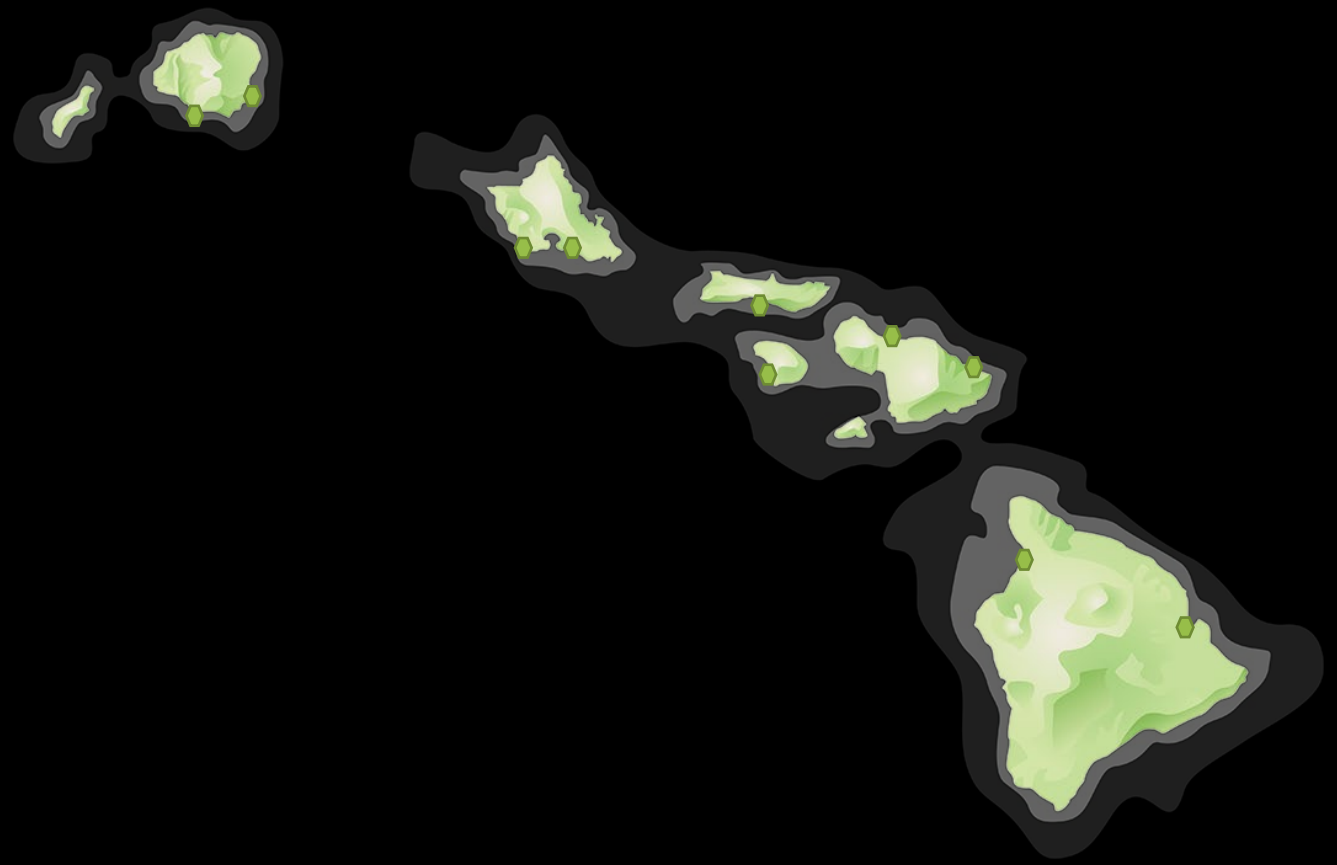
No.	Airport	Total Area (Acres)	Not Flooded (Acres)	SLR Flooded (Acres)	% Flooded
1	Dillingham Airfield	274.8	268.8	6.0	2.2%
2	Daniel K. Inouye International Airport	3015.5	2737.8	277.7	9.2%
3	Hana Airport	139.2	138.9	0.3	0.2%
4	Hilo International Airport	1251.6	1251.6	-	-
5	Kapalua Airport	57.3	57.3	-	-
6	Kalaeloa Airport	804.1	784.3	19.8	2.5%
7	Ellison Onizuka Kona International Airport at Keahole	4189.2	4172.1	17.1	0.4%
8	Lihue Airport	884.2	881.1	3.0	0.3%
9	Lanai Airport	508.0	508.0	-	-
10	Kalaupapa Airport	58.8	56.8	2.0	3.3%
11	Molokai Airport	206.8	206.8	-	-
12	Waimea Kohala Airport	89.8	89.8	-	-
13	Kahului Airport	1560.7	1353.4	207.2	13.3%
14	Port Allen Airport	185.3	130.5	54.8	29.6%
15	Upolu Airport	92.1	89.9	2.2	2.4%

Climate Adaptation Harbors

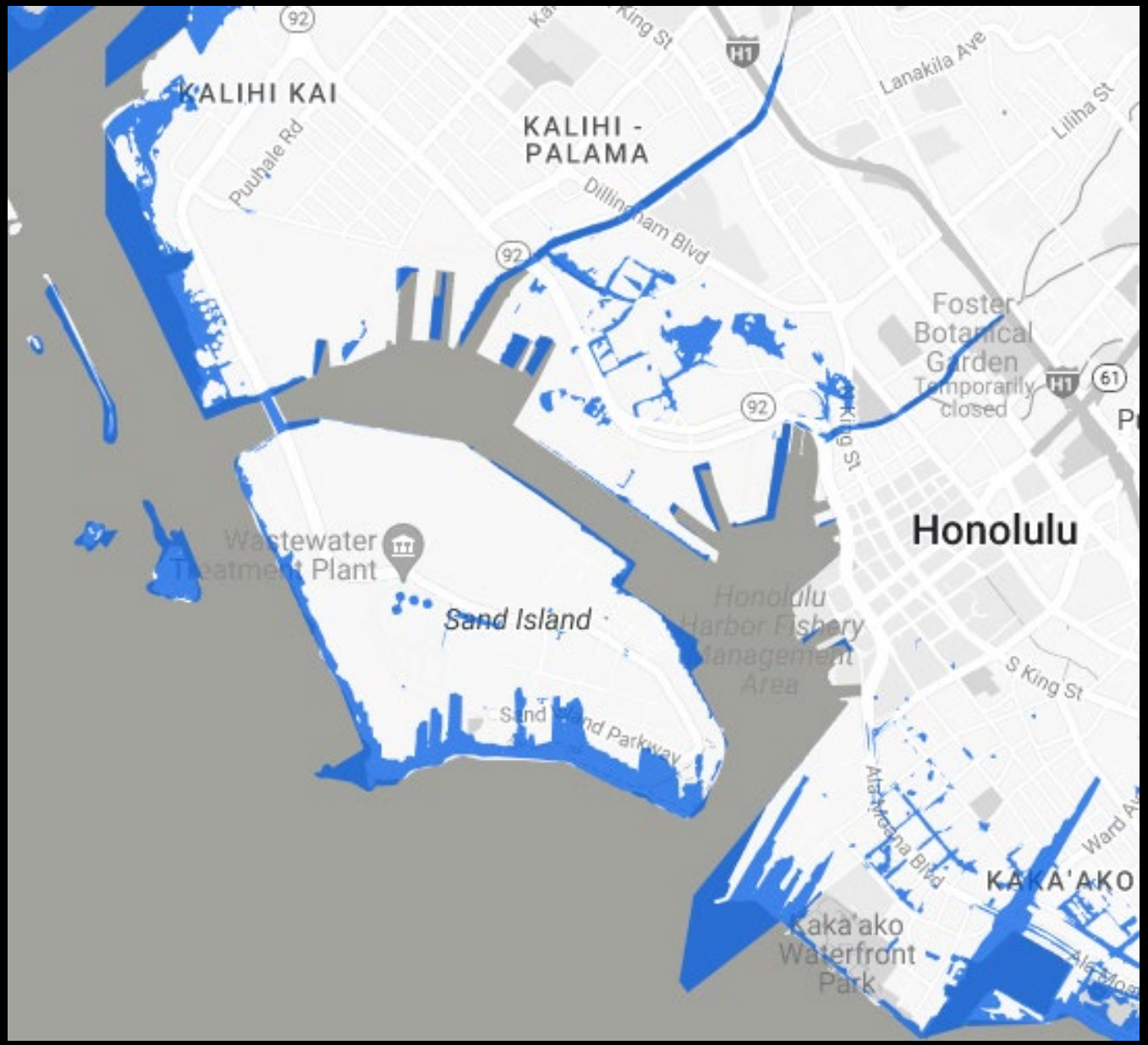


Considerations for commercial ports

- Climate change adaptation plan (2024-2025)
- Problems:
  - Adequate pier height
  - Substructure erosion
  - Flooding
- Physical improvements:
  - Raise piers?
  - Build sheet piles?
  - Re-engineering drainage?
  - Other options?
  - What's happening at other ports?
- How to cover costs?
  - Federal grants
  - User fee increases

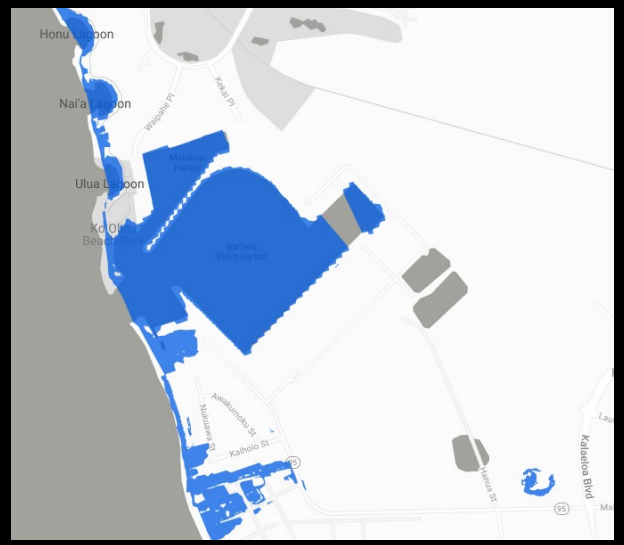


HONOLULU



SEA LEVEL EXPOSURE AREA (SLR-XA) – 3.2FT

NĀWILIWILI



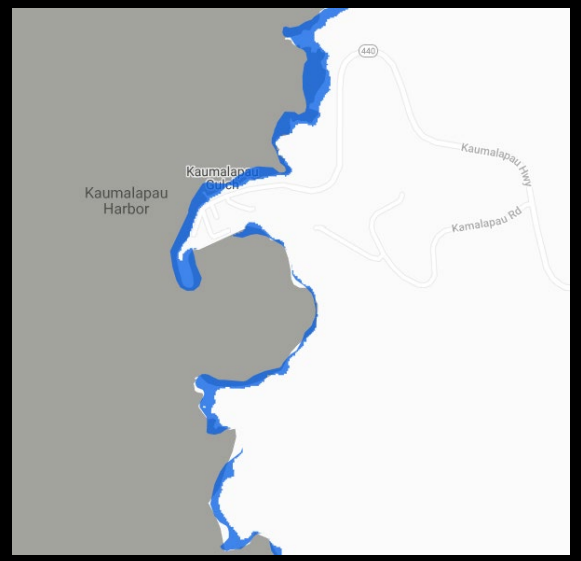
KALAELOA

KAUNAKAKAI

KAWAIHAE

PORT ALLEN

KAHULUI



KAUMALAPAU

HILO

SEA LEVEL EXPOSURE AREA (SLR-XA) – 3.2FT

SHEET PILE SOLUTION: COSTS ($135,000/linear foot*)

**** Based on median project bid price for Kapālama Container Terminal (2020)***

Harbor	Linear Feet	Est. Cost
Nāwiliwili – Piers 1-3	1,860	$251.1 M
Honolulu – Piers 1, 39/40, 51-53	10,202	$1,377.3 M
Kahului – Piers 1-3	3,052	$412.0 M
Kaunakakai	689	$93.0 M
Kaumalapau	400	$54.0 M
Kawaihae, Piers 1-2	1,562	$210.9 M
Hilo, Piers 1-3	2,605	$351.7 M

CLIMATE EXPOSURE SUMMARY BY STRESSOR

CLIMATE STRESSOR	Rockfalls and Landslides
EXPOSURE ASSESSMENT	Segments exposed to marine flooding and groundwater inundation considering three sea level rise scenarios
ROADS EXPOSED [MILE]	167.6 miles
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of Kūhiō Highway in Hanalei and near Wainiha; Waimea Canyon Road and Koke'e Road • O'ahu District: portions of Farrington Highway near Mākua Beach and Nānākuli; along Likelike Highway and Pali Highway; along Kalaniana'ole Highway in Waimānalo • Maui District: Hāna Highway in East Maui; portions of Honoapi'ilani Highway in West Maui • Hawai'i District: Māmalahoa Highway on Hāmākua Coast

CLIMATE STRESSOR	Passive flooding
EXPOSURE ASSESSMENT	Segments associated with sites prioritized in HDOT's Rockfall Protection Program and sites determined to have high and very susceptibility according to USGS
ROADS EXPOSED [MILE]	3.2 miles (0.5-ft SLR), 3.4 mile (1.1-ft SLR), 4.1 mile (2.0-ft SLR), and 9.4 miles (3.2-ft SLR)
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of North, West, and East Kaua'i, including Kūhiō Highway between Hanalei and Wainiha; Kaumuali'i Highway in Kekaha/Waimea; Kūhiō Highway over Wailua River and through Kapa'a • O'ahu District: portions of Farrington Highway on the Wai'anae Coast; Kamehemaha Highway on the North Shore and Windward shore (Kahana to Kahuku), Sand Island and Ala Moana Boulevard; Kalaniana'ole Highway in Hawai'i Kai • Maui District: North Kihei Road by Kealia Pond; portions of Kamehameha V Highway on south coast of Moloka'i

CLIMATE STRESSOR	Annual high wave flooding
EXPOSURE ASSESSMENT	Segments exposed to annual high wave flooding considering three sea level rise scenarios
ROADS EXPOSED [MILE]	2.8 miles (0.5-ft SLR), 4.2 miles (1.1-ft SLR), 9.5 miles (2.0-ft SLR), and 23.9 miles (3.2-ft SLR)
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of North, West, and East Kaua'i, including Kūhiō Highway between Hanalei and Wainiha; Kaumuali'i Highway in Kekaha/Waimea; Kūhiō Highway over Wailua River and through Kapa'a • O'ahu District: portions of of Kamehemaha Highway on the North Shore and Windward shore (Kualoa to La'ie); Ala Moana Boulevard; Kalaniana'ole Highway in Hawai'i Kai and Waimānalo • Maui District: portions of Honoapi'ilani Highway in West Maui (Lahaina to Olowalu); North Kihei Road by Kealia Pond

CLIMATE STRESSOR	Coastal erosion
EXPOSURE ASSESSMENT	Segments exposed to coastal erosion considering three sea level rise scenarios
ROADS EXPOSED [MILE]	8.4 miles (0.5-ft SLR), 12.1 miles (1.1-ft SLR), 17.9 miles (2.0-ft SLR), and 23.7 miles (3.2-ft SLR)
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of North, West, and East Kaua'i, including Kūhiō Highway between Hanalei and Wainiha; Kaumuali'i Highway in Kekaha; Kūhiō Highway by Wailua River and Kapa'a • O'ahu District: portions of Farrington Highway on the Wai'anae Coast; Kamehemaha Highway on the North Shore and Windward shore (Kualoa to La'ie), Kalaniana'ole Highway in Waimānalo • Maui District: portions of Honoapi'ilani Highway in West Maui (Lahaina to Olowalu); North Kihei Road by Kealia Pond

CLIMATE STRESSOR	Storm surge
EXPOSURE ASSESSMENT	Segments exposed to storm surge due to hurricanes of Categories 1 through 4
ROADS EXPOSED [MILE]	74.1 miles
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of North, West, and East Kaua'i, including Kūhiō Highway between Hanalei and Wainiha; Kaumuali'i Highway in Kekaha/Waimea; Kūhiō Highway over Wailua River and through Kapa'a • O'ahu District: portions of Farrington Highway on the Wai'anae Coast, Ewa Beach, areas of Kamehemaha Highway on the North Shore and Windward shore (Kualoa to La'ie); Sand Island , Nimitz Highway, and Ala Moana Boulevard; Kalaniana'ole Highway through Hawai'i Kai • Maui District: portions of Honoapi'ilani Highway in West Maui (Olowalu to Pāpalaua); North Kihei Road by Kealia Pond; roads surrounding Kahului Harbor; portions of Kamehameha V Highway on south coast of Moloka'i • Hawai'i District: roads along Hilo Bay and Kawaihae Harbor

CLIMATE STRESSOR	Wildfire
EXPOSURE ASSESSMENT	Segments associated with 1-km2 areas where more than one wildfire ignition occurred between 2000 and 2012
ROADS EXPOSED [MILE]	139.2 miles
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of Kūhiō Highway including Lihu'e and Kapa'a areas • O'ahu District: Leeward O'ahu, including Wai'anae Coast, 'Ewa, Pearl City, urban Honolulu, as well as Wahiawā and Hale'iwa • Maui District: roads in Kahului, Kihei, and Lahaina areas • Hawai'i District: portions of Queen Ka'ahumanu Highway on the Kona Coast

CLIMATE STRESSOR	Tsunami
EXPOSURE ASSESSMENT	Segments exposed to historical (1946, 1952, 1957, 1960, and 1964) and hypothetical tsunamis (two great Aleutian earthquakes with moment magnitudes of 9.3 and 9.6)
ROADS EXPOSED [MILE]	178.1 miles
EXAMPLES OF EXPOSED AREAS	• Kaua'i District: portions of North, West, and East Kaua'i, including Kūhiō Highway between Hanalei and Hā'ena; Kaumuali'i Highway in Kekaha/Waimea; Kūhiō Highway over Wailua River and through Kapa'a • O'ahu District: most coastal roads of O'ahu, including Kamehameha Highway and Farrington Highway; Sand Island , Nimitz Highway, and Ala Moana Boulevard; Kalaniana'ole Highway through Hawai'i Kai and Waimānalo • Maui District: roads in West and Central Maui, including Honoapi'ilani Highway and Hana Highway to Spreckelsville/Paia; Kamehameha V Highway on south coast of Moloka'i • Hawai'i District: roads along Hilo Bay and Kawaihae Harbor

CLIMATE STRESSOR	Lava flow
EXPOSURE ASSESSMENT	Segments associated with lava flow hazard zones 1 through 3 on the Island of Hawai'i and zone 1 in the Maui District
ROADS EXPOSED [MILE]	151.8 miles
EXAMPLES OF EXPOSED AREAS	• Hawai'i District: portions of Māmalahoa Highway/Hawai'i Belt Road through Hilo, Puna, and Volcano area to Kailua-Kona; Queen Ka'ahumanu Highway and Māmalahoa Highway mauka of Waikoloa Village.

LEGEND

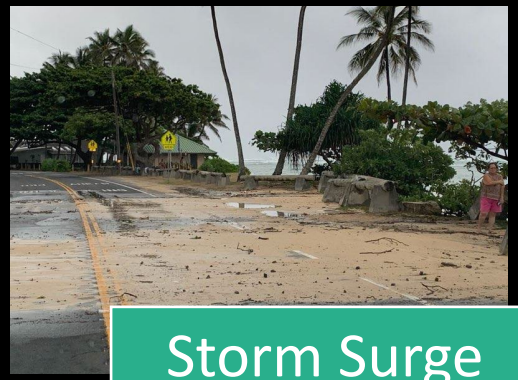
- Highway Asset Exposed to Climate Hazard
- Highway Asset Not Exposed to Climate Hazard

Note - More detailed information on locations of concern can be found in the on-line map viewer prepared to accompany this document

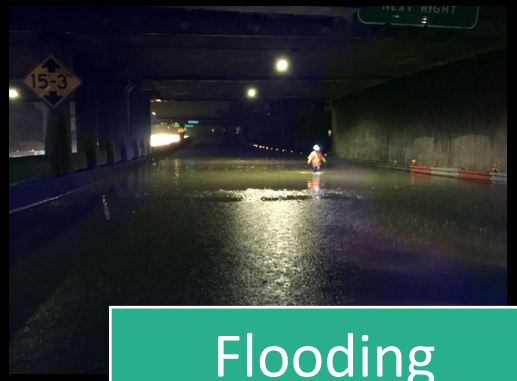
Source: State-Owned Roads: HDOT Highways Division, LRMS; Base maps: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community; World Ocean Reference: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors

Landslide

Wildfire



Storm Surge



Flooding

Coastal Erosion

Lava / Seismic

Natural Disasters, Emergencies, and Highways

Rockfall

High Surf

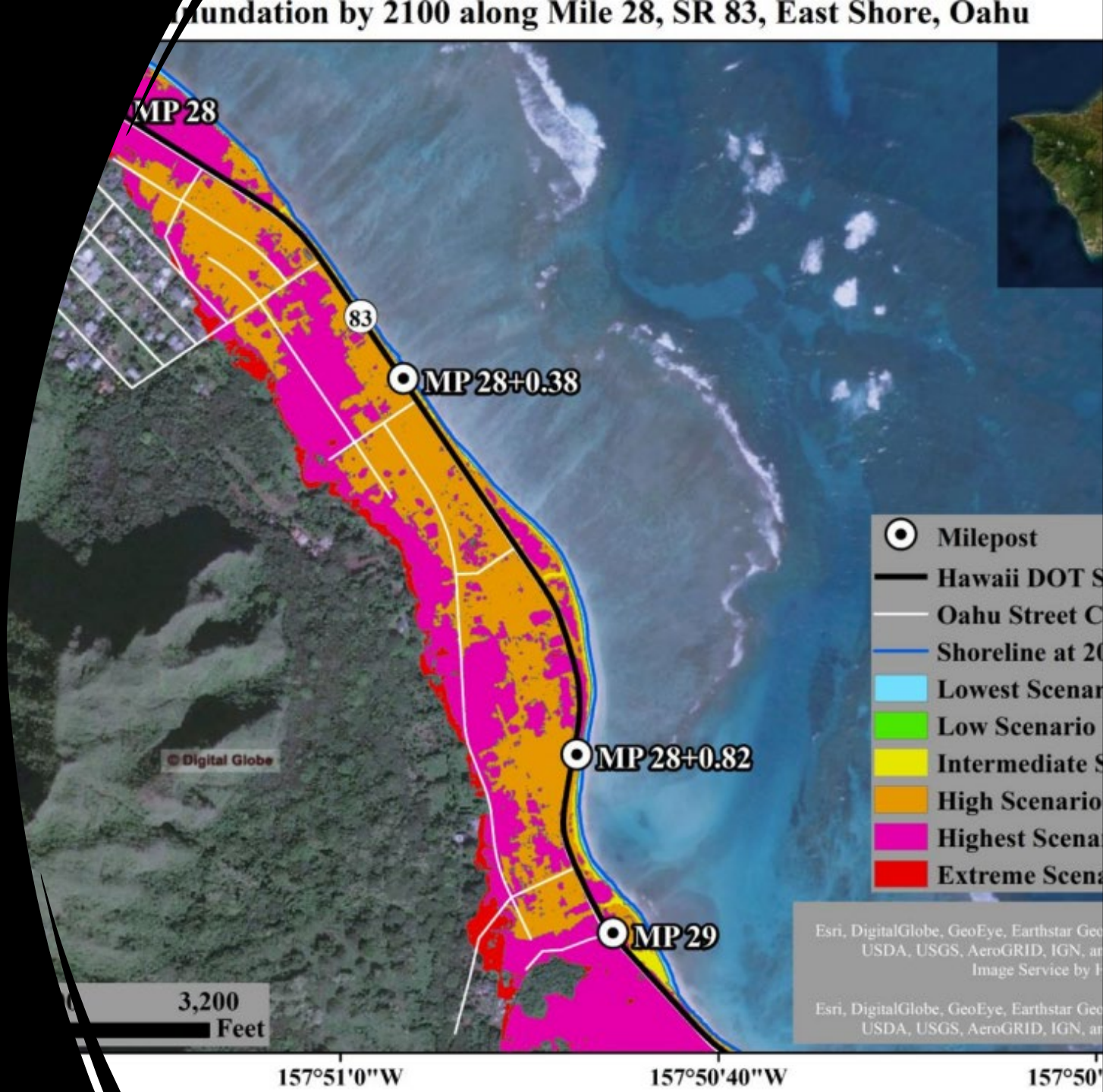
Table ES- 1 Mileage of HDOT Highways Exposed to Climate Hazards (to 3.2 feet Seal Level Rise (SLR)

	Roads		Bridges		Culverts		Tunnels	
Hazard	*Miles*	*%*	*Units*	*%*	*Units*	*%*	*Units*	*%*
Rockfall and landslide	167.6	17%	126	32%	11	15%	6	100%
Sea Level Rise	9.4	1%	92	23%	7	10%	0	0%
Annual high wave flooding	23.9	2%	50	13%	6	8%	0	0%
Coastal erosion	23.7	2%	22	6%	2	3%	0	0%
Storm surge	74.1	8%	120	30%	9	12%	0	0%
Tsunami	178.1	18%	135	34%	15	21%	0	0%
Wildfire	139.2	14%	97	24%	18	25%	0	0%
Lava flow	151.8	16%	18	5%	15	21%	0	0%

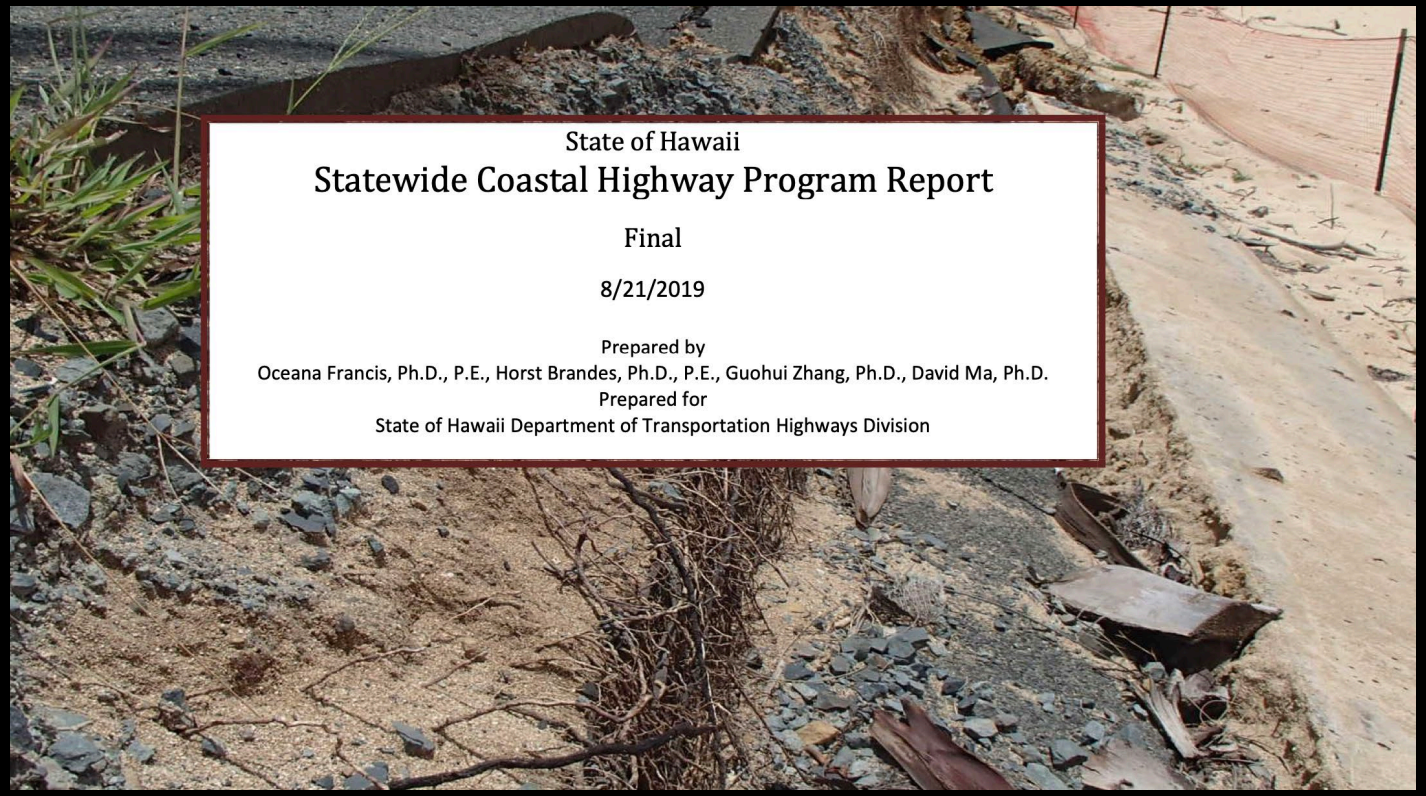
3.2 feet used for the summary utilizing values from the Hawaii Sea Level Rise Vulnerability and Adaptation Report (2017)

Statewide Coastal Highway Program Report

- Key findings include:
- Prioritization of coastal highway sections taking into account susceptibility of sections to erosion and system connectivity
- Creation of index approach (CRESI) that addresses Hawaiian geomorphology and existing infrastructure
- Need for future study of the effects of mitigation on surrounding shorelines



Coastal Road Erosion Susceptibility Index Top 10 Sites

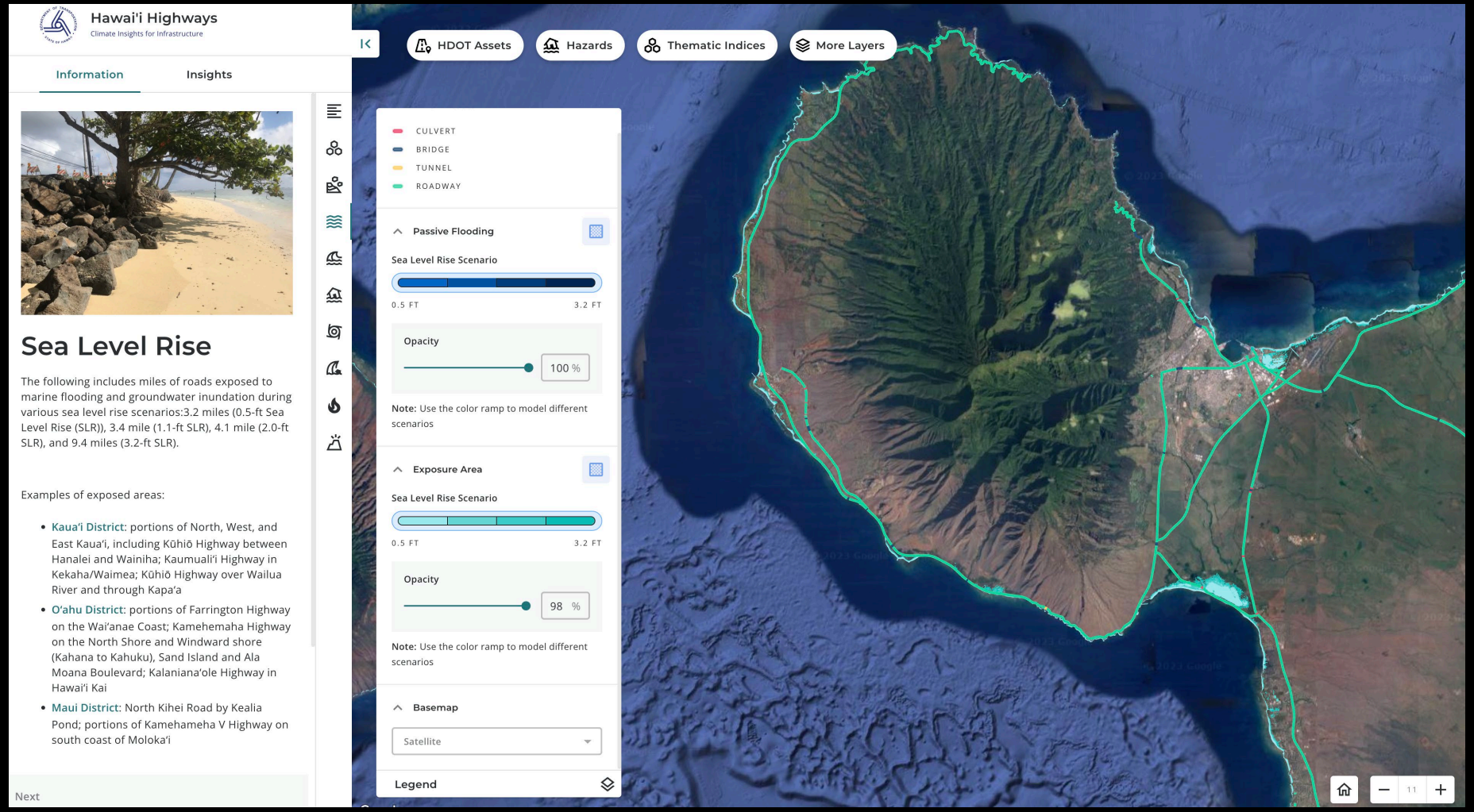


Final Rank	Island	Name	Milepost(s)[1]	CRESI Values
1	Oahu	Hauula	22 22+0.45[1]	29 34
2	Maui	Mopua	14+0.30 14+0.32 14+0.43 14+0.49	16 22 44 22
3	Oahu	Kaaawa South	28+0.38 28+0.82	29 25
4	Kauai	Waikoko	4+0.11 4+0.25 4+0.39 4+0.51	26 30 22 24
5	Oahu	Waimanalo	5+0.93 6 6+0.19	30 28 26
6	Molokai	Kalua'aha	14+0.70	37
7	Molokai	Puko'o	16+0.27	37
8	Oahu	Kaaawa to Kahana	27+0.25 27+0.79	29 21
9	Oahu	Kualoa	30+0.54	28
10	Oahu	Kualoa to Kaaawa	29+0.71	26

Statewide Rockfall Prioritization

- Cost to implement rockfall protection at priority sites exceeds $100 million.
- Five of the sites on Kuhio Highway and Pali Highway have been addressed following emergency events.

Climate Insights for Infrastructure Platform: https://climate-resilience.hidot.hawaii.gov/



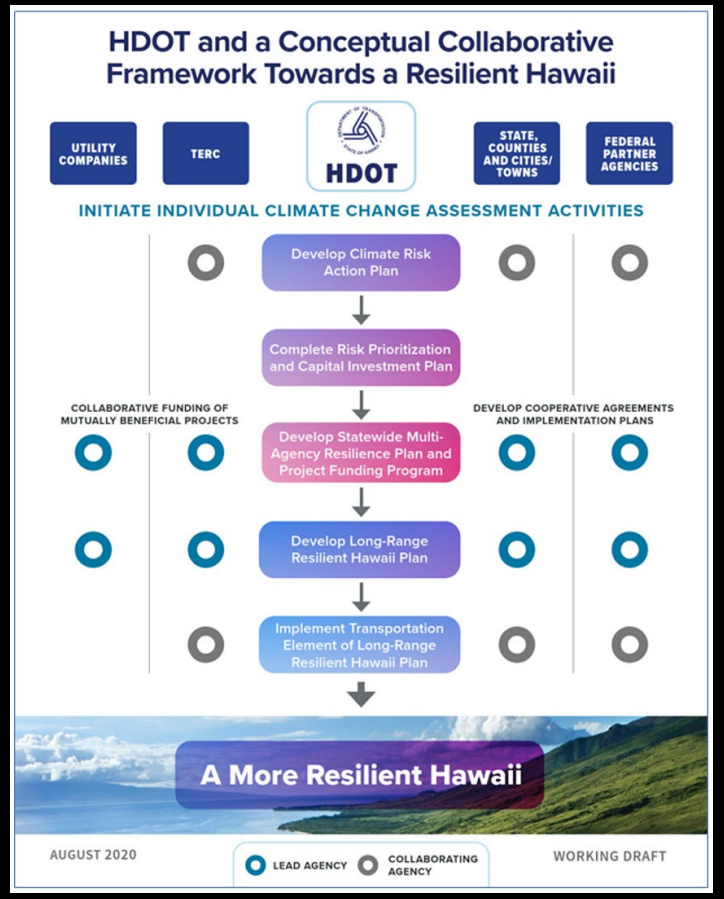
Resiliency Consideration Checklist

Project Information:

Project title: _____
Project location: _____
Project manager: _____
Contact number: _____

A) Using the HDOT Hazard Viewer, complete the following:

Hazard	Consideration	Yes/No
Rockfall and Landslide	1. Is the project within a segment associated with sites prioritized in the Department of Transportation's Rockfall Protection Program and sites determined to have high and very high susceptibility according to the United States Geological Survey (refer to Chapter 3)?	
Passive Flooding	2. Is the project within a segment exposed to marine flooding and groundwater inundation considering three sea level rise scenarios (refer to Chapter 4)?	
Annual High Wave Flooding	3. Is the project within a segment exposed to annual high wave flooding considering three sea level rise scenarios (refer to Chapter 4)?	
Coastal Erosion	4. Is the project within a segment exposed to coastal erosion considering three sea level rise scenarios (refer to Chapter 4)?	
Storm Surge	5. Is the project within a segment exposed to storm surge due to Category 1 through 4 hurricanes (refer to Chapter 5)?	
Tsunami	6. Is the project within a segment exposed to historical (1946, 1952, 1957, 1960, and 1964) and hypothetical tsunamis (two great Aleutian earthquakes with moment magnitudes of 9.3 and 9.6) (refer to Chapter 6)?	



Resilience Policies & Project Checklist

Project managers fill out a resilience consideration check list that identifies the hazards in the area and the lifespan of a project. Based on this background information and site assessments the most cost-effective design and investment responses are determined.

End Goal


PLAN
DESIGN
BUILD
OPERATE
MAINTAIN
RESCUE
RECOVER
REBUILD
EVENT