US Army Corps of Engineers ®
Honolulu District

# Appendix B

American Samoa Final Watershed Plan

# Economics and LifeSim

**July 2022**

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# 1 Study Area

American Samoa is an unincorporated territory of the United States located in the mid-South Pacific Ocean, a part of the Samoan Islands archipelago in Polynesia (see Figure 1-1). American Samoa consists of five main islands (Tutuila, Aunu'u, Ofu, Olosega, and Tau), a smaller privately owned island (Swains Island), and one coral atoll (Rose Atoll) (Figure 1-2). Tutuila is the largest and most populous island, with a 58 square mile land area and approximately 48,000 residents. Aunu'u Island is 0.59 square miles and located one mile southeast of Tutuila, with less than 450 residents. The islands of Ofu, Olosega, and Tau, located approximately 70 miles east of Tutuila, are collectively referred to as the Manu'a Islands and have a combined population of 850.


Figure 1-1. American Samoa in the South Pacific Ocean

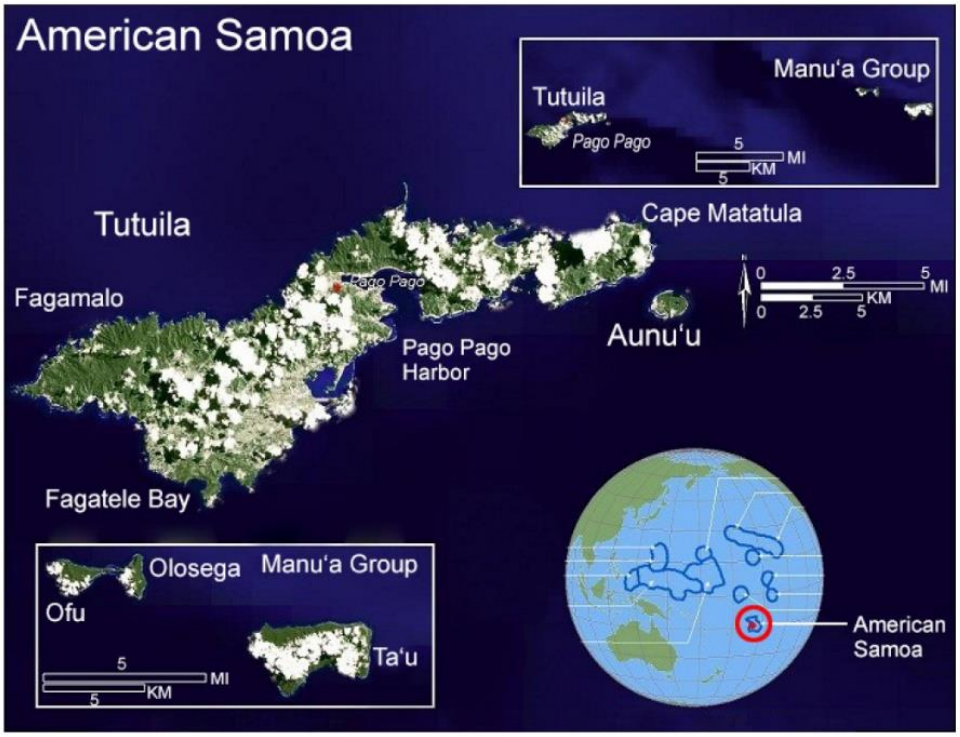


Figure 1-2. American Samoa Islands

American Samoa is represented by Congresswoman Aumua Amata (R), a delegate to the U.S. House of Representatives.

Due to the steep terrain of the islands, most development, including critical infrastructure such as the Lyndon B. Johnson (LBJ) Tropical Medical Center, the primary petroleum tank farm, and the primary roads are located along narrow areas between the mountains and the shoreline. Even Pago Pago harbor, which is central to the economy of American Samoa, is built within very limited space between steep slopes and the coast. The Tafuna-Leone Plain on the southwestern area of Tutuila is the largest relatively flat area of all the islands and subsequently is the largest area of development.

## 1.1 Population

The 2020 U.S. Census of American Samoa recorded a total population of 49,710. There was a 10.5% decrease in the 2020 census from the previous decade, a trend that conforms with discussions with local sponsors of people moving from the islands to pursue opportunities elsewhere. This contrasts with Figure 1-5, which shows the largest cohorts in the 0- to 15-year-old categories. The decline is likely due to diaspora of the younger cohorts as well as older generations nearing end of life.

The Eastern and Western Districts which encompass the Island of Tutuila and Aunu'u are the islands which are home to more than 95% of the population. The Eastern District is home to 17,059 people and the Western District is home to 31,819 people. Further to the east, the Manu'a District is home to 832 people.

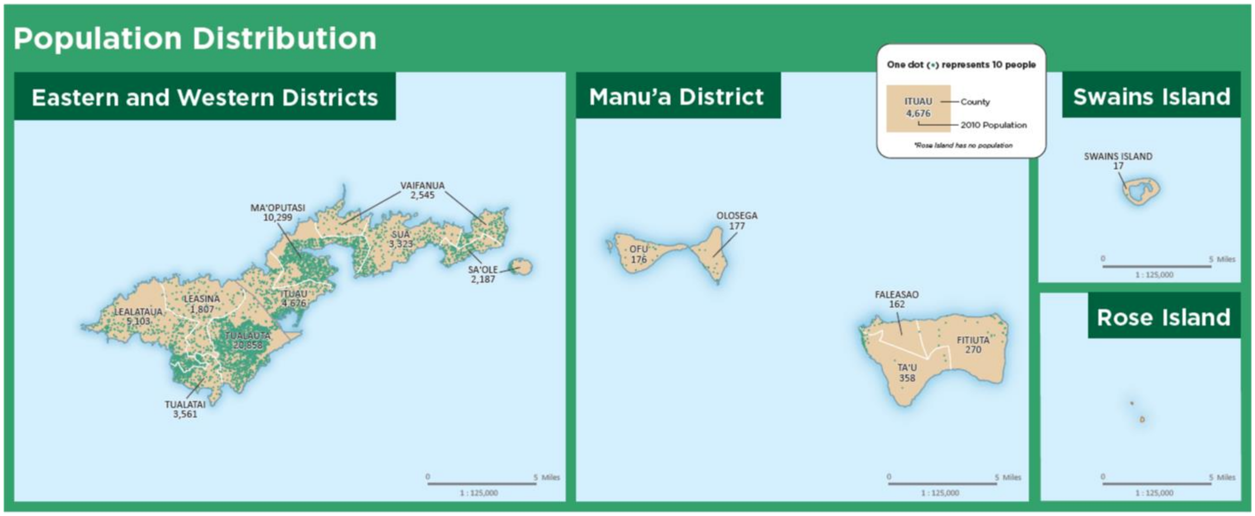


Figure 1-3: Population Distribution of American Samoa. Source: [U.S. Census Bureau, 2010 Census: Understanding the Population of American Samoa]

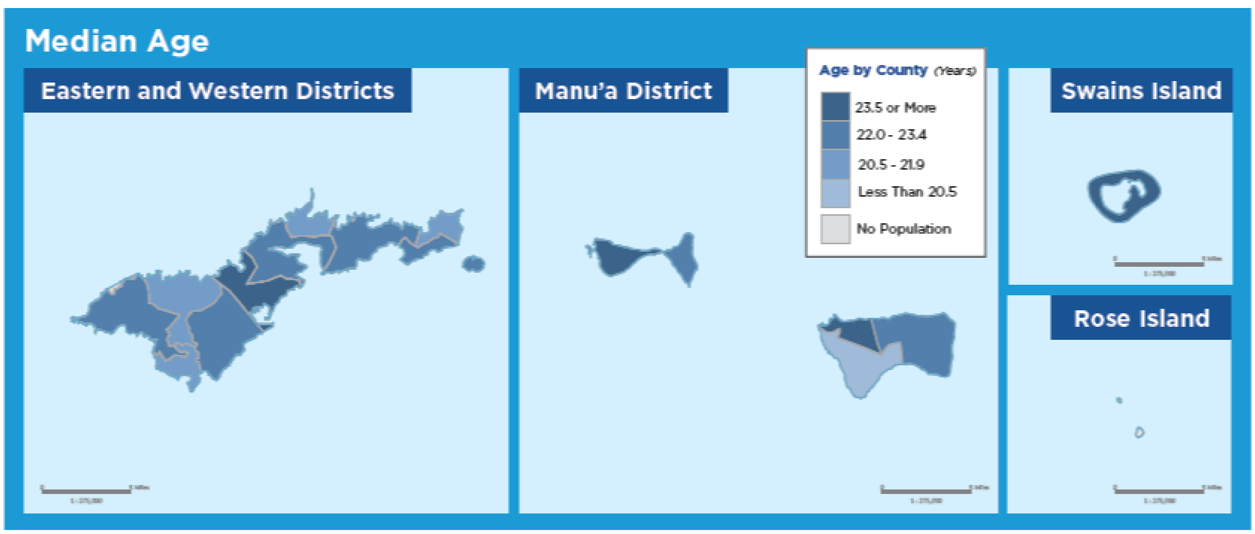


Figure 1-4: Age distribution (map) of American Samoa. Source: [U.S. Census Bureau, 2010 Census: Understanding the Population of American Samoa]

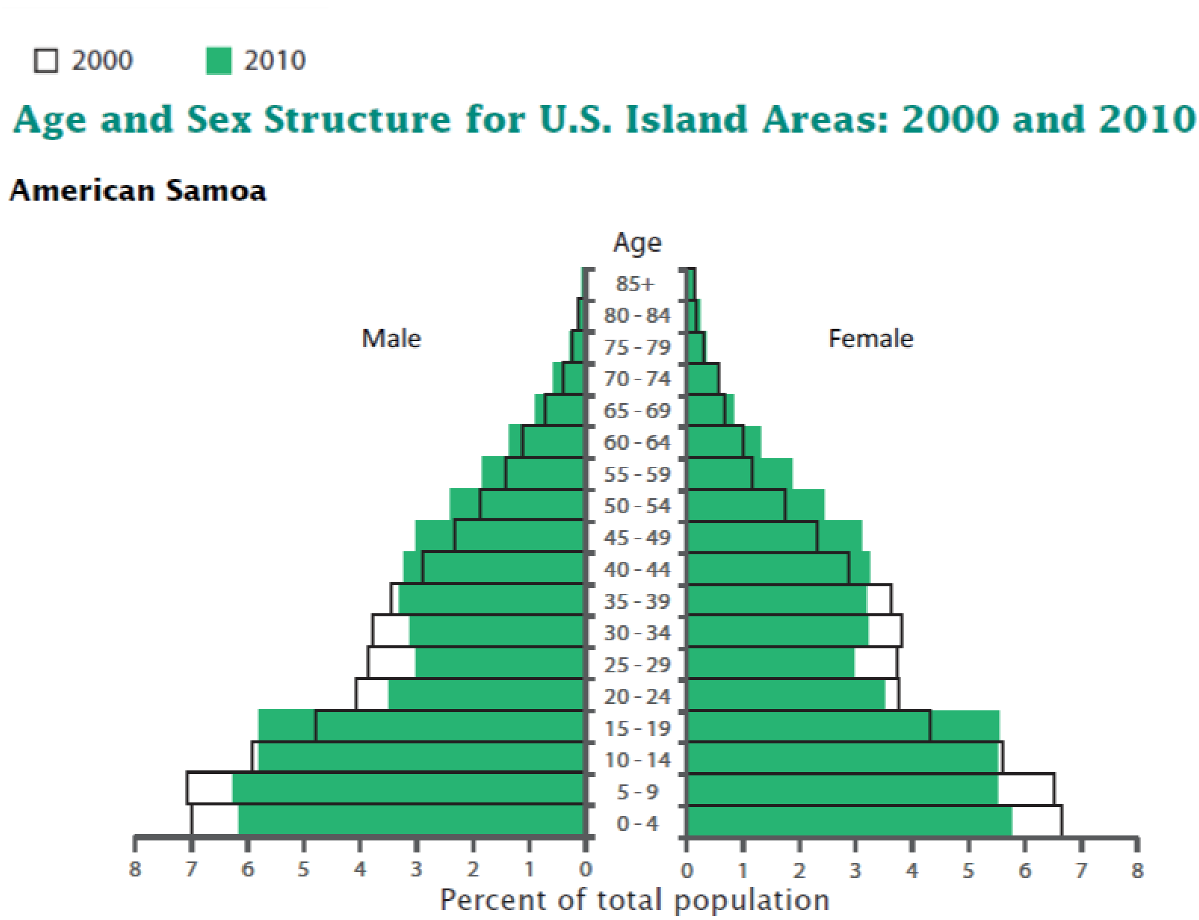


Figure 1-5: Age and Sex Distribution (chart) of American Samoa. Source: [U.S. Census Bureau, 2010 Census: Recent Population Trends for the U.S. Island Areas: 2000 to 2010]

### 1.2 Economy

The remoteness of American Samoa has led to challenges for a diversified economy. Over eighty percent of the islands' exports are from canned and pouched tuna. This concentrated reliance on a single export increasing American Samoa's susceptibility to economic shock (GAO, 2020). From 2007 to 2017, American Samoa experienced a GDP contraction of 18.2%. In 2018, GDP rose by 2.2%, however, the 2019 Bureau of Economic Analysis estimated that GDP for the islands had decreased by 1.4% from the previous year, primarily due to government spending, exports, and private fixed investment (BEA, 2020). It is likely that GDP will experience a period of decline from 2020 to the end of the Covid-19 Pandemic due to travel restrictions and sharp declines in tourism on a global scale. (Brookings, 2021).

Employees in American Samoa generally earn low wages when compared to the continental US, averaging $16,415 annually (2017 Economic Census Snapshot). The main employment sectors are Manufacturing, Retail Trade, Health Care and Social Assistance, Accommodation and Food Services, and Construction (2017 Economic Census Snapshot).

According to the American Samoa Comprehensive Economic Development Strategy, the sector seen locally as having the most potential for growth is Information Communication and Technology. This confidence stems from recent large investments in fiber optic cable infrastructure on the islands. The other sectors seen as being potentials for growth were capital investment projects leveraging new investors, eco and general tourism, and federal expenditures such as grant programs (CEDS 2018-2022).

The StarKist Tuna Cannery is vital and central to the economy of American Samoa. It is the last remaining cannery, and local opinion shows a low confidence that the cannery will remain open in the future (CEDS 2018-2022). A loss of StarKist could cause the loss of nearly 2,500 jobs on the island and drop exports from the island by approximately 80%.

In 2007 the Fair Minimum Wage Act raised the minimum wage by $0.50 in American Samoa and included a provision to, over time, increase the minimum wage to current federal levels. By 2016, StarKist was the only cannery still operating in American Samoa and continues to face financial challenges due to periodic raises in the minimum wage ($5.96 in 2021), as well as a $100 million fine for price fixing in 2019 (GAO, 2020).

## 1.3 Infrastructure

No comprehensive and complete structure inventories have been available to the PDT for American Samoa, so a generalized structure inventory was created to describe the layout of infrastructure on the islands. In total, 11,805 structures were recorded in the structure inventory, which closely aligns with the 11,807 total housing units estimated in the 2020 U.S. Census, but falls well below the more than 17,000 structures listed in the 2020 Hazard Mitigation Plan (HMP). Housing unit and structure estimates often produce differing results due to the defining characteristics of each. For example, multiple housing units can be contained within a single structure such as an apartment complex, or multi-family home.

### 1.3.1 Structure Inventory

To build the generalized structure inventory, visible structures were marked using GIS to create a point-shapefile, and attributes for the points were generated based on the distributions of attributes from the National Structure Inventory of the island of Maui, HI. A targeted ATR review has been completed for the generalized structure inventory methodology. However, it is important to caveat that this structure inventory is generalized and using details of structures and attributes is not appropriate for feasibility level analysis. The inventory shows a broad-scope description of structure locations and possible areas of concentrated risk.

Due to the steep terrain of the islands, most development, including critical infrastructure such as the LBJ Tropical Medical center, the primary petroleum tank farm, and the primary roads are located along narrow areas between the mountains and the shoreline. Even Pago Pago harbor, which is central to the economy of American Samoa is built within very limited developable space between steep slopes and the coast (see Figure 1-6). The Tafuna-Leone plain on the southwestern area of Tutuila is the largest area of development and is the largest relatively flat area of all the islands (see Figure 1-7).

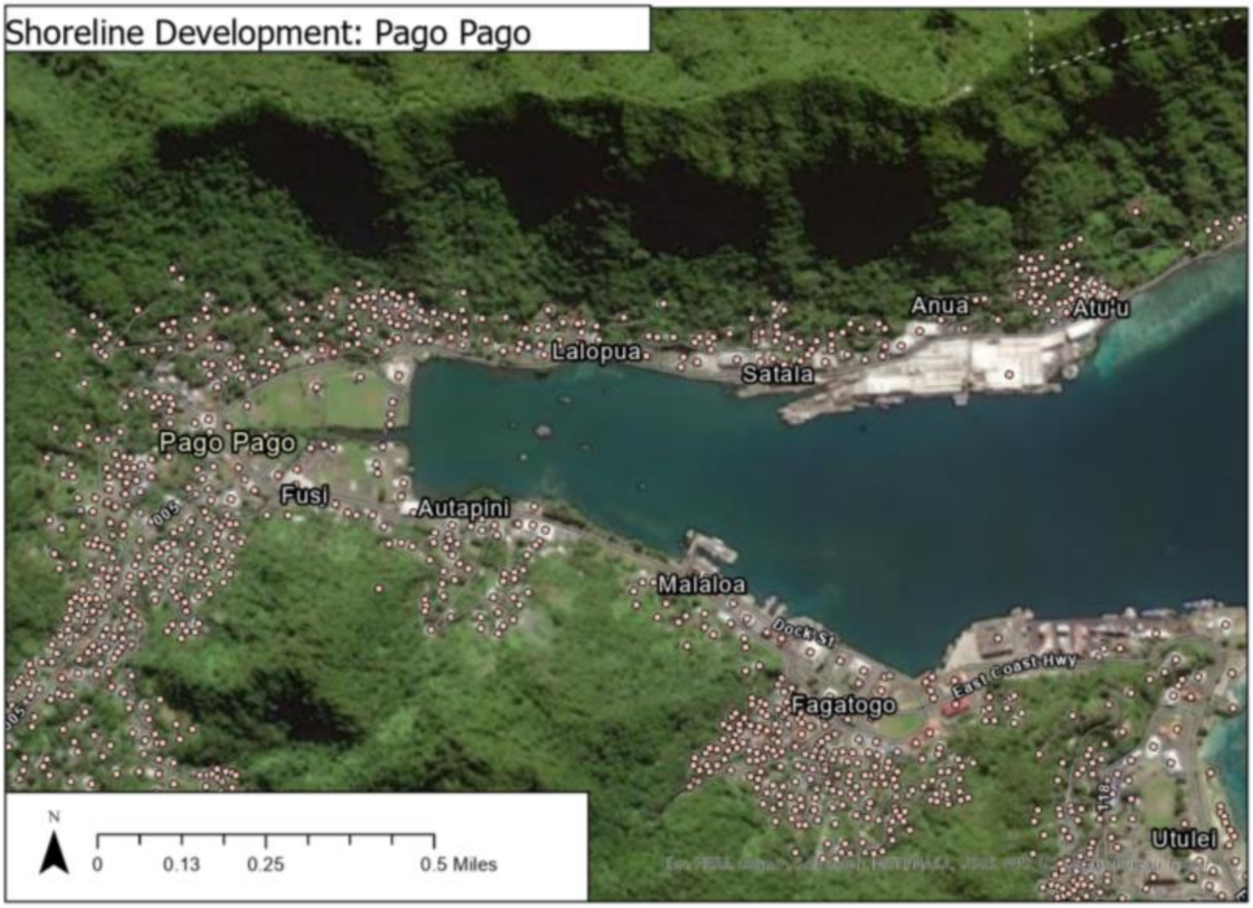


Figure 1-6: Shoreline development near Pago Pago Harbor. Source: [USACE, 2021]

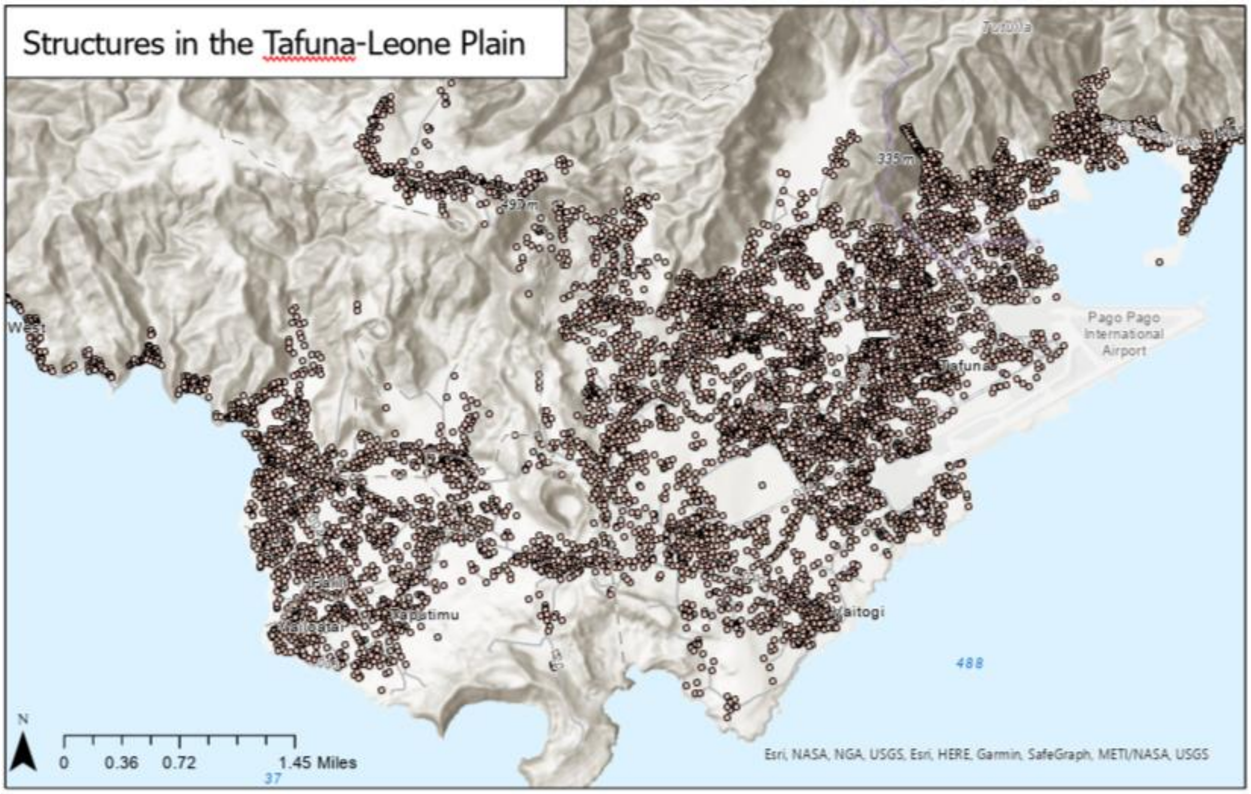


Figure 1-7: Tafuna-Leone Plain structures. Source: [USACE 2021]

As with the population, most structures are located within the Eastern and Western Districts on the Islands of Tutuila and Aunu'u (Figure 1-8 and Figure 1-9 ), with additional structures within the Manu'a District islands of Ofu, Olosega (Figure 1-10), and Ta'u (Figure 1-11). Overall, there are approximately 11,805 structures in American Samoa, 11,152 of which are on the islands of Tutuila and Aunu'u.

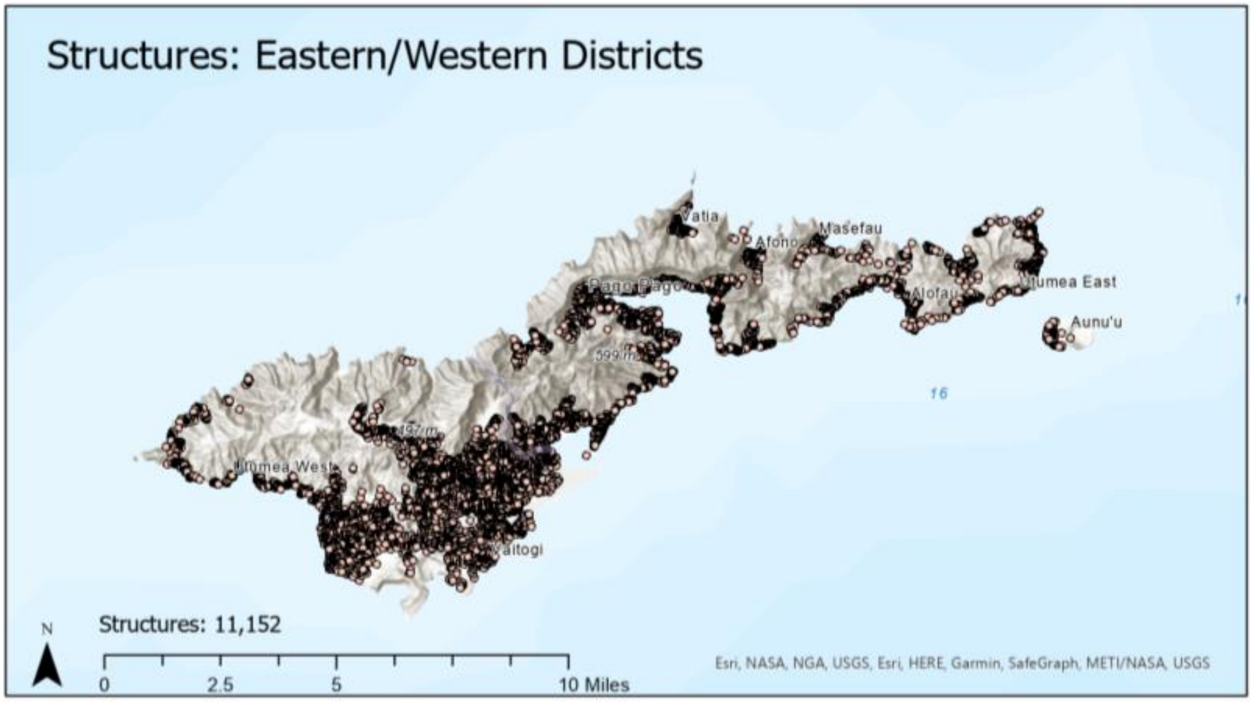


Figure 1-8: Easter/Western District Structures, Tutuila and Aunu'u. Source: [USACE 2021]

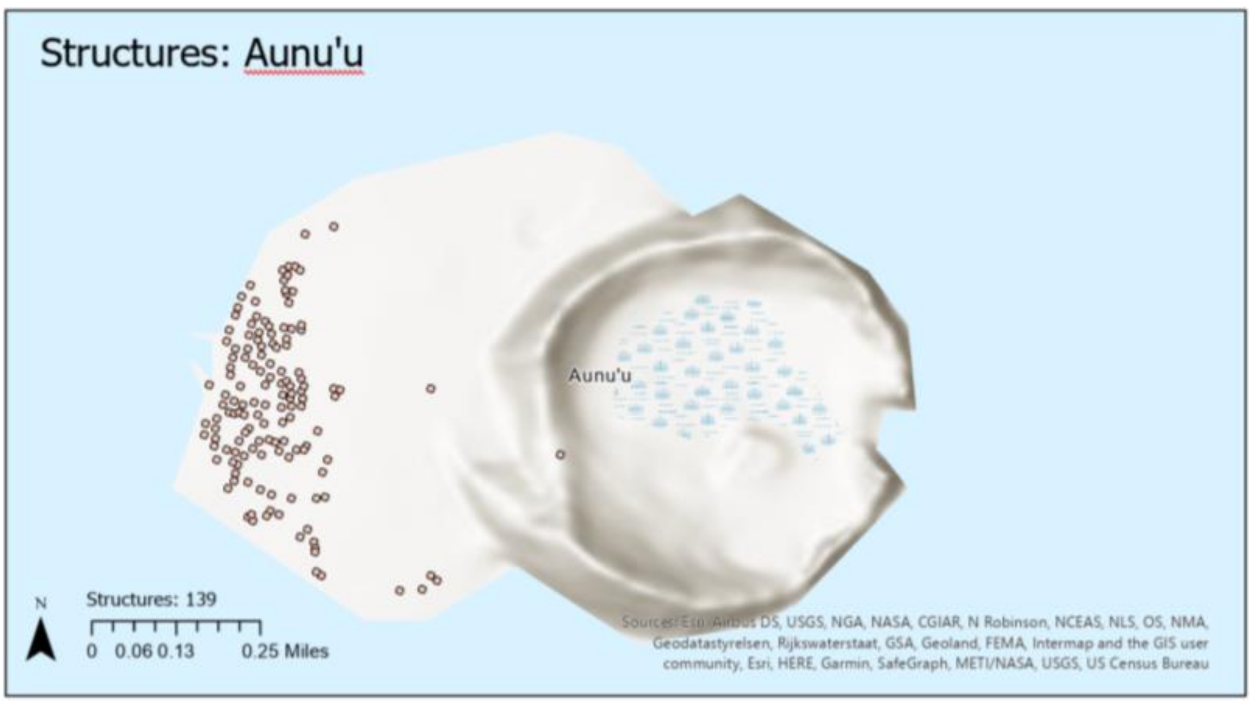


Figure 1-9: Eastern/Western Structures, focus: Aunu'u. Source: [USACE 2021]


Figure 1-10: Manu'a District Structures, Ofu and Olesega. Source: USACE 2021

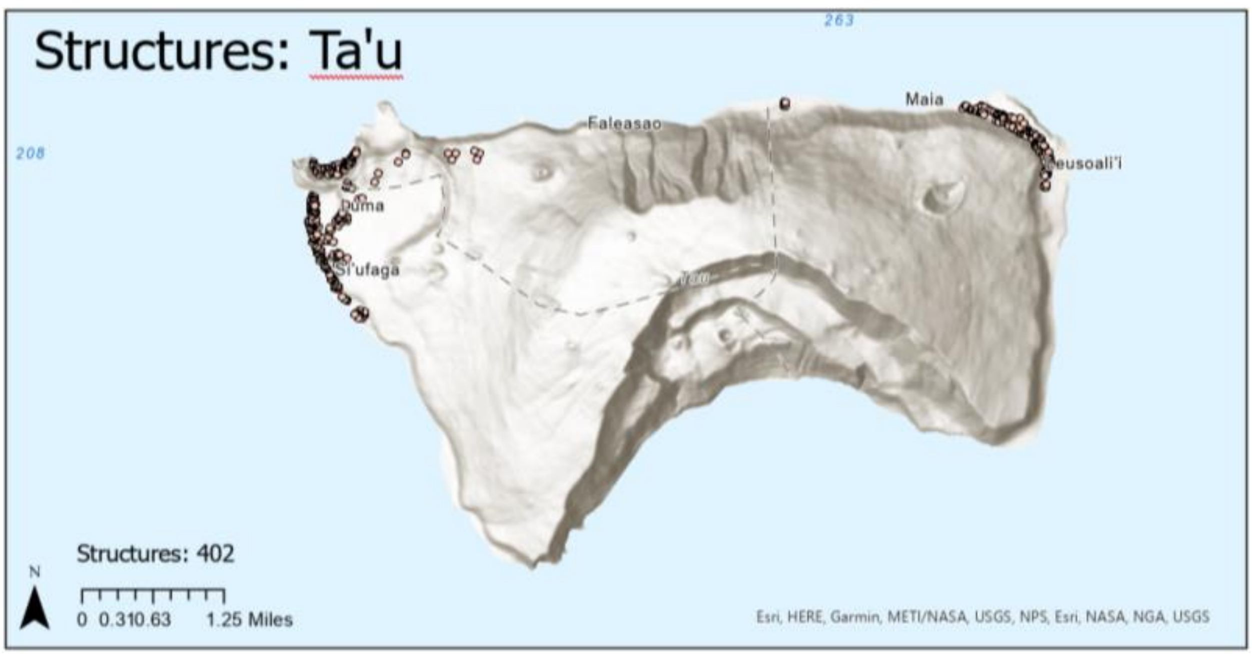


Figure 1-11: Manu'a District Structures, Ta'u. Source: USACE 2021

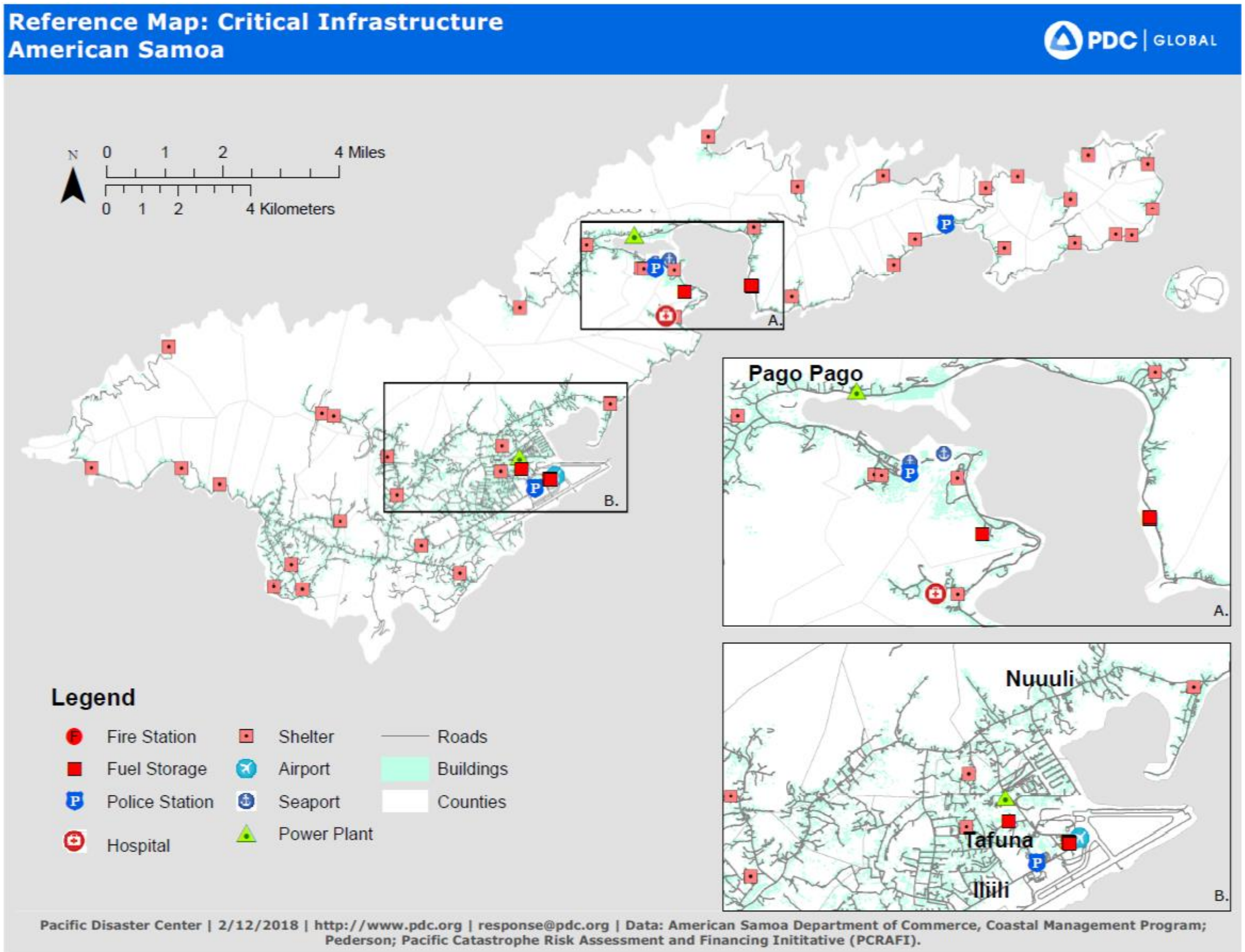


Figure 1-12: Tutuila Critical Infrastructure. Source: Pacific Disaster Center, 2018

### 1.3.2 Energy Infrastructure

American Samoa currently produces 97% of their electricity using diesel generation, with the remaining 3% being solar power generation. The diesel generation plants for Tutuila are located near the airport on the Tafuna plain, and on the northern coastline of Pago Pago harbor (Figure 1-12). Most of the solar generation is from the newly constructed Ta'u photovoltaic site, which supplies 100% of the island's generation and accounts for a total of 13% of the total generating capacity for the islands. However American Samoa only partially utilizes this capacity due to the photovoltaic site being on the island of Tau which has a small population and not having an effective method to transmit the generated solar power to Tutuila. Because of this, solar only accounts for 3% of the energy generation despite the additional capacity the photovoltaic site provides. The Ta'u site alone reduces American Samoa's dependency on imported diesel fuel by 100,00 gallons per year (EIA, 2022).

### 1.3.3 Healthcare Infrastructure

The Lyndon B. Johnson Medical Center is the sole hospital for American Samoa. Located in Faga'alu on Tutuila, the center was assessed by USACE in 2019 in response to Hurricane Gita. The USACE report found that the hospital was in a structural state of failure due to age, exposure, and lack of preventive maintenance. At the current rate of degradation, the hospital risks the ability to provide sufficient space to properly support long-term patient care and risks the denial of accreditation in the future. The construction of a new facility near the airport on Tutuila was proposed in 2016, however major concerns regarding the time which would be required for ambulances to reach the facility from the eastern villages was considered prohibitive. The 2019 USACE report concluded the best recommendation for the future would be to replace the existing facility, and to make interim repairs to deficient systems immediately (USACE, 2019).

# 2 LifeSim Model

The economic analysis for the Post-Disaster Watershed Assessments focused on direct, event-based impacts from flooding in an existing and future scenario with relative sea level change (RSLC) which accounts for localized changes in sea level. The USACE Institute of Water Resources, Risk Management Center's LifeSim 2.0.1 model (LifeSim) was the analytical tool used to estimate structure damages, road inundation, areas with population at risk of flooding (PAR), and exposed PAR. The main engineering and economic LifeSim inputs, along with the proposed methods, techniques, assumptions, and data underpinning those inputs, are described in the following sections.

The LifeSim Model for the Study Area generated snapshot outputs highlighting areas vulnerable to existing and future conditions and aided in the prioritization of measures to help identify and reduce future risk. LifeSim analyzed storm surge of existing and future conditions that incorporate RSLC based on the USACE RSLC curves.

### 2.1.1 Economic Uncertainty

The Watershed Assessment is meant to be a screening level analysis to broadly show the changes to economic damages and the estimated increase in PAR due to RSLC. Essentially, the goal is to show changes, and not exact results. Since the existing and future inventories and populations will be held constant, the change in damages and PAR can be attributed solely to RSLC.

Within the model all depth damage functions, and stability criteria utilized standard functions within the LifeSim model. All life safety and evacuation calculations such as warning issuance delay, first alert, and protective action initiation were selected from the built-in "unknown" options for maximum uncertainty. Under the guidance of subject matter experts, public warning issuance was set to be 96 hours prior to the storm event to ensure that identified risk does not capture the evacuation process itself, but the exposed population that remains during an event.

### 2.1.2 Analysis Years:

The analysis year for the existing condition will be defined as the current calendar year and year in which the modeling was initiated (2022). The future conditions analysis year will be 50 years after the existing condition year to account for the 50-year projections of RSLC in the H&H data. In a USACE feasibility analysis, the base year would be set as when measures are implemented. This would allow for comparison of alternatives. However, the purpose of this watershed study is to provide information as part of the post-disaster watershed assessment. Therefore, this analysis set the base year as 2022 since no alternatives were compared and it was the most recent year. As modeled, the existing condition year selected was 2022, and the future conditions year selected was 2071.

### 2.1.3 LifeSim Engineering Inputs

Engineering inputs were taken from NOAA storm surge Maximum Envelope of Water (MEOW) data for American Samoa. This is a composite product representing the maximum height of storm surge water in a given basin grid cell using hypothetical storms with the same attributes (NOAA).

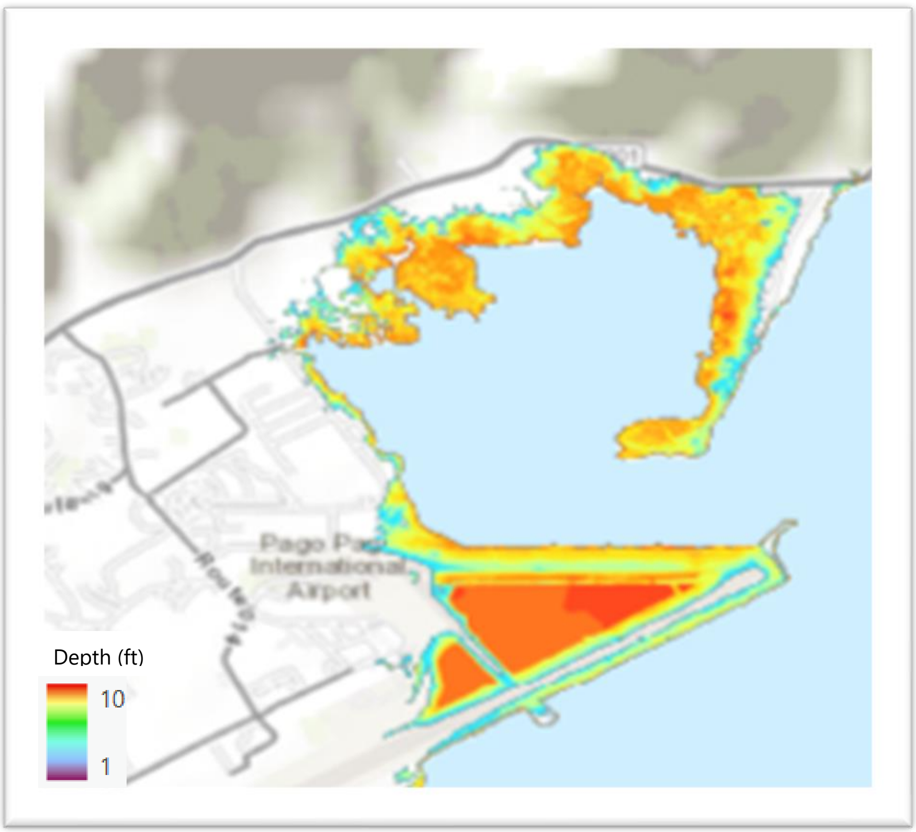


Figure 2-1: NOAA MEOW Inundation on Tutuila, American Samoa. Source: USACE 2021

For the Manu'a islands of American Samoa, FEMA 1% ACE Coastal Flood Maps were built by creating cross sections along the coastline every 50 feet from a mean sea level (MSL) zero point to the 1% ACE inundation boundary high point obtained from the digital elevation map (DEM). Values were then subtracted to produce depths.

### 2.1.4 Structure Inventory

There are currently no comprehensive structure inventories for the American Samoa that were able to be acquired for the purposes of this watershed study. For the purposes of the watershed assessment, the team developed a GIS-based generalized structure inventory. This process created standardized point shapefiles for use in LifeSim. Attributes were then populated based on the NSI2.0 structure inventory for Maui, HI. The Maui inventory was selected as the template for the watershed inventories based upon team judgement and conversations with PDT members familiar with American Samoa and other Pacific Islands.

#### 2.1.4.1 Generalized Inventory Construction

As stated previously, the NSI2.0 structure inventory attribute frequencies for Maui, HI were used to generate attributes for the structures of the watershed study structure inventory. Structure inventory data were randomly assigned to physical structure locations based on the values and distributions of the NSI2.0 of Maui, HI. This results in some structures, by randomness alone, being assigned attributes such as foundation height which could misrepresent the true risk to a particular structure. We recognize the limiting nature of the resulting data from this technique, however given the nature of the watershed study, and use of the LifeSim outputs as a planning guide and not for rigorous assessment of damages as a test for feasibility of alternatives or life loss for project evaluation, the level of accuracy from this generalized inventory was seen as appropriate to identify areas of potential risk and compare baseline existing values to future values.

Standard occupancy types used in the NSI2.0 were combined in some cases to reduce the number of calculations needed to generate attributes for the generalized inventories. Generally, occupancy types most similar were combined, such as all single-family occupancy types were combined into one occupancy type (RES1). This resulted in 16 Occupancy Types with specific distributions for generating the generalized inventory:

Table 2-1: Occupancy Type Distributions

| Occupancy Type | Distribution Within Inventory |
|---|---|
| **Single-family Dwelling (RES1)** | 48.22% |
| **Single-family Dwelling (RES1 (2 Story))** | 29.72% |
| **Multi-Family Dwelling 3-4 Units (RES3B)** | 1.06% |
| **Multi-Family Dwelling 20-49 Units (RES3E)** | 3.22% |
| **Retail Trade (COM1)** | 4.23% |
| **Wholesale Trade (COM2)** | 6.69% |
| **Hospital (COM6)** | 0.04% |
| **Medical Office/Clinic (COM7)** | 0.83% |

| Occupancy Type | Distribution Within Inventory |
|---|---|
| **Entertainment & Recreation (COM8)** | 2.03% |
| **Theaters (COM9)** | 0.03% |
| **Heavy Industry (IND1)** | 2.00% |
| **Agriculture (AGR1)** | 0.42% |
| **Religion (REL1)** | 0.65% |
| **General Services (GOV1)** | 0.45% |
| **Emergency Response (GOV2)** | 0.07% |
| **Schools/Libraries (EDU1)** | 0.32% |
| **Colleges/Universities (EDU2)** | 0.02% |

Once Occupancy Types were generated, the associated attributes selected for evaluation in LifeSim were also generated from the Maui NSI2.0 structure inventory distributions. The attributes generated are listed in the table below:

Table 2-2: Structure Inventory Generated Attributes

| Attribute | Label | Type of Calculation |
|---|---|---|
| **Foundation Type** | Found_Type | Randomly Generated from Maui NSI2.0 Distribution using @Risk assuming normal distribution |
| **Foundation Height** | Found_Ht | Randomly Generated from Maui NSI2.0 Distribution using @Risk assuming normal distribution |
| **Year Built** | YrBuilt | Randomly Generated from Maui NSI2.0 Distribution using @Risk assuming normal distribution |
| **Building Type (Construction Class)** | BldgType | Randomly Generated from Maui NSI2.0 Distribution using @Risk assuming normal distribution |
| **Number of Stories** | Num_Story | Randomly Generated from Maui NSI2.0 Distribution using @Risk assuming normal distribution |
| **Square Feet** | SqFt | Generated via the Excel random number generator and descriptive statistics of the attribute in the Maui NSI2.0 |
| **Structure Value** | Val_Struc | Generated via the Excel random number generator and descriptive statistics of the attribute in the Maui NSI2.0 |

| Attribute | Label | Type of Calculation |
|---|---|---|
| **Population (Day)** | Day_Pop | Calculated using Hazus formulas for population per square foot |
| **Population (Night)** | Night_Pop | Calculated using Hazus formulas for population per square foot |

Foundation type, foundation height, year built, building type, and number of stories were all randomly generated directly from the Maui NSI2.0 distributions of those attributes using @Risk software, assuming normal distributions. Summary statistics can be found in the following tables:

Table 2-3: Summary of Values for number of stories

| Type | Number of Stories | | | |
|---|---|---|---|---|
| | **Max** | **Min** | **Range** | **Average** |
| **SFR1** | 1 | 1 | 0 | 1 |
| **SFR2** | 3 | 2 | 1 | 2 |
| **MFR1** | 3 | 1 | 2 | 2 |
| **MFR2** | 36 | 1 | 35 | 2 |
| **COM1** | 13 | 1 | 12 | 1 |
| **COM2** | 51 | 1 | 50 | 1 |
| **HOS** | 1 | 1 | 0 | 1 |
| **MED** | 15 | 1 | 14 | 2 |
| **REST** | 35 | 1 | 34 | 2 |
| **COM9** | 4 | 1 | 3 | 2 |
| **IND1** | 5 | 1 | 4 | 1 |
| **AG** | 4 | 1 | 3 | 1 |
| **REL1** | 3 | 1 | 2 | 1 |
| **GOV1** | 15 | 1 | 14 | 2 |
| **GOV2** | 5 | 1 | 4 | 2 |
| **EDU1** | 9 | 1 | 8 | 1 |
| **EDU2** | 1 | 1 | 0 | 1 |

Table 2-4: Summary of Values for foundation height

| Type | Foundation Height | | | |
|---|---|---|---|---|
| | **Max** | **Min** | **Range** | **Average** |
| **SFR1** | 8 | 1 | 7 | 4 |
| **SFR2** | 8 | 1 | 7 | 4 |
| **MFR1** | 8 | 1 | 7 | 4 |
| **MFR2** | 8 | 1 | 7 | 5 |
| **COM1** | 8 | 1 | 7 | 4 |

| Type | Foundation Height | | | |
|---|---|---|---|---|
| **COM2** | 8 | 1 | 7 | 3 |
| **HOS** | 7 | 1 | 6 | 2 |
| **MED** | 8 | 1 | 7 | 3 |
| **REST** | 8 | 1 | 7 | 4 |
| **COM9** | 7 | 1 | 6 | 5 |
| **IND1** | 8 | 1 | 7 | 3 |
| **AG** | 8 | 1 | 7 | 3 |
| **REL1** | 8 | 1 | 7 | 3 |
| **GOV1** | 8 | 1 | 7 | 3 |
| **GOV2** | 7 | 1 | 6 | 3 |
| **EDU1** | 8 | 1 | 7 | 3 |
| **EDU2** | 1 | 1 | 0 | 1 |

Table 2-5: Summary of Values for year built

| Type | Year Built | | | |
|---|---|---|---|---|
| | **Max** | **Min** | **Range** | **Average** |
| **SFR1** | 2016 | 1858 | 158 | 1978 |
| **SFR2** | 2016 | 1905 | 111 | 1989 |
| **MFR1** | 2012 | 1920 | 92 | 1978 |
| **MFR2** | 2014 | 1920 | 94 | 1980 |
| **COM1** | 2015 | 1910 | 105 | 1978 |
| **COM2** | 2015 | 1910 | 105 | 1978 |
| **HOS** | 1997 | 1914 | 83 | 1970 |
| **MED** | 2015 | 1914 | 101 | 1978 |
| **REST** | 2015 | 1914 | 101 | 1978 |
| **COM9** | 1997 | 1914 | 83 | 1968 |
| **IND1** | 2015 | 1914 | 101 | 1977 |
| **AG** | 2015 | 1914 | 101 | 1977 |
| **REL1** | 2015 | 1914 | 101 | 1977 |
| **GOV1** | 2015 | 1914 | 101 | 1977 |
| **GOV2** | 2003 | 1914 | 89 | 1976 |
| **EDU1** | 2015 | 1914 | 101 | 1976 |
| **EDU2** | 1983 | 1914 | 69 | 1949 |

Table 2-6: Summary of Values for square feet of structure

| Type | Sq Ft | | | |
|---|---|---|---|---|
| | **Max** | **Min** | **Range** | **Average** |
| **SFR1** | 1,640 | 957 | 683 | 1,252 |
| **SFR2** | 4,132 | 1,729 | 2,403 | 2,639 |
| **MFR1** | 15,278 | 896 | 14,382 | 3,763 |
| **MFR2** | 226,142 | 388 | 225,754 | 12,237 |
| **COM1** | 198,613 | 62 | 198,552 | 6,227 |
| **COM2** | 112,866 | 14 | 112,852 | 2,663 |
| **HOS** | 33,514 | 10 | 33,504 | 9,195 |
| **MED** | 98,037 | 33 | 98,004 | 3,499 |
| **REST** | 308,076 | 79 | 307,997 | 8,818 |
| **COM9** | 11,909 | 316 | 11,593 | 5,431 |
| **IND1** | 196,353 | 14 | 196,338 | 3,809 |
| **AG** | 99,159 | 9 | 99,150 | 3,191 |
| **REL1** | 137,678 | 30 | 137,648 | 4,372 |
| **GOV1** | 147,592 | 23 | 147,570 | 4,875 |
| **GOV2** | 35,730 | 91 | 35,640 | 10,899 |
| **EDU1** | 307,146 | 31 | 307,115 | 11,360 |
| **EDU2** | 3,399 | 15 | 3,383 | 1,707 |

Table 2-7: Summary of Values for structure value

| Type | Structure Value | | | |
|---|---|---|---|---|
| | **Max** | **Min** | **Range** | **Average** |
| **SFR1** | $368,899 | $75,670 | $293,229 | $169,460 |
| **SFR2** | $849,873 | $163,769 | $686,104 | $368,445 |
| **MFR1** | $1,859,130 | $103,001 | $1,756,129 | $446,212 |
| **MFR2** | $59,016,145 | $39,157 | $58,976,988 | $2,251,576 |
| **COM1** | $22,006,367 | $6,852 | $21,999,515 | $690,750 |
| **COM2** | $19,189,364 | $2,298 | $19,187,065 | $444,532 |
| **HOS** | $11,483,798 | $3,257 | $11,480,541 | $3,150,907 |
| **MED** | $24,195,144 | $8,002 | $24,187,142 | $862,123 |
| **REST** | $71,442,507 | $18,156 | $71,424,351 | $2,035,680 |
| **COM9** | $2,040,293 | $54,097 | $1,986,196 | $930,512 |
| **IND1** | $25,274,244 | $1,503 | $25,272,741 | $461,829 |
| **AG** | $10,809,652 | $1,018 | $10,808,634 | $347,429 |
| **REL1** | $25,672,684 | $5,411 | $25,667,273 | $809,344 |
| **GOV1** | $20,603,664 | $3,182 | $20,600,482 | $681,969 |
| **GOV2** | $8,526,640 | $21,614 | $8,505,026 | $2,600,956 |

| | | | | |
|---|---|---|---|---|
| **EDU1** | $55,116,455 | $5,516 | $55,110,939 | $2,033,906 |
| **EDU2** | $672,397 | $3,030 | $669,367 | $337,713 |

# 3 Coastal Flooding Impacts Existing Scenario

To assist in the planning process, LifeSim 2.0.1 model was used to identify areas of risk within the coastal flooding areas under the Existing Scenarios. The generalized structure inventory developed for this study and NOAA MEOW Storm Surge depth grids were used to show rough order of magnitude impacts along the coast of Tutuila and Aunu'u. For the islands of Ofu, Olosega and Ta'u, less-detailed depth grids were created using elevations from the FEMA flood zone maps and are less accurate.

### 3.1.1 Vulnerability of Critical Facilities

The 2020 Hazard Mitigation Plan for American Samoa (HMP, 2020) identified 240 critical facilities on the island of Tutuila and 42 critical facilities on Ta'u with potential risk to coastal flooding under Existing Scenarios. The analysis of the HMP considered facilities to be potentially at risk if the facility was spatially located within FEMA coastal flood zones. The method of the HMP differs from the LifeSim modeling within this assessment by not considering additional criteria such as water surface elevations at the structures and foundation heights. To avoid miscommunicating potential risk posed to critical facilities, data from the HMP is used to describe risk to critical facilities in American Samoa.

## 3.2 Existing Scenario LifeSim Results

It is important to caveat the nature of the results in this analysis. Due to the broad assumptions made within the underlaying data such as the structure inventory and NOAA MEOW Storm Surge data which is a synthetic storm showing a possible worst-case scenario, all results must be viewed as very rough order of magnitude potential results and should not be taken as accurate depictions of real scenarios or used beyond a planning aid. Underlying structure inventory data were randomly assigned to physical structure locations based on the values and distributions of the NSI2.0 of Maui, HI. This results in some structures, by randomness alone, being assigned attributes such as foundation height which could misrepresent the true risk to that structure. Improvements to the structure inventory could be made via local surveys of structures, noting foundation height, occupancy type, age and building construction types. As technology continues to advance, it is likely that more areas will have recorded Google Street Views available, and possible virtual windshield surveys could produce more accurate values than were used in this modeling effort. Having these values more specifically defined for the area could improve the accuracy of the modeled results, as well as aid in future planning efforts.

Due to the inability of the model and input data to portray coastal dynamics of wave forces and severe velocities, the results of the LifeSim analysis are limited in the level of detail. In essence, the model will show what PAR, infrastructure, and depths of inundation at structures/locations that exist in the current and future scenarios. These results can be overlaid with other risk maps, such as landslides, and inland/flash flooding maps to highlight where compounding risks may occur today and in the future with RSLC.

### 3.2.1 Population at Risk and Inundation of Structures

Results for life safety risks carry the same caveat for rough order of magnitude accuracy and are meant to show areas of risk and the associated change in risk from 2021 to 2071, not necessarily specific values for risk. Due to the roughness of data, risk is primarily described as the population that is located within the inundation extents and could experience flooding, referred to as PAR. A more specific exposed PAR is the PAR that, according to the model, experiences actual flooding based on depth and location. Exposed PAR should be seen as an indication where risk is expected to be more than simply population that resides within the possible flooding extent. However, the level of uncertainty is high due to a lack of area specific data to inform nuances within the model. LifeSim results show areas with identified PAR and exposed PAR to coastal flooding on every island (locations listed in Table 3-1). Values for population and structures were held constant within the model framework across scenarios for three primary reasons: First, prior to the 2000 US Census, there was an increase in population within American Samoa, however 2010 and 2020 US Census shows a decline in population. Secondly, most of the land within American Samoa is customary land and communally owned and regulated by tribal leadership. Lastly the availability of developable land is scarce due to the naturally steep topography of the island.

Table 3-1, below shows the areas where PAR has been identified in the existing scenario as a baseline for comparison to the future scenario later in this appendix. Due to the limited availability of easily developable land apart from areas near the shoreline, it logically follows that many of the villages of American Samoa are shown to have PAR.

Table 3-1: Areas with identified population at risk to NOAA MEOW Storm Surge. Blank cells will be used later in this appendix for future risk scenario discussion. Source: USACE, 2021

| Island/Village | PAR – Existing | PAR - Future | Additional PAR in Future |
|---|---|---|---|
| **Aunuu** | | | |
| - Aunu'u | x | | |
| **Ofu and Olosega** | | | |
| - Ofu | x | | |
| - Olosega | x | | |
| **Ta'u** | | | |
| - Faleasao | x | | |
| - Luma | x | | |
| - Si'ufaga | x | | |
| **Tutuila** | | | |
| - Afono | x | | |
| - Alao | x | | |
| - Alofau | x | | |
| - Amanave | x | | |
| - Anua | x | | |
| - Aoa | x | | |
| - Aua | x | | |
| - Auma | x | | |
| - Auto | x | | |
| - Faga'alu | x | | |
| - Faga'itua | x | | |
| - Fagatogo | x | | |
| - Lauli'i | | | |
| - Leone | x | | |
| - Masefau | x | | |
| - Nu'uuli | x | | |
| - Pagai | x | | |
| - Pago Pago | x | | |
| - Tafuna | x | | |
| - Utulei | x | | |
| - Utumea East | x | | |
| - Vatia | x | | |

In the Existing Scenario for the islands, a total of 626 structures experienced inundation at an average depth of 2.4 feet with a maximum depth of 21.2 feet (Table 3-2). Table 3-2 shows rough order potential PAR for the islands as well as the number of structures that experience flooding and maximum depth.

Table 3-2: Risk to American Samoa structures under Existing Scenarios of the NOAA MEOW Storm Surge data. Source: [USACE, 2021]

| Island | Structures Inundated | Maximum Structure Depth (ft) |
|---|---|---|
| Aunu'u | 48 | 3.0 |
| Ofu & Olosega | 42 | 21.2 |
| Ta'u | 100 | 14.7 |
| Tutuila | 436 | 6.0 |
| All Islands | 626 | 21.2 |

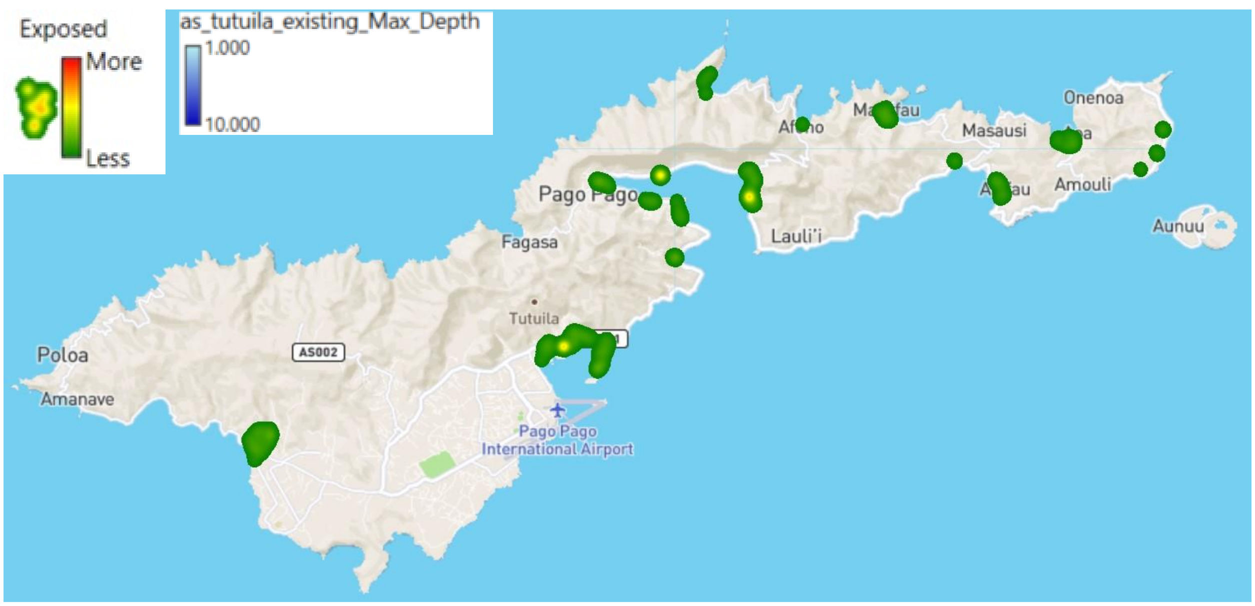


Figure 3-1: Heat map of areas with exposure of the PAR to flooding depths measured in feet for the island of Tutuila under the NOAA MEOW Storm Surge event. Source: [USACE, 2021]**.** Areas of more exposure appear as yellows and is due to higher concentration of people living or working within areas vulnerable to coastal flooding and storm surge.

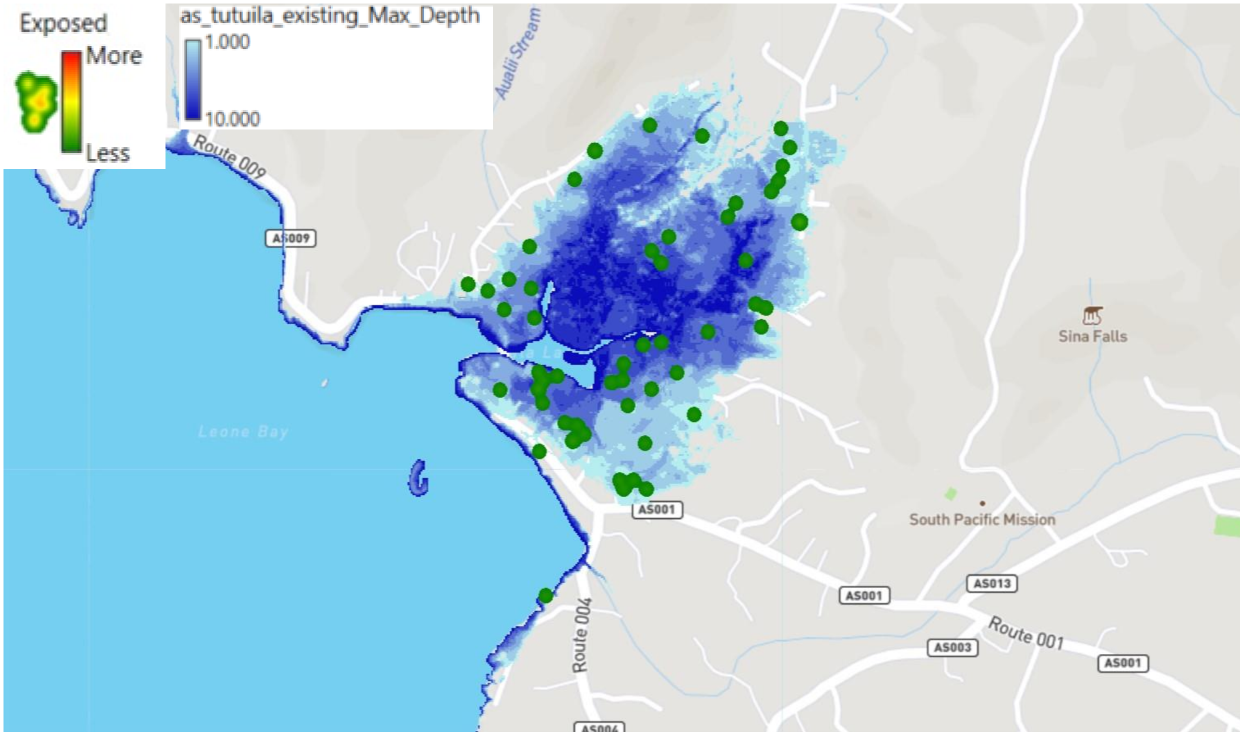


Figure 3-2: Exposed PAR to flooding depths measured in feet in the area near Pala Lagoon on the western edges of the Tafuna-Leone Plain. Source: USACE, 2021. The presence of only green shading at this scale indicates many individual residential structures are exposed to flood depths between 1 and 10 feet.


Figure 3-3: Exposed PAR to flooding depths measured in feet near Pago Pago Harbor. The StarKist tuna factory (shown as exposed PAR closest to Atu'u) is especially vulnerable due to the potential for hundreds of workers that could be present during a flood hazard.

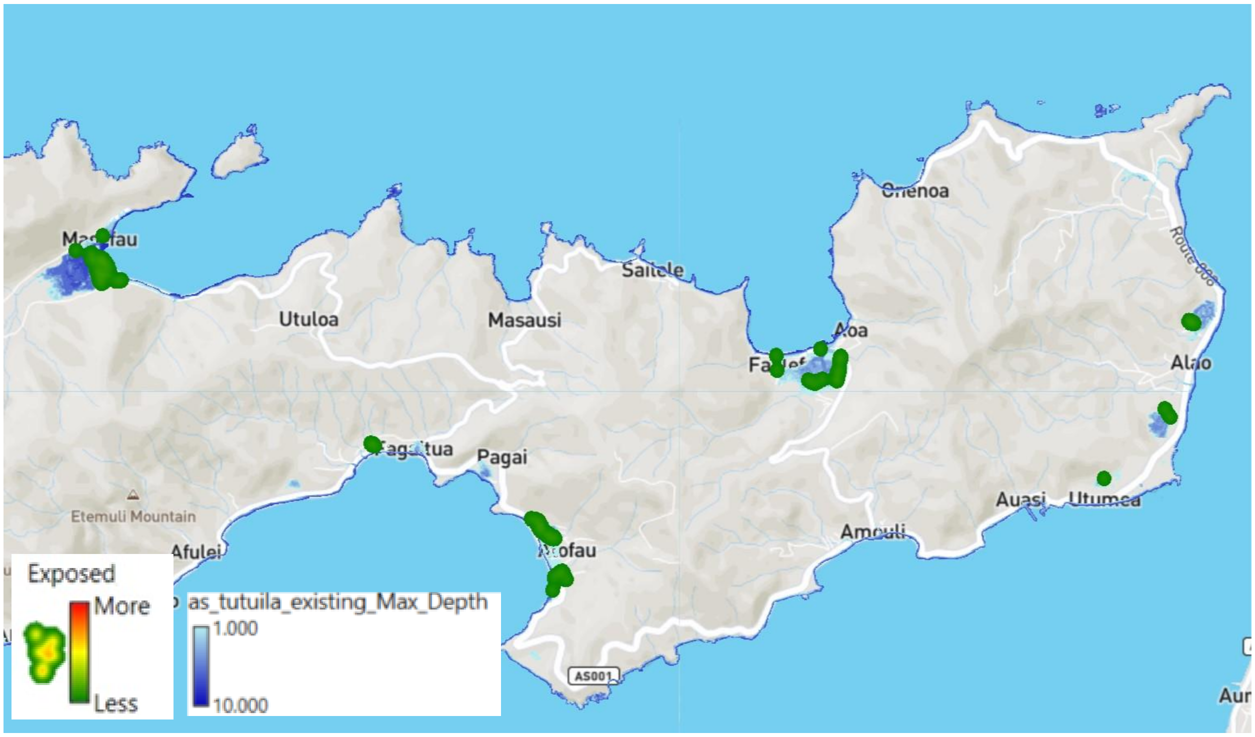


Figure 3-4: Exposed PAR to flooding depths measured in feet in the Eastern District of Tutuila. Although less vulnerable overall than the Western District, the Eastern district is vulnerable to being isolated from emergency services and evacuation due to the susceptibility of flooding of Route 1, which is the only road connecting the Eastern District to the LBJ medical center and the Airport.

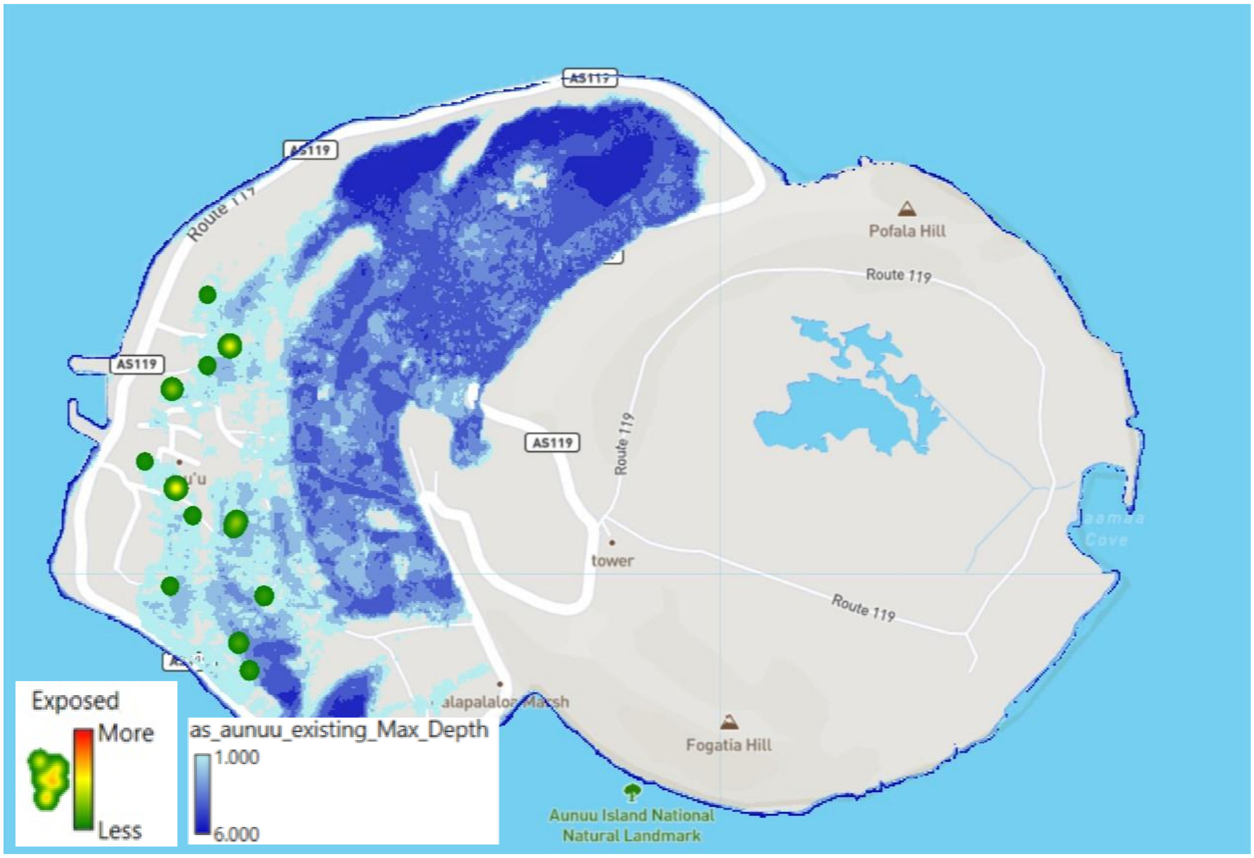


Figure 3-5: Heat map of areas with exposed PAR to flooding depths measured in feet on the island of Aunu'u under the NOAA MEOW Storm Surge event. Source: USACE, 2021. Yellow shading indicates concentrations of exposed PAR, such as buildings in which many people work or live.


Figure 3-6: Heat map of areas with exposed PAR to flooding depths measured in feet on the islands of Ofu and Olosega under the NOAA MEOW Storm Surge event. Source: USACE, 2021. Shading into the yellows and reds indicates concentrations of exposed PAR due to development near the coast and at lower elevations above sea level. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies.

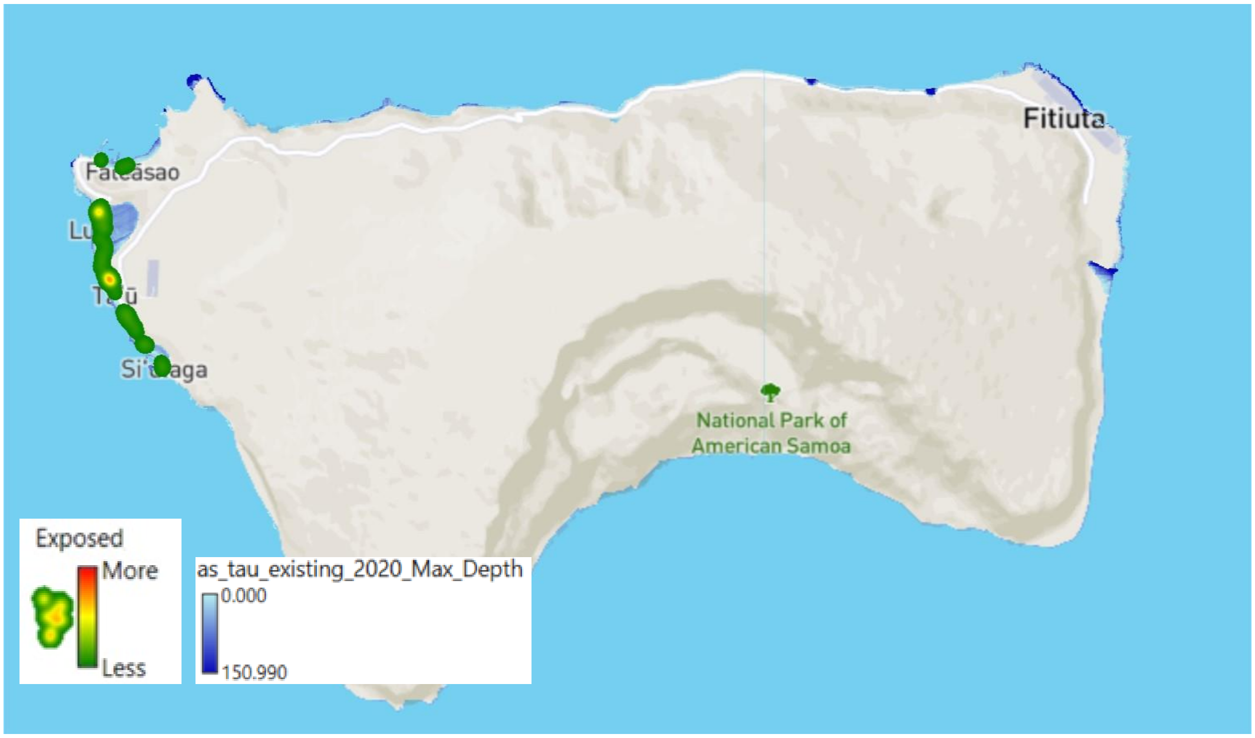


Figure 3-7: Heat map of areas with exposed PAR to flooding depths measured in feet on the island of Ta'u under the NOAA MEOW Storm Surge event. Source: USACE, 2021. Shading into the yellows and reds indicates concentrations of exposed PAR due to development near the coast and at lower elevations above sea level. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies.

### 3.2.2 Exposed Road Infrastructure

Due to the terrain constraints and limited space for construction, roads on the islands are built very close to the coastline and are highly exposed to coastal inundation. Route 1 is highly exposed and is an especially important thoroughfare for the island of Tutuila as it connects the eastern and western villages to critical facilities such as the LBJ Tropical Medical Center. Route 20 on Ofu and Olosega is the only road that connects the eastern island of Olosega to the island of Ofu which is the location of the small harbor and airport which are the primary transportation hubs to Tutuila and Ta'u. Similarly, on Ta'u a single road which hugs the coastline connects the eastern and western villages.

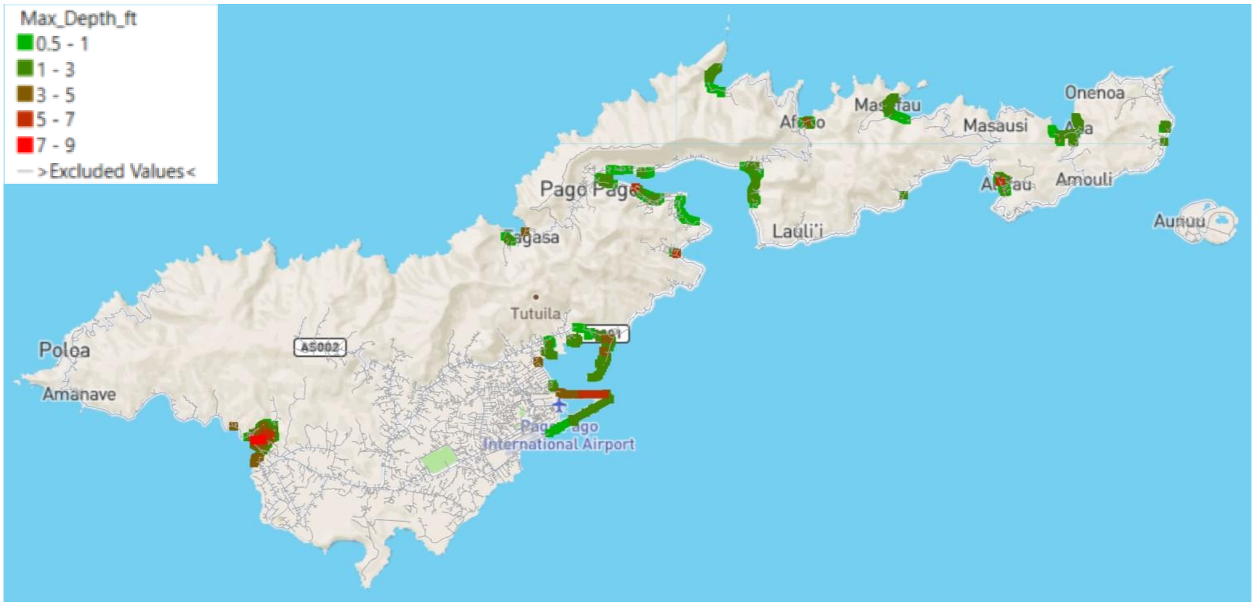


Figure 3-8: Map of Existing Scenario inundation hazard on Tutuila roads under the NOAA MEOW Storm Surge event. Source: USACE, 2021. Greater depths of inundation appear as reds, while shallower depths over roads appear as green.

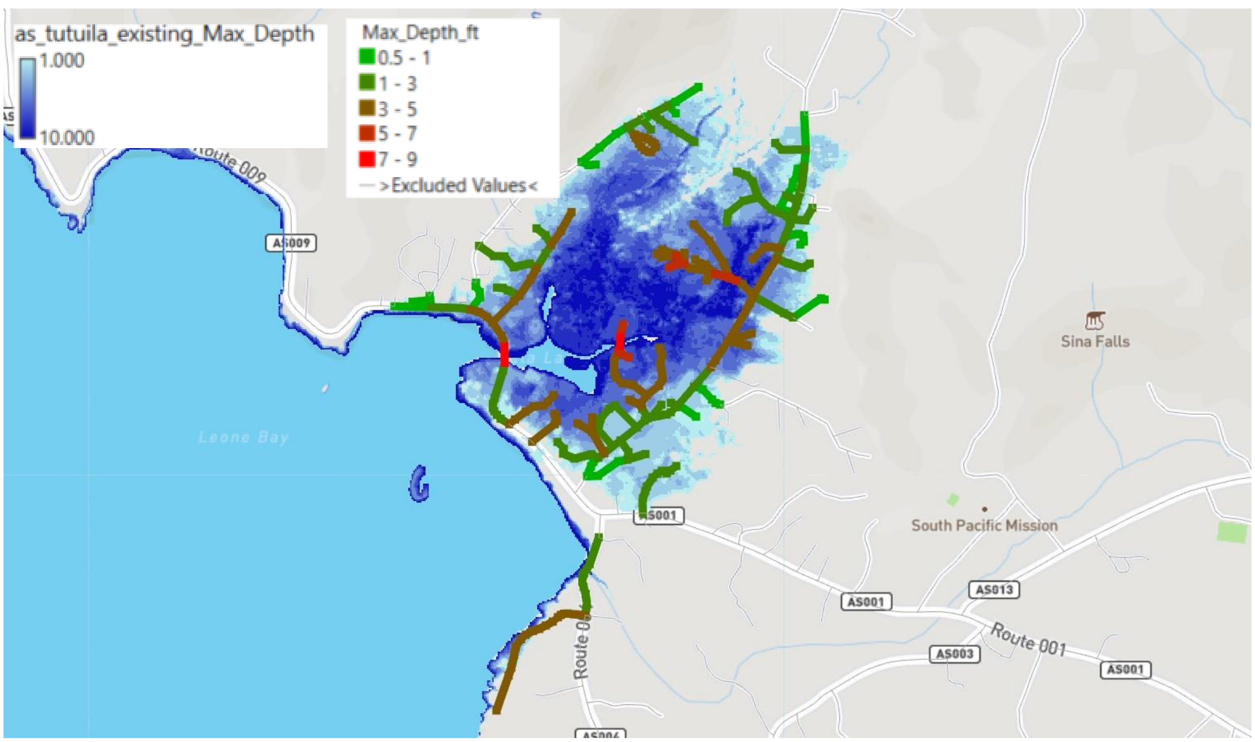


Figure 3-9: Map of Existing Scenario inundation hazard on roads under the NOAA MEOW Storm Surge event located in Leone near Pala Lagoon on the island of Tutuila. Source: [USACE, 2021](). Greater depths of inundation appear as reds, while shallower depths over roads appear as green. This image

highlights the possibility for roads to become inundated to a depth that could prevent passenger vehicles from reaching shelter locations in the Tafuna Plain.

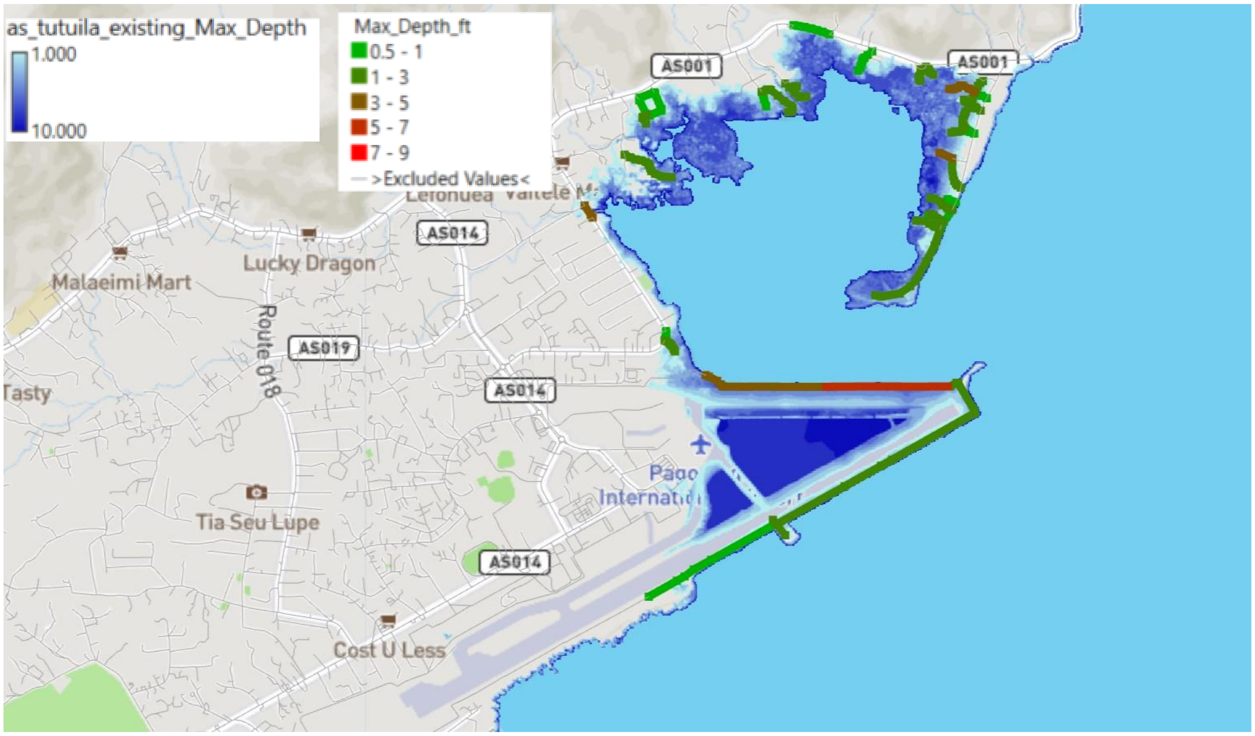


Figure 3-10: Map of Existing Scenario inundation hazard on roads under the NOAA MEOW Storm Surge event located in Nu'uuli on the island of Tutuila. Source: USACE, 2021. This image highlights how Route 1 can be exposed to coastal flooding and prevent transportation from the eastern areas to the Tafuna Plain, or from the western areas to critical facilities such as the hospital.

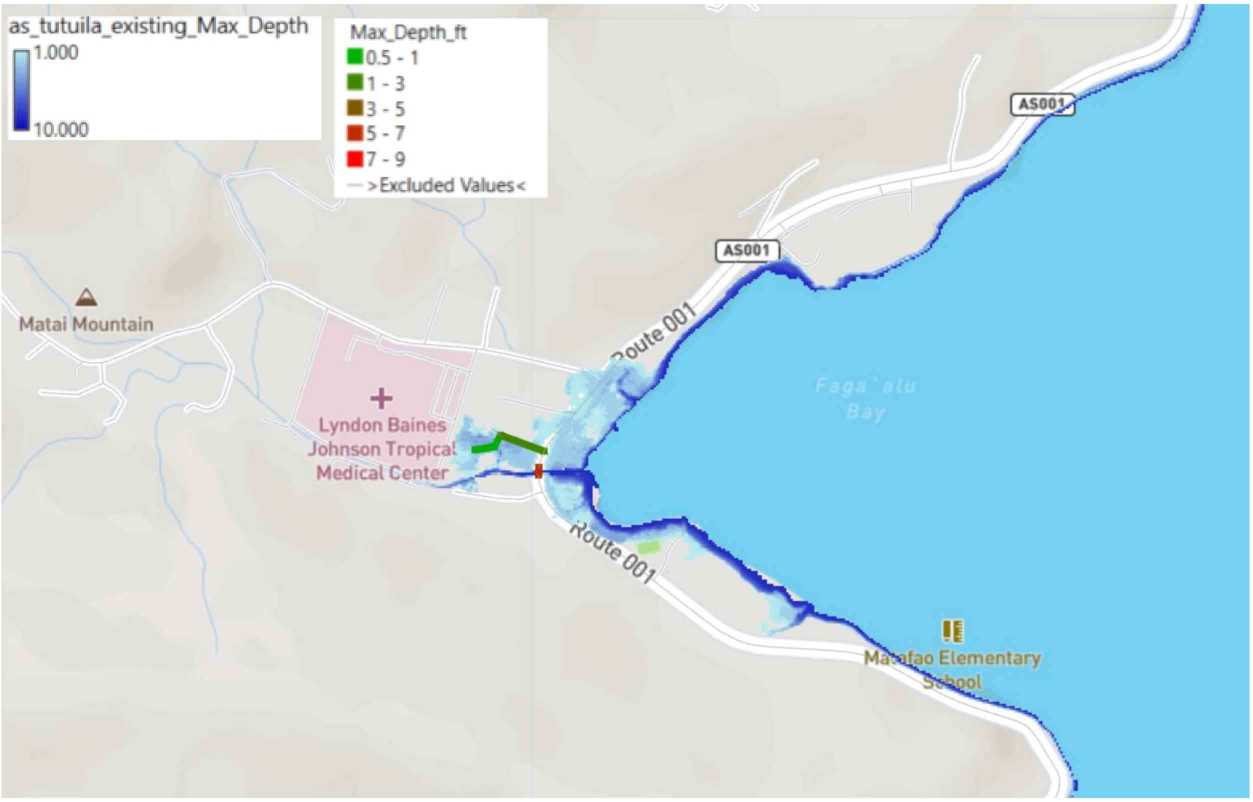


Figure 3-11: Map of Existing Scenario inundation hazard on roads under the NOAA MEOW Storm Surge event at the LBJ Tropical Medical Center centrally located on the island of Tutuila. The LBJ Tropical Medical Center is the only hospital in American Samoa, and the only vehicle route is via Route 1. Source: USACE, 2021


Figure 3-12: Map of Existing Scenario inundation hazard on roads near Pago Pago on the island of Tutuila under the existing NOAA MEOW Storm Surge event at Pago Pago, further showing the vulnerability of Route 1. Source: USACE, 2021

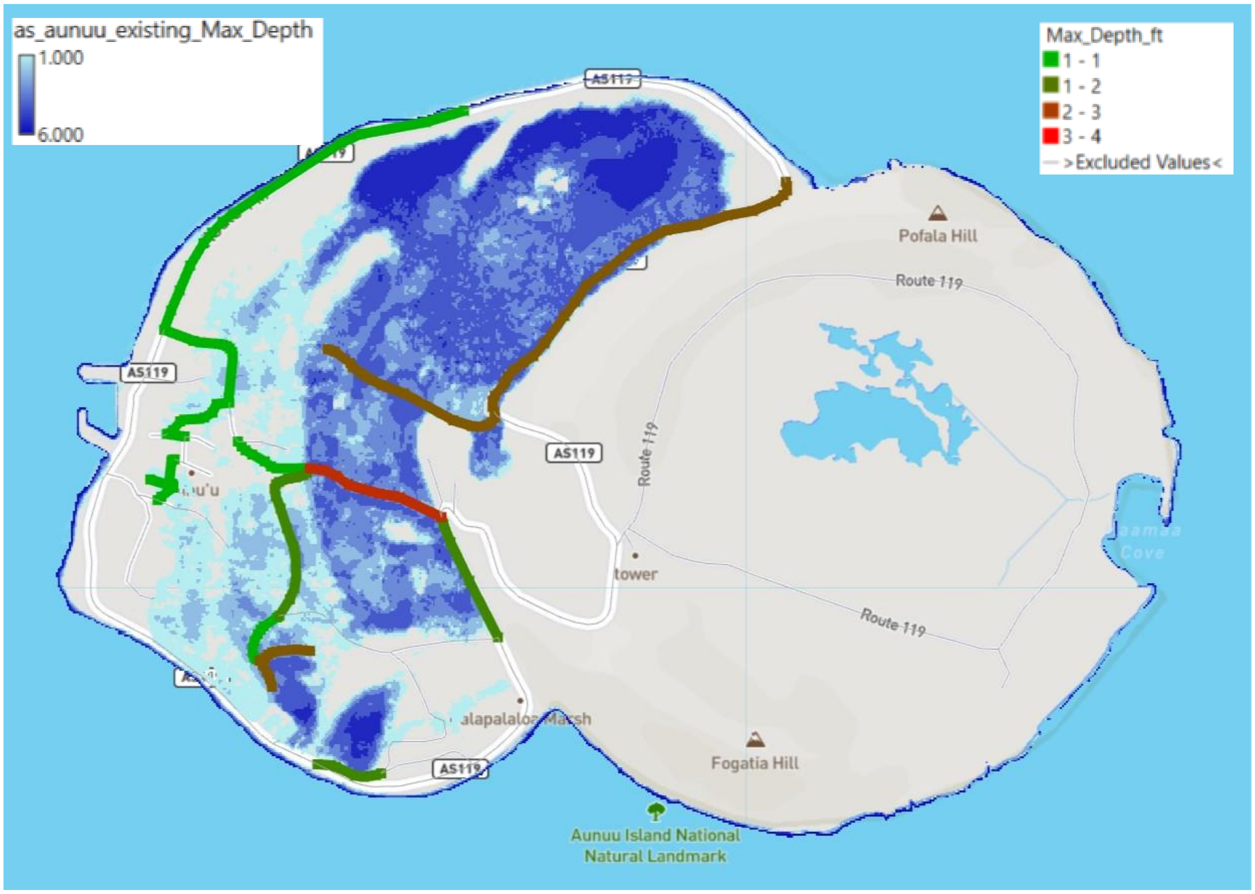


Figure 3-13: Map of risk on roads on the island of Aunu'u under the existing NOAA MEOW Storm Surge event. Source: USACE, 2021. Flooding on Aunu'u roads reaches depths of 2-3 feet, and risks cutting PAR off from off island evacuation, or from reaching higher ground at the eastern area of the island.


Figure 3-14: Map of risk on roads on the islands of Ofu and Olosega under the existing NOAA MEOW Storm Surge event. Source: USACE, 2021. Inundation along the roads on Ofu and Olosega has the potential to isolate PAR and prevent off-island evacuation due to depths of over 3 feet on the roads between the islands and between villages.

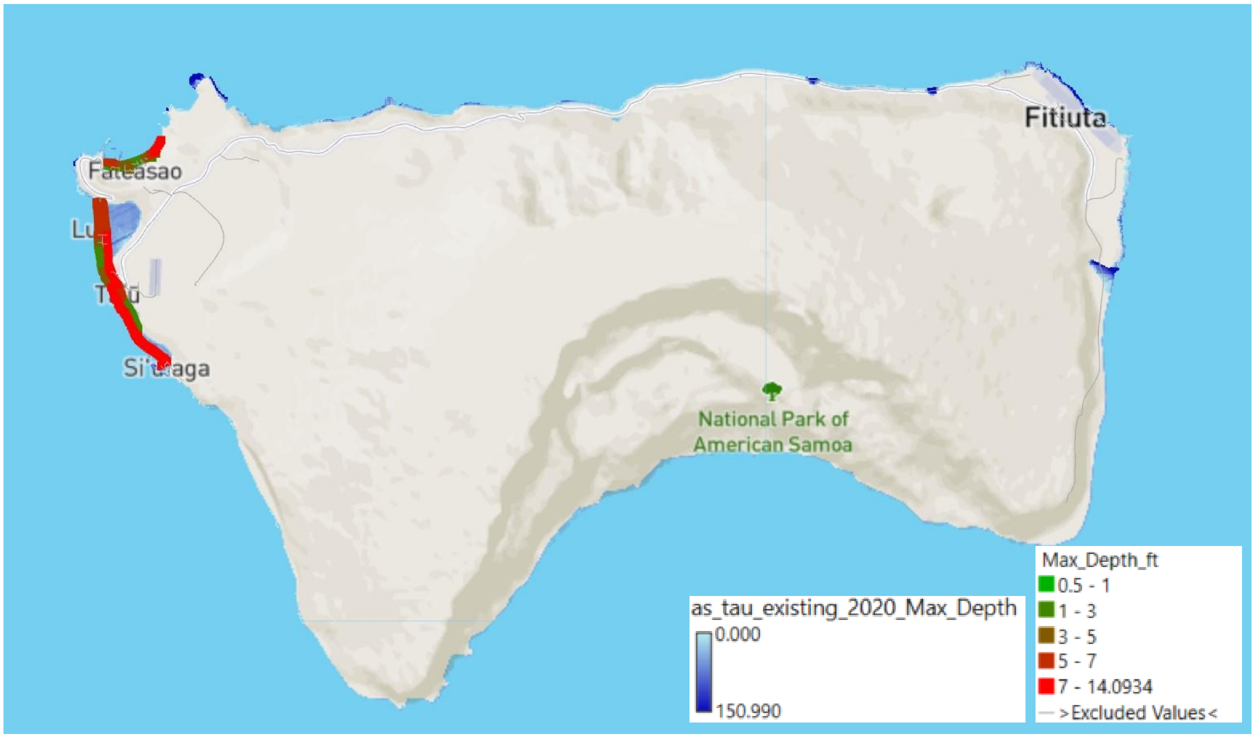


Figure 3-15: Map of risk on roads on the island of Ta'u under the existing NOAA MEOW Storm Surge event. Source: USACE, 2021. Flooding along the roads at depths of over 7 feet can prevent movement and reaching the harbor for off-island evacuations.

# 4 Coastal Flooding Impacts, Future Scenario

To assist in the planning process, the LifeSim model was used to identify areas of risk within the coastal flooding areas under the Future Scenario which adds RSLC to surge elevations based on the USACE RSLC high curve. The same generalized structure inventory was used in both the Existing and Future Scenario to highlight the risk and vulnerability to the impacts of RSLC. All changes in impacts from the Existing Scenario to the Future Scenario are attributable to the difference in RSLC on water surface elevations. Again, estimates are rough-order of magnitude and should not be used for feasibility level of analysis or damage forecasts. The focus of interest is the changes that occur from the existing to future Scenario. These changes, such as additional structures inundated, or additional PAR are the basis for identifying the vulnerability of American Samoa to storm surge inundation depths increasing due to RSLC.

### 4.1.1 Future Scenario LifeSim Results

Figure 4-1 below shows the heat map of risk areas for the islands of Tutuila and Aunu'u under the MEOW Storm Surge event with RSLC.

Table 4-1 below continues from Table 3-1 with the additional results from the future scenario with RSLC. The one new area is shown to have risk that was not in the existing scenario was the village of Lauli'I on the island of Tutuila. As seen in the table below, many of the villages that have PAR in the existing scenario see an increase in PAR moving towards the future scenario. Overall, there was a PAR increase of 6% from the existing scenario, with the largest individual area increases occurring in the villages of Olosega (+81%), Pagai (+78%), and Aoa (+71%).

#### 4.1.2 Future Scenario Population at Risk

Table 4-1: Areas and PAR vulnerable to RSLC in the future. Source: USACE, 2021

| Island/Village | PAR - Existing | PAR - Future | Additional PAR in Future |
|---|---|---|---|
| **Aunuu** | | | |
| - Aunu'u | x | x | +11% |
| **Ofu and Olosega** | | | |
| - Ofu | x | x | +1% |
| - Olosega | x | x | +81% |
| **Ta'u** | | | |
| - Faleasao | x | x | |
| - Luma | x | x | |
| - Si'ufaga | x | x | |
| **Tutuila** | | | |
| - Afono | x | x | |
| - Alao | x | x | |
| - Alofau | x | x | +54% |
| - Amanave | x | x | |
| - Anua | x | x | |
| - Aoa | x | x | +71% |
| - Aua | x | x | +1% |
| - Auma | x | x | |
| - Auto | x | x | +50% |
| - Faga'alu | x | x | +10% |
| - Faga'itua | x | x | +29% |
| - Fagatogo | x | x | +14% |
| - Lauli'i | | x | New PAR due to RSLC |
| - Leone | x | x | |
| - Masefau | x | x | +8% |
| - Nu'uuli | x | x | |
| - Pagai | x | x | +78% |

| Island/Village | PAR - Existing | PAR - Future | Additional PAR in Future |
|---|---|---|---|
| - Pago Pago | x | x | +5% |
| - Tafuna | x | x | |
| - Utulei | x | x | |
| - Utumea East | x | x | |
| - Vatia | x | x | +17% |
| **All Villages** | | | +6% Overall Increase |

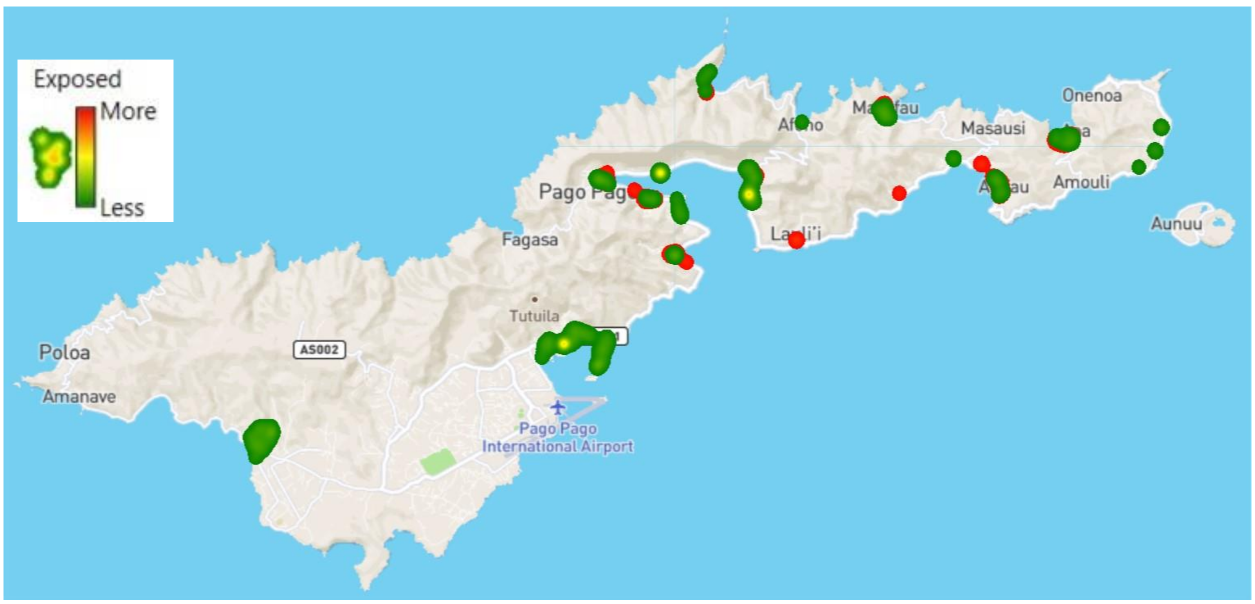


Figure 4-1: Heat map of risk areas for the islands of Tutuila under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC . Source: [USACE, 2021]

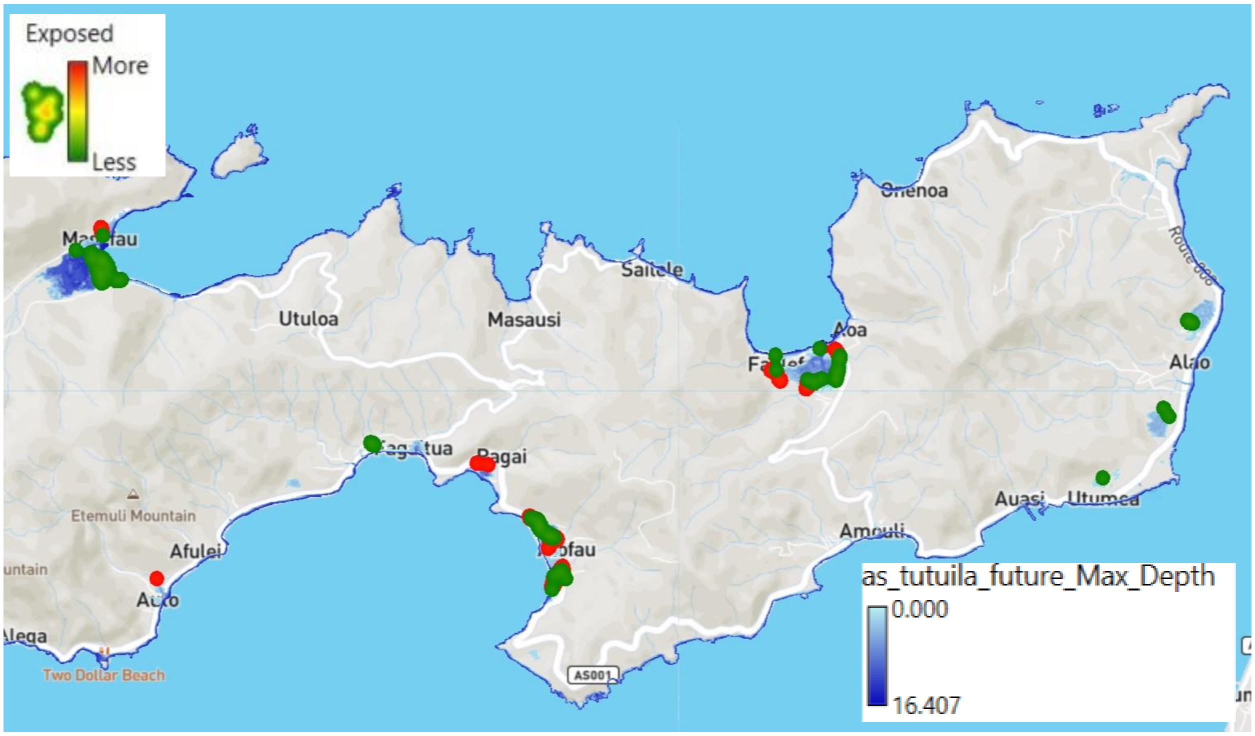


Figure 4-2: Heat map of exposed PAR in the eastern villages of Tutuila under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Source: [USACE, 2021]

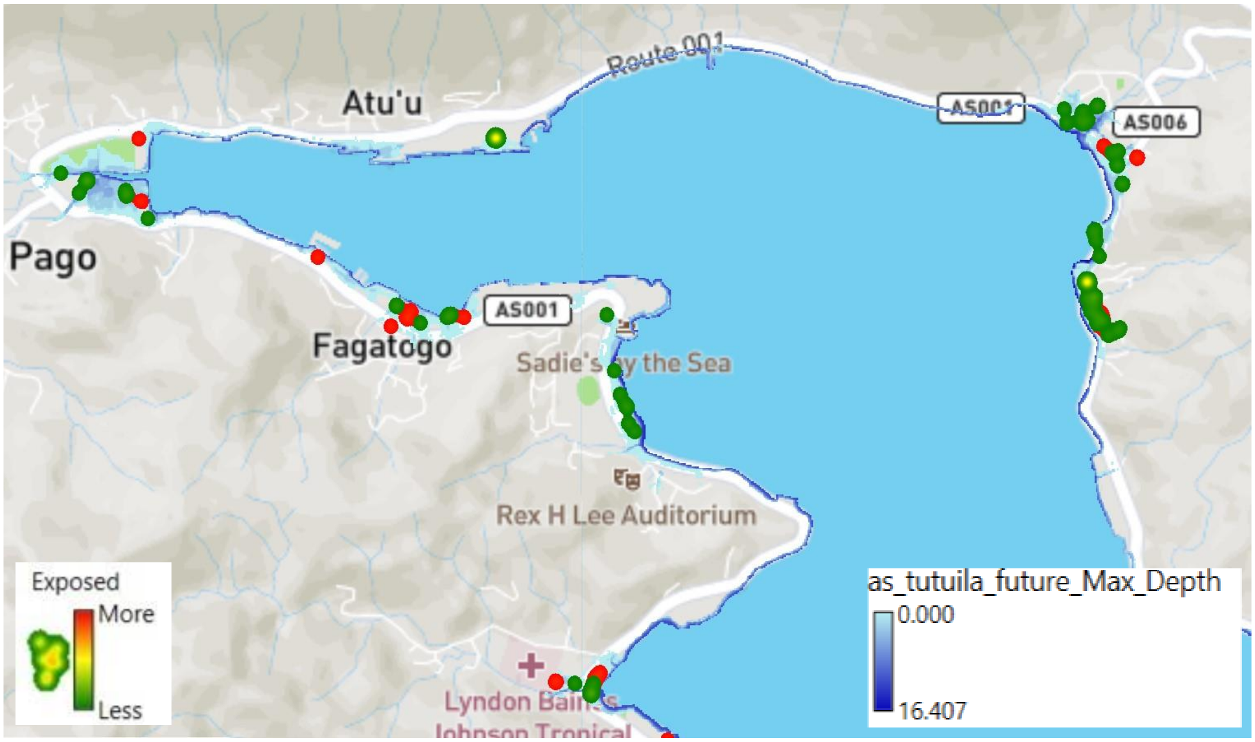


Figure 4-3: Heat map of exposed PAR near Pago Pago under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Source: [USACE, 2021](#)

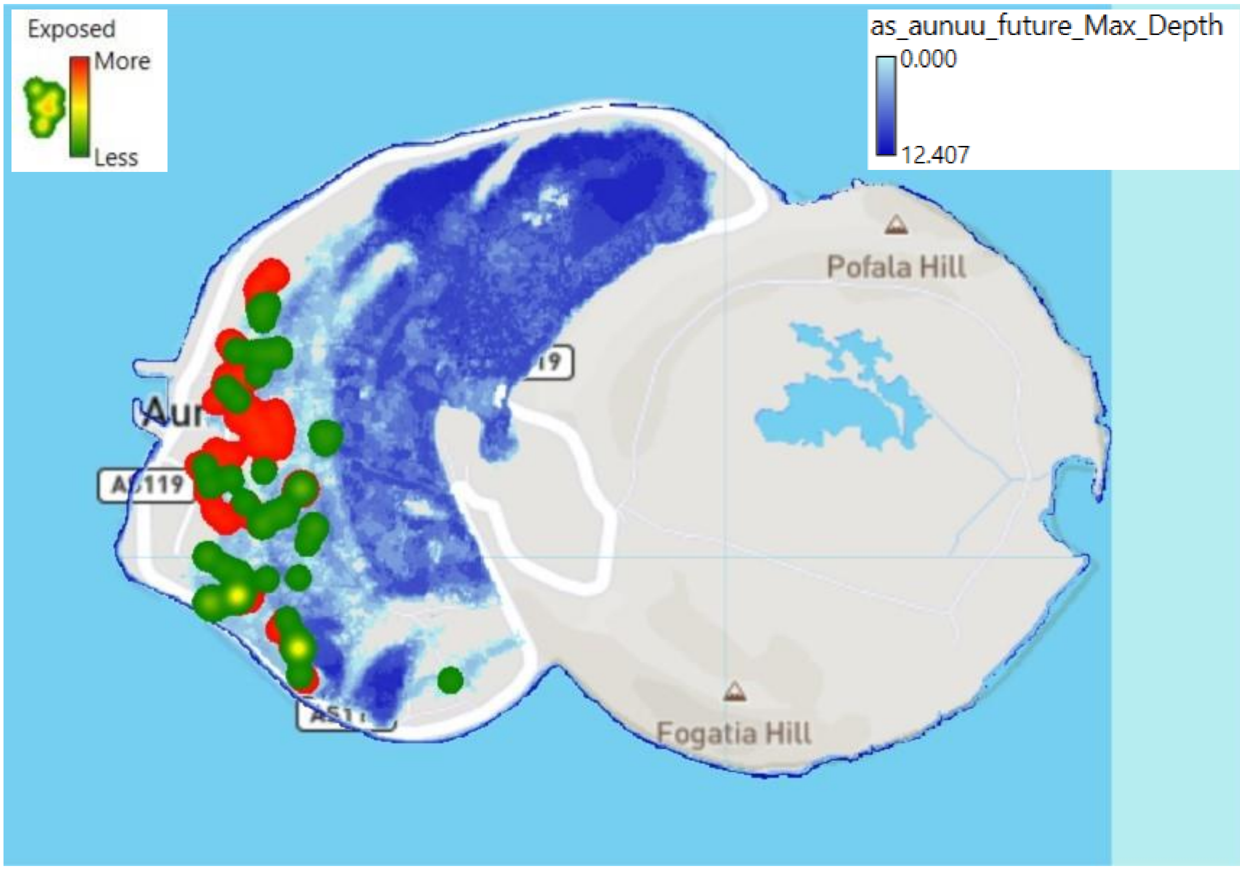


Figure 4-4: Heat map of exposed PAR on the island of Aunu'u under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Source: [USACE, 2021]

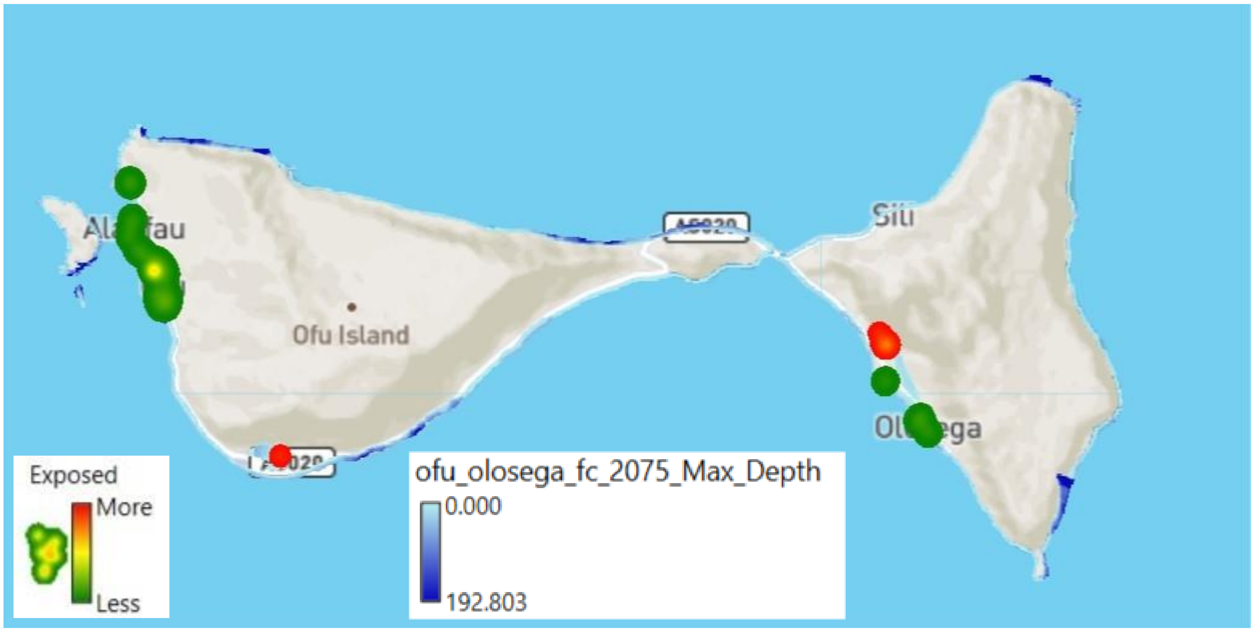


Figure 4-5: Heat map of exposed PAR on the islands of Ofu and Olosega under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies. Source: USACE, 2021

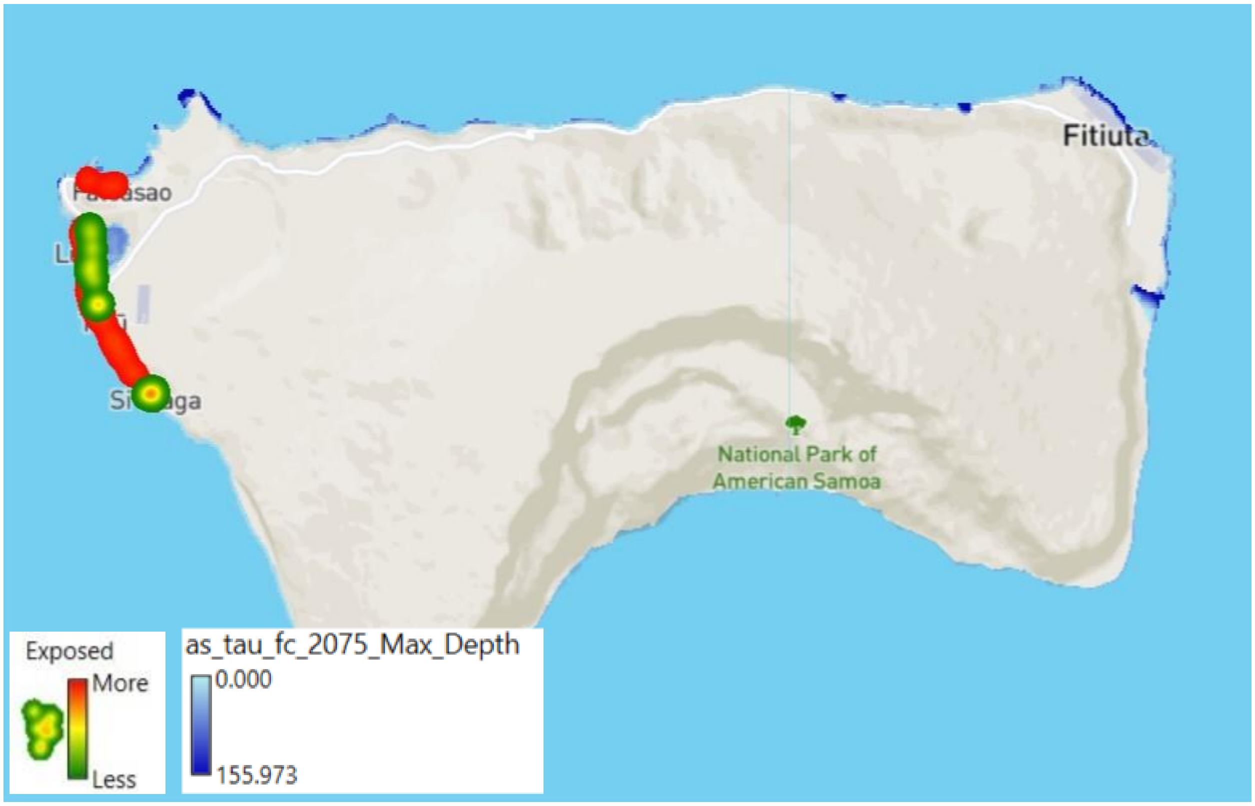


Figure 4-6: Heat map of exposed PAR on the island of Ta'u under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies. Source: USACE, 2021

### 4.1.3 Exposed Road Infrastructure Future Scenarios

As stated previously, roads in American Samoa are highly exposed to coastal flooding and inundation. Given the bathtub nature of the Future Scenario inundation, all previous depths impacting the road network continue to exist in the Future Scenario, with additional areas of inundation due to the expanded MEOW attributable to the impacts of RSLC. Additional analysis of impacts of the road network due to coastal erosion can be found in Appendix C - Engineering Analysis.

An important risk from flooding on roads in American Samoa is that once a main route is inundated such as Route 001 in Pago Pago, essentially all vehicle traffic from the eastern half of Tutuila would be unable to reach the only hospital on the island. Similarly, for Route 009 near Pala Lagoon, all traffic from Poloa and the westernmost villages would be severely limited.

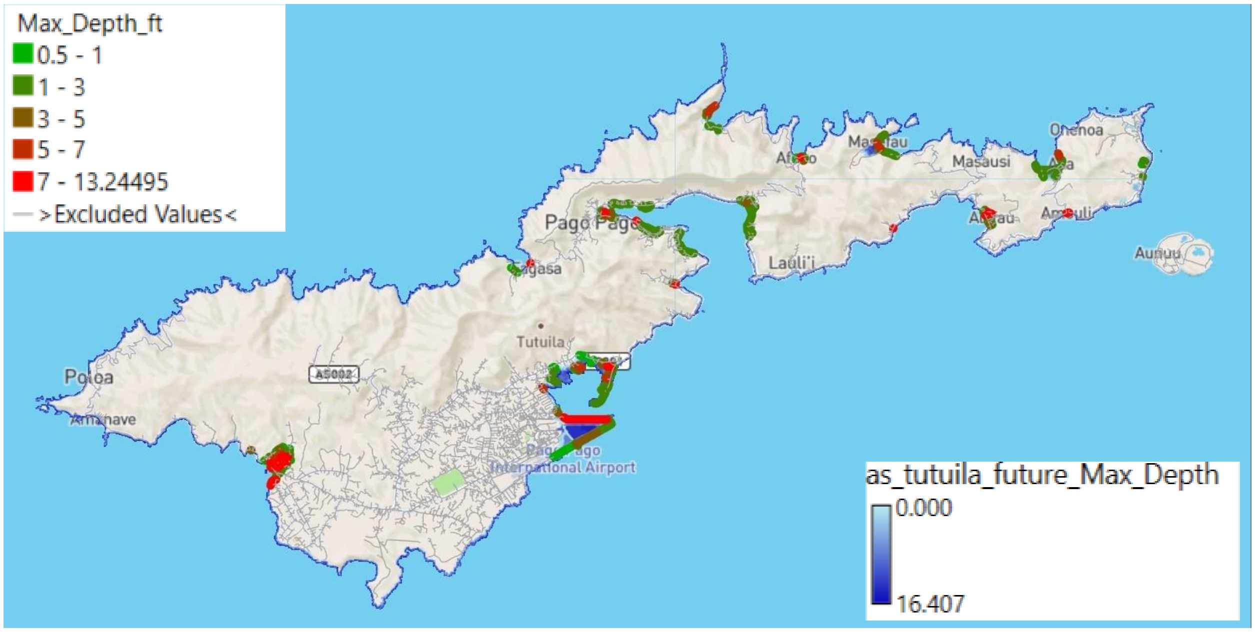


Figure 4-7: Map of risk on Tutuila roads under the future MEOW Storm Surge scenario with RSLC. Source: USACE, 2021

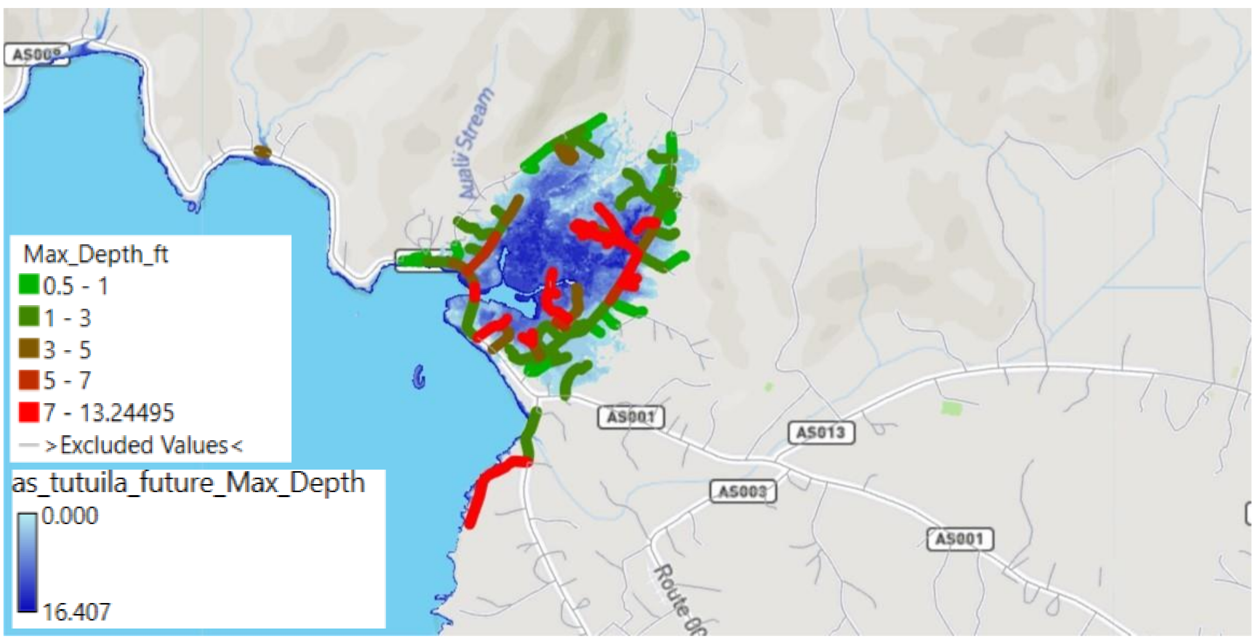


Figure 4-8: Map of Future Scenario inundation hazard on roads under the MEOW Storm Surge event located in Leone near Pala Lagoon on the island of Tutuila. This location is critical since Route 009 is the only road connecting the westernmost areas of Tutuila to the Tafuna-Leone plains, and the LBJ Tropical Medical Center. Source: **USACE, 2021.**

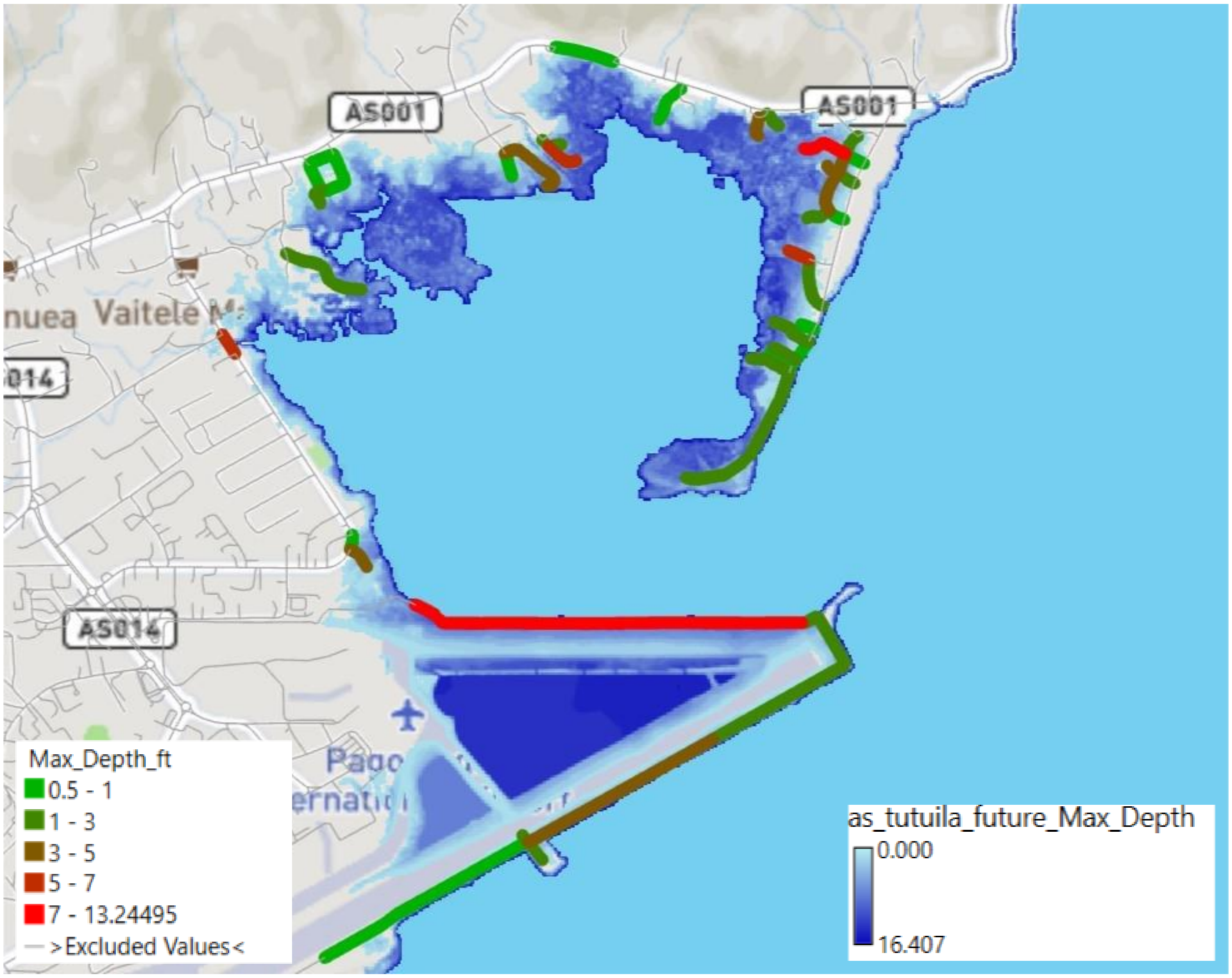


Figure 4-9: Map of risk on roads under the future MEOW Storm Surge scenario with RSLC in the Nu'uuli area. This area is critical due to Route 001 being the only vehicle path between the eastern and western districts. Should this location of Route 001 become severely inundated, vehicle access to the LBJ Tropical Medical Center will be extremely limited. Source: USACE, 2021.

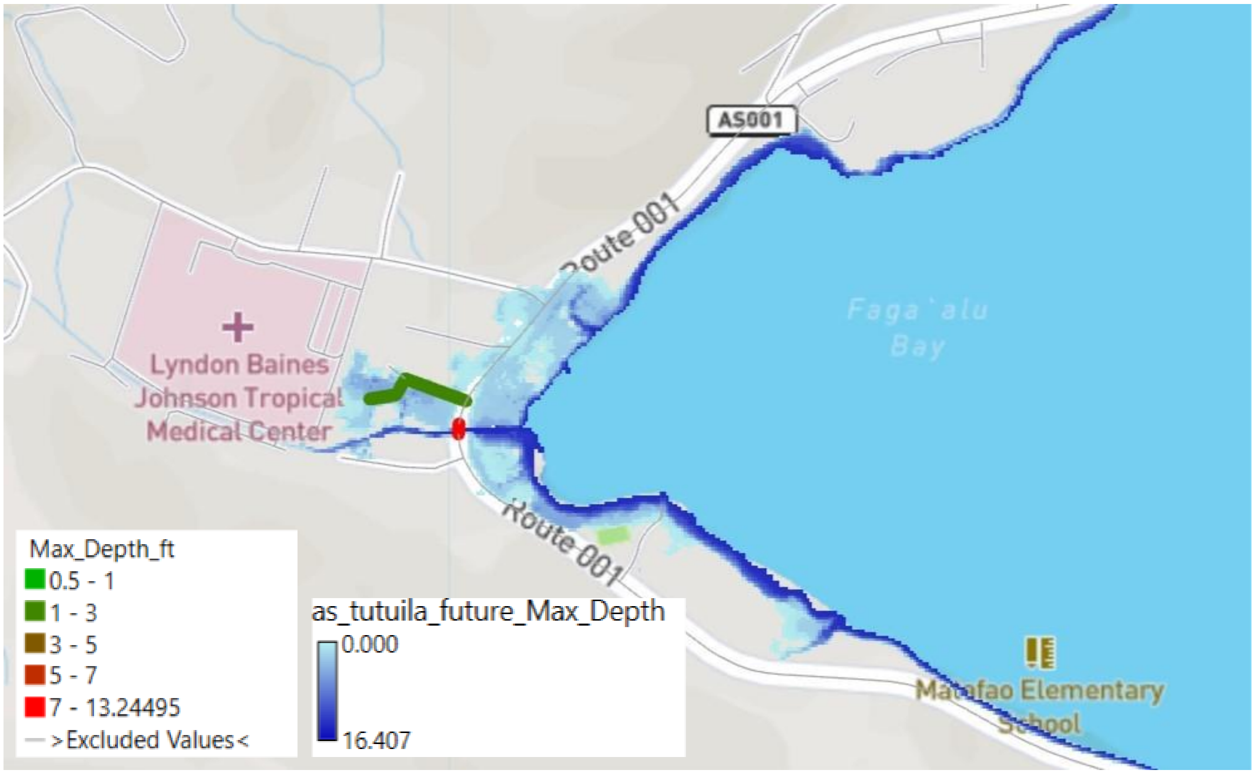


Figure 4-10: Map of risk on roads under the future MEOW Storm Surge scenario with RSLC near the LBJ Tropical Medical Center. Increased depths along Route 001 creates a potential hazard for people needing to reach the hospital for emergencies via vehicles during coastal flooding events. Source: USACE, 2021.

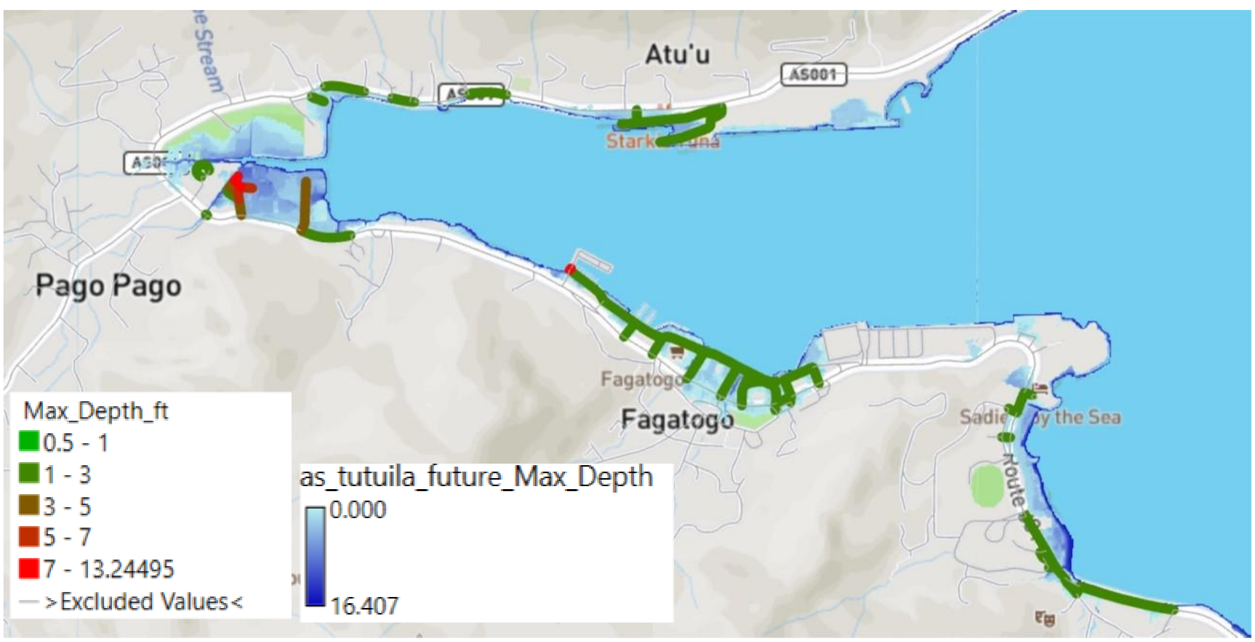


Figure 4-11: Map of risk on roads under the future MEOW Storm Surge scenario with RSLC. The future scenario showed additional locations of road hazards. Source: USACE, 2021.

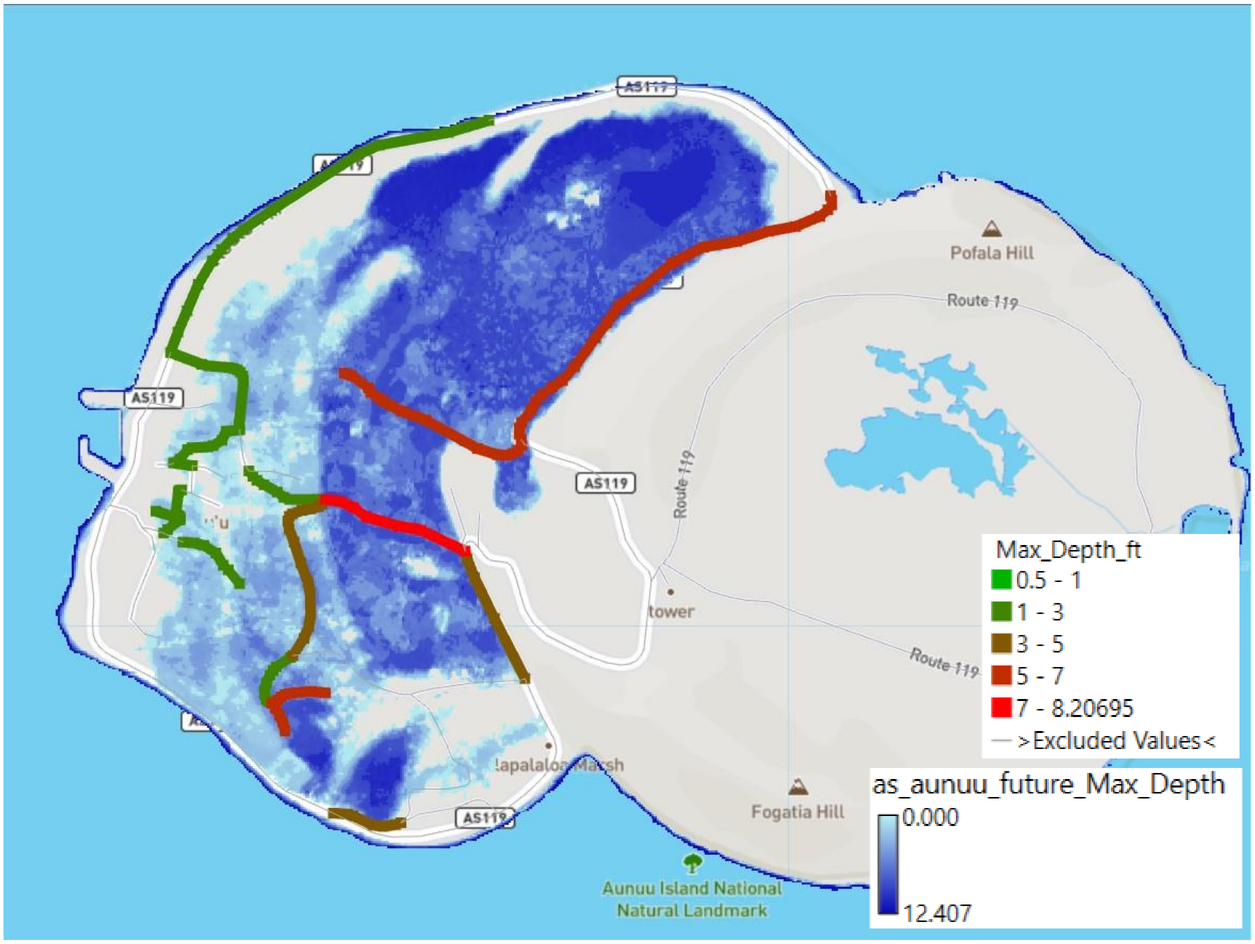


Figure 4-12: Road inundation on the island of Aunu'u under the future MEOW Storm Surge scenario. No additional roads experience flooding, however, depths increase by several feet on route 119 which can prevent vehicle traffic to the higher elevations to the east. Source: USACE, 2021.

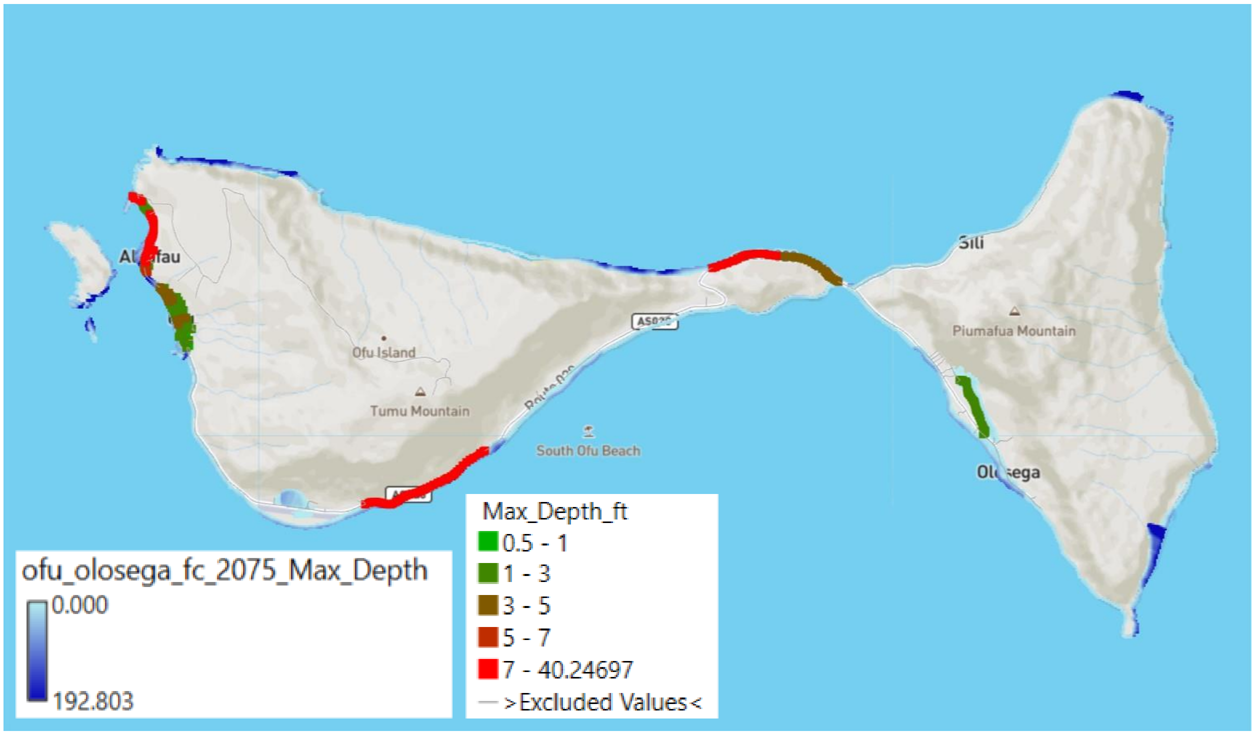


Figure 4-13: Road inundation on Ofu and Olosega under future MEOW Storm Surge scenario. Depths increase under the future scenario, as well as additional roads in the village of Olosega. Note: the decreased access to the Ofu-Olosega Bridge, which is the only vehicle route between the two islands. Route 020 which navigates from the northwest corner of Ofu along the southern coastline of the island across the Ofu-Olosega Bridge, and to the island and village of Olosega experiences dangerous depths which effectively isolate all the coastal villages during the flood event. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies. Source: USACE, 2021

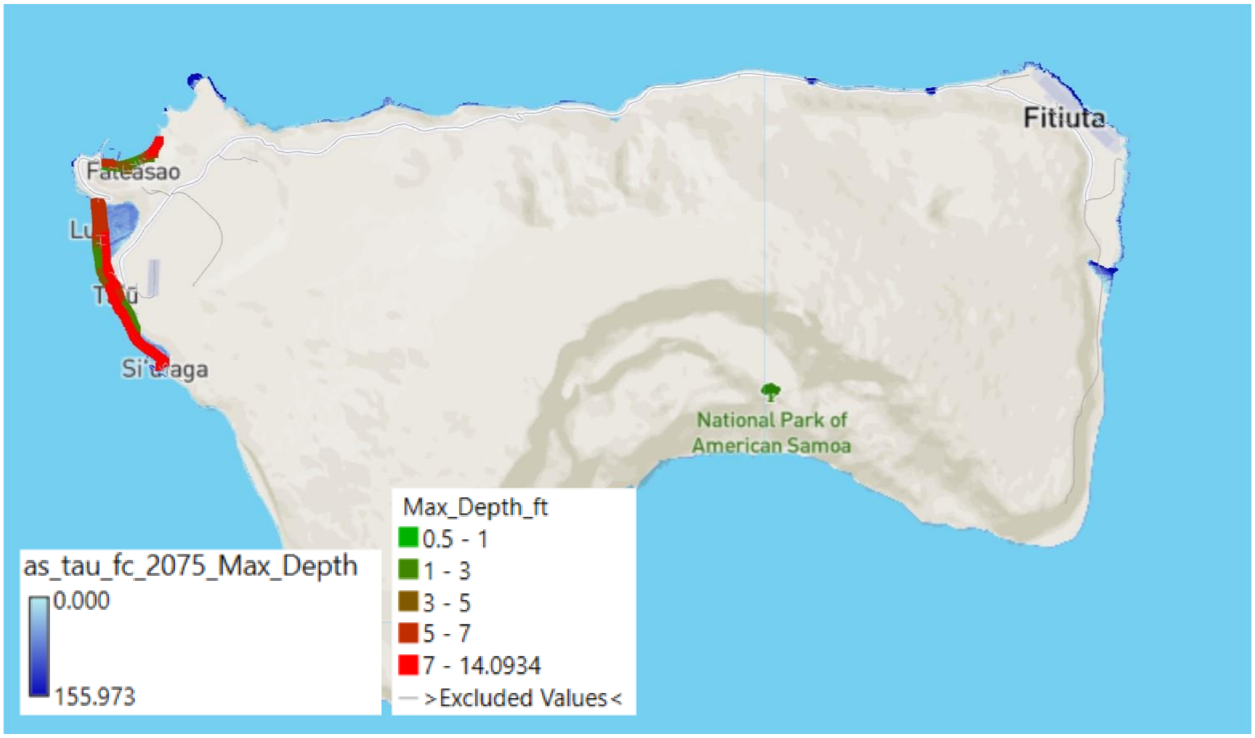


Figure 4-14: Road inundation on Ta'u under future MEOW Storm Surge scenario including projected RSLC/SLC. No additional roads are inundated when compared to the existing scenario, however, depths increase under the future scenario causing an increase in the hazard. The increased depths could prevent travel from east and west via vehicle. Extreme depths occur due to the roughness of the data and some overlapping of cross section areas, leading to the sea floor appearing within dry land segments. Increasing the number of cross sections or using depth grid data as it becomes available will lead to fewer discrepancies. Source: **USACE, 2021**

## 4.2 Findings and Discussion

Aunu'u is shown to have the largest area specific changes from the existing to future scenario with an 11% increase in PAR, 67% increase in the number of structures inundated and a very large increase in damages of over 300%. Refinement of the structure inventory could change the damage percent increase significantly. More accurate measurements of foundation heights and square footage can affect the calculated depth at which damages occur and in combination with capturing more accurate structures' values will result in more accurately calculated damage values. The large changes on the island of Aunu'u can be expected given that nearly all structures are within the FEMA VE ZONE even under the existing scenario. The roads to higher ground can become more inundated causing risk to increase during last minute evacuations. Once these roads become inundated, the model assumes nearly all remaining people will shelter in place, and due to the increased flood depths, risk within those structures used for shelter is increased. A factor contributing to the risk displayed on Aunu'u is that the structures are almost entirely located on a slightly elevated plain between the coast and higher ground, with an area of lower elevation that receives greater flood depths between the higher ground and the structures on the island.

Tutuila also sees increasing risk in the future scenario with an additional 6% PAR, 11% more structures inundated, and damage increases of over 79% attributable to greater inundation depths. Notably, in the future scenario Lauli'i shows PAR which was not shown to have PAR in the existing scenario. Again, all increases to PAR noted herein are attributable to increases in inundation, and not from increases in population projections.

The Manu'a islands of Ta'u, Ofu and Olosega also experience increases in PAR, structures inundated and damaged under the future scenario, and given their remoteness, even small shifts in risk can be relatively significant given the limited availability of emergency services and storm shelters.

### 4.2.1 Changes to PAR

The nature of development on the islands of American Samoa leaves them susceptible to coastal flood risk. Steep terrain that leaves little area between mountains and shore causes development to be concentrated in narrow areas at the coastline. With the additional elevations expected in the future due to RSLC, the risk of living in these areas will increase, causing approximately 6% more people to be exposed to flooding if no actions to raise structures or reduce the development within these areas occurs.

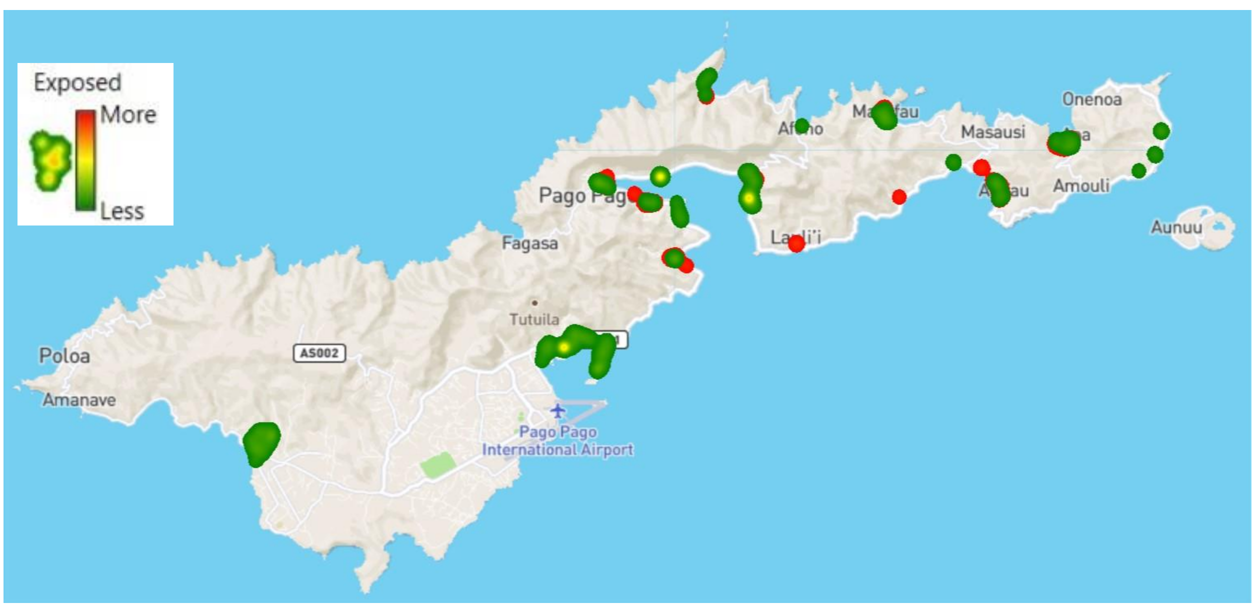


Figure 4-15 (repeated): Heat map of risk areas for the islands of Tutuila under the MEOW Storm Surge event with Future Scenario RSLC. Solid Red Indicates new exposure in the Future Scenarios that did not occur in Existing Scenarios and can be considered a result of RSLC. Source: [USACE, 2021]

Table 4-2: Changes to PAR from existing to future scenarios. Increases in future scenario are due to inundation changes only and not from population projections. Source: USACE 2021.

| Location | PAR Total - Existing | PAR Total - Future | Percent Change in Future |
|---|---|---|---|
| Aunu'u | 651 | 722 | 11% |
| Ofu & Olosega | 124 | 150 | 21% |
| Ta'u | 754 | 754 | 0% |
| Tutuila | 6,769 | 7,164 | 6% |
| Grand Total | 8,298 | 8,790 | 5.9% |

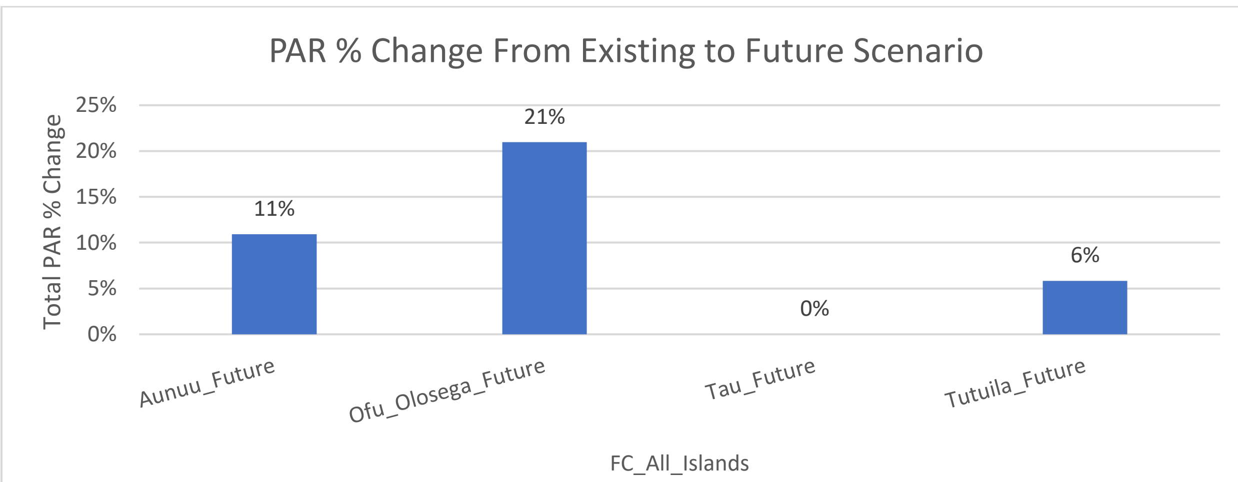


Figure 4-16: Total population at risk percent change from existing to future scenarios. No increase to populations were projected to future scenario. All increased PAR was due to additional inundation. Source: **USACE, 2021**

### 4.2.2 Changes to Structures Inundated

Overall, the change from existing to future scenarios leads to an increase of nearly 14% of structures impacted by coastal flooding due solely to RSLC. For the same reasons seen in the increase of PAR, such as development in narrow low laying areas near the shore. Land availability naturally leads to development in areas susceptible to coastal flooding, and overall, the change from existing to future scenarios leads to an increase of nearly 14% of structures impacted by coastal flooding due solely to RSLC.

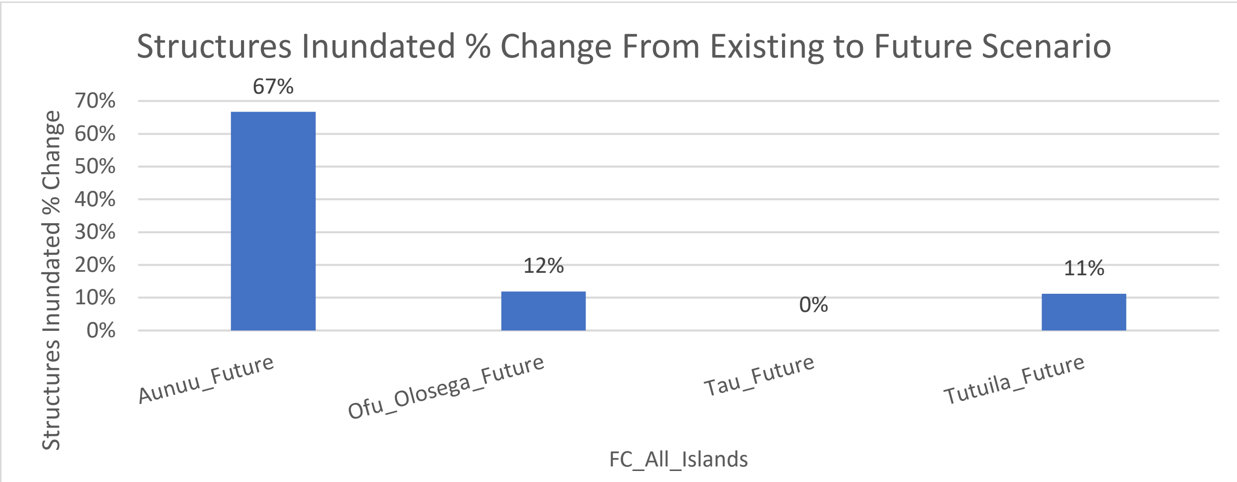


Figure 4-17: Percent change in structures inundated from existing to future scenarios. Source: USACE, 2021

Table 4-3: Changes in number of structures inundated and percent change from existing. Source: USACE, 2021.

| Location | Structures Inundated - Existing | Structures Inundated - Future | Percent Change in Future |
|---|---|---|---|
| Aunu'u | 48 | 80 | 67% |
| Ofu & Olosega | 42 | 47 | 12% |
| Ta'u | 100 | 100 | 0% |
| Tutuila | 436 | 485 | 11% |
| Grand Total | 626 | 712 | 13.7% |

### 4.2.3 Changes to Structure Damages

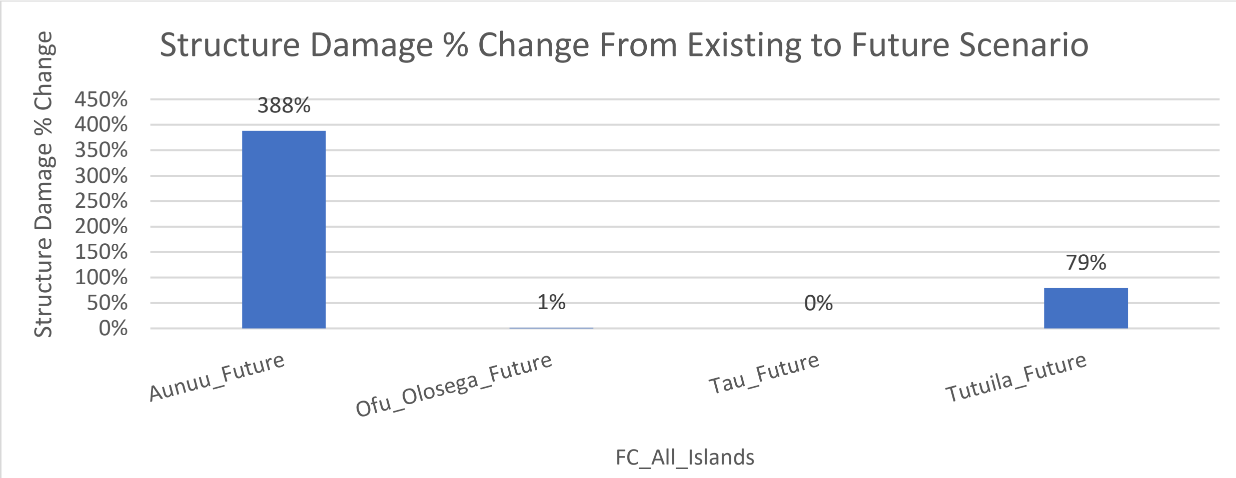


Figure 4-18: Structure damage percent change from existing to future scenarios. Source: [USACE, 2021]

Table 4-4: Changes to expected damages from the NOAA MEOW storm surge inundation under existing and future scenarios. Numbers are screening level only. Increases in future conditions are due to RSLC. Source USACE, 2021.

| Location | Structure Damage - Existing | Structure Damage - Future | Percent Change in Future |
|---|---|---|---|
| Aunu'u | $133,000 | $649,000 | 388% |
| Ofu & Olosega | $1,138,000 | $1,154,000 | 1% |
| Ta'u | $6,608,000 | $6,608,000 | 0% |
| Tutuila | $7,930,000 | $14,222,000 | 79% |
| Grand Total | $15,809,000 | $22,633,000 | 43.2% |

The results pertaining to structural damages are less about exact numbers, and more about showing which areas receive the greatest change. For example, the island of Aunu'u receives nearly 4x damage in the future scenario, highlighting the acute vulnerability to the risk of RSLC at those structures. The Manu'a islands see smaller changes, but even smaller changes can lead to the need to evaluate what structure might be most at risk.

Increased elevation of coastal flooding in the future scenario due to RSLC is likely to increase the amount of damages to structures within American Samoa, with the island of Aunu'u having nearly all of its development at low elevation at much more risk to increased future depths. Many structures just above the level of flooding under the existing scenario could potentially start to experience flooding solely due to RSLC.

Overall, American Samoa sees across the board increases of consequences in the future scenario which includes RSLC via a 5.9% increase in PAR, a 13.7% increase in the number of structures that are flooded, and 43.2% increase in the amount of expected damages. These results highlight the increased level of coastal storm risk that American Samoa can expect in the future.

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