The Commonwealth of the Northern Mariana Islands

Final Watershed Plan

APPENDIX B

Economics and LifeSim Analysis

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US Army Corps of Engineers ®
Honolulu District

Contents

1 Study Area

Located just north of the U.S. Territory Guam, the Commonwealth of the Northern Mariana Islands (CNMI) is composed of 14 islands located within the Mariana Archipelago in the western Pacific Ocean. This U.S. Territory has a total land area just under 184 square miles with approximately 47,000 residents living on the three most populous islands – Saipan, Tinian, and Rota – at the southern end of the archipelago (U.S. Census Bureau, 2020).

The other 11 islands remain uninhabited due to natural disaster threats and/or economic limitations such as access to education or commercial ports. The study area for this WA focuses on the three populated islands of Saipan, Tinian, and Rota, which are also the largest islands in terms of land area. Focusing on these three islands allows the WA to address the territory-wide need most efficiently for community resilience.

1.1 Population

The 2020 U.S. Census of CNMI recorded a total population of 47,329 which is a 12.2% decrease from the 2010 census. In the 2010 Census, the total population was 55,883 which was a 22% decrease from the previous decade. In Rota, the population is 1,893. In Tinian, the population is 2,044. In Saipan, the population is 43,385. According to the U.S. Energy Information Administration, from between 2000 to 2020, several garment factories closed which resulted in the decline of foreign contract workers (EIA, 2020,).

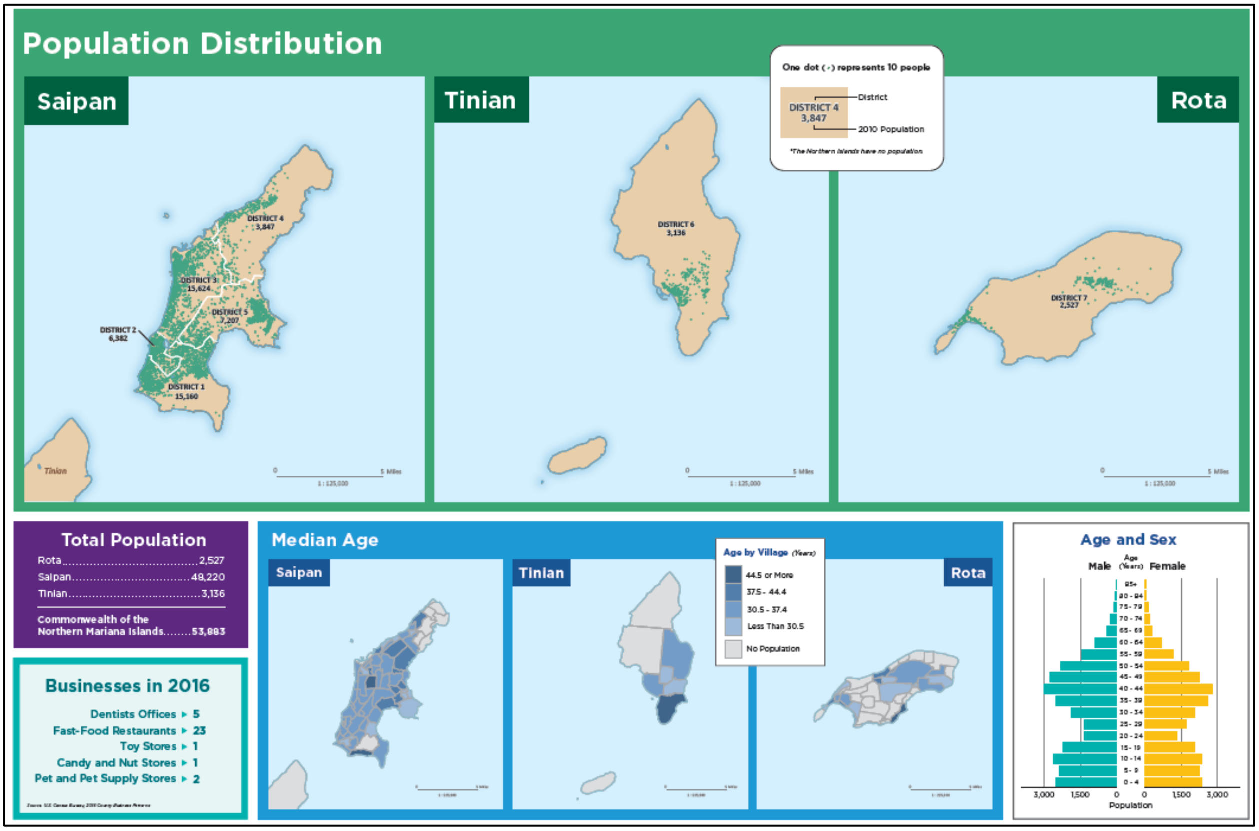

Figure 1-1: Understanding the population of CNMI. (Source: Census, 2010)

1.2 Economy

The economy of the CNMI was primarily centered around textile manufacturing from the late 1970's to approximately 2009 at which point the tourism and casino industry became the CNMI's largest economic sector. Since the CNMI is a territory of the United States, textiles manufacturers there were able to label products as "Made in the USA" while utilizing lower cost labor due to local control of wages and not being held to US minimum wage requirements (CNMI OPD, 2019).

The US Congress passed the Fair Minimum Wage Act of 2007, which phased in Federal minimum wage requirements for US territories including the CNMI, which had previously had more control over wages for the territory. The increases in minimum wages led to the departure of the textile industry and reliance on the tourism industry as the primary source of the territory's GDP (CNMI OPD, 2019). From 2007 to 2017 the tourism sector grew from 12 to 45 percent of GDP, and during the same time period the already shrinking textile industry fell from 19 to 1 percent of GDP (GAO, 2020). As of the 2020 GAO report on economic and workforce trends, the ratio of foreign to US workers remained close to 50 percent, with the largest employment sector being accommodation and food services as seen in Figure 1-2 below.

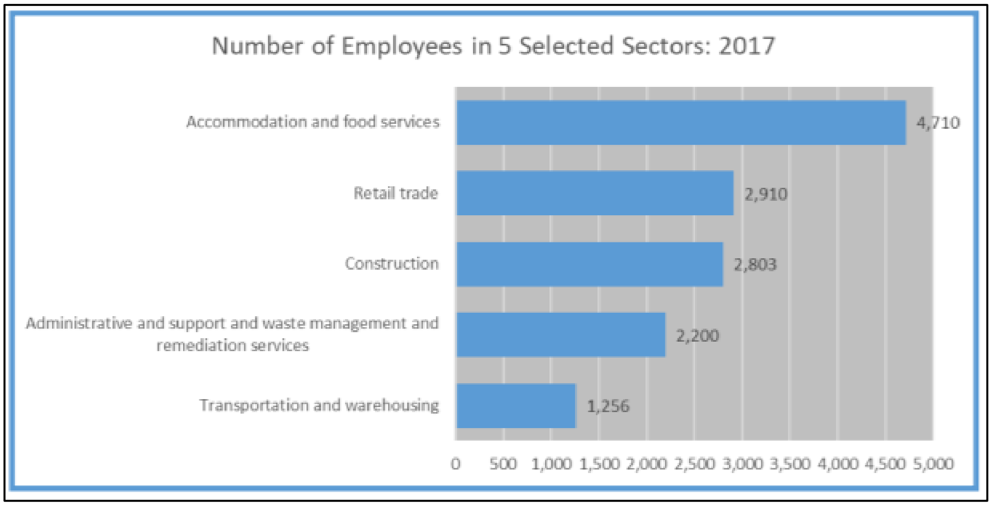

Figure 1-2: Number of employees in the top 5 sectors. (Source: US Census Economic Snapshot, 2017)

The shift towards the accommodation and food services industry has recently become centered around the resort and casino industry since the signing of Public Law 18-38 which authorized gaming licenses on Saipan. The shift towards the expansion of the tourism industry has several challenges:

- US Public Law 110-28: To bring local wages to Federal Minimum Wages of the US; raising the cost of labor.
- US Public Law 110-229: To control immigration under the US Dept of Homeland Security's Customs and Immigration Services; reducing the supply of non-resident workers.
- Development outpacing updates to infrastructure.

Periods of economic growth in 2016 and 2017 were followed by declines in 2018 and 2019. The most recent estimates of 2019 report a decline in tourism and outputs from the casino industry (BEA, 2021). The CNMI's location and lack of exports since the decline of the textile era have led to challenges in establishing a diversified economy and relies heavily on the tourism and gaming industry which have been shown to swing widely from periods of growth and decline beyond the CNMI's control.

1.3 Infrastructure

1.3.1 Structure Inventory

To create an account of the total number of built structures in the CNMI, parcel and building shapefiles were used to create a synthetic structure inventory for the islands. The total number of structures recorded was 10,527. In the 2010 U.S. Census, the total number of housing units that were recorded is 20,850. In the 2020 U.S. Census, the total number of housing units that were recorded is 18,290, this is a 12.3% decrease from the 2010 Census. There are multiple reasons for the disparity between recorded structures and total housing units. Certain structure types, such as apartments or multi-family homes, get recorded as a single structure, but contain multiple housing units.

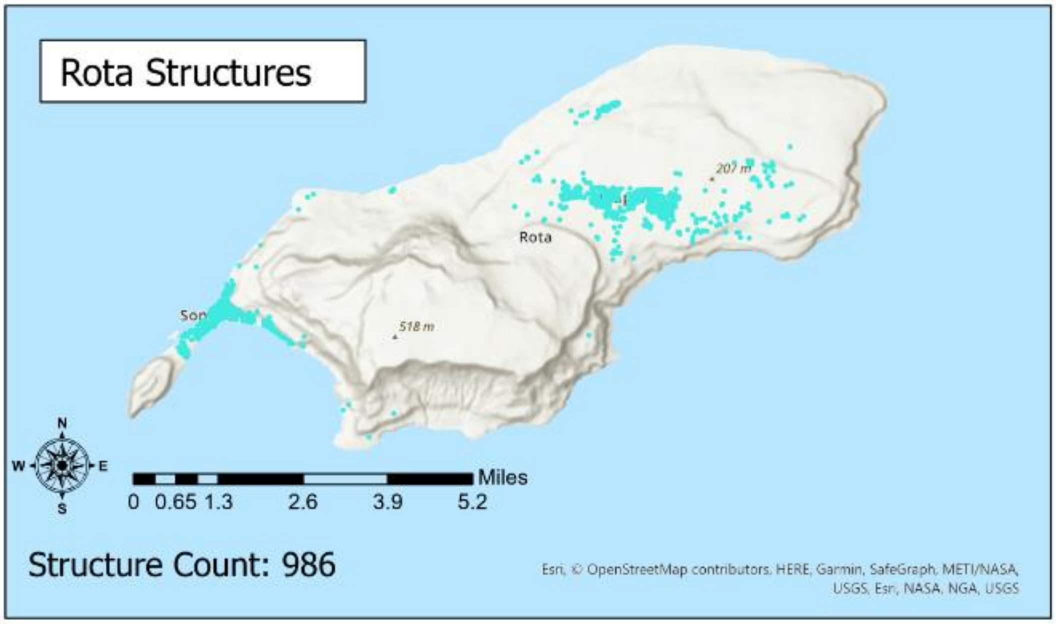

Figure 1-3: Rota structures.

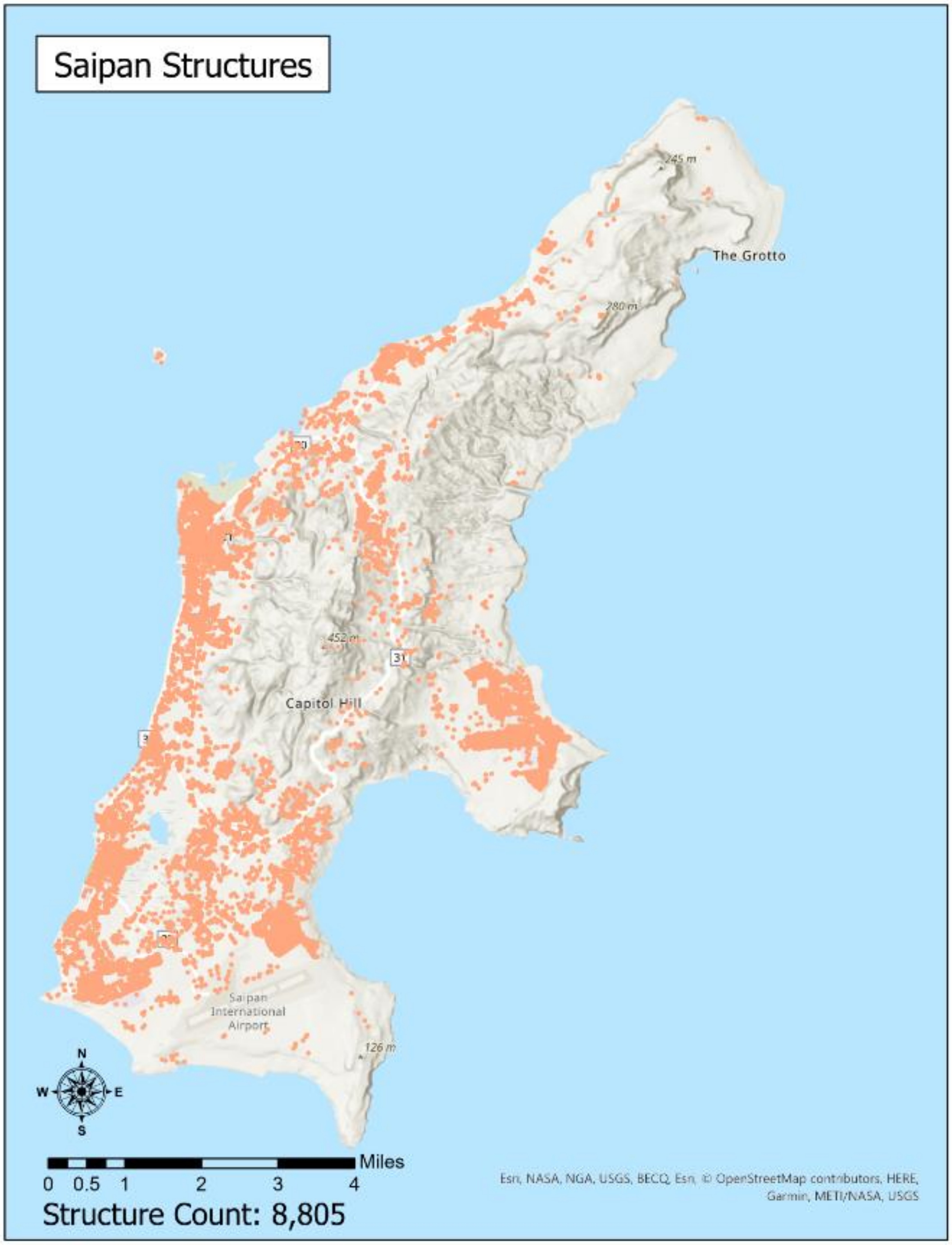

Figure 1-4: Saipan structures.

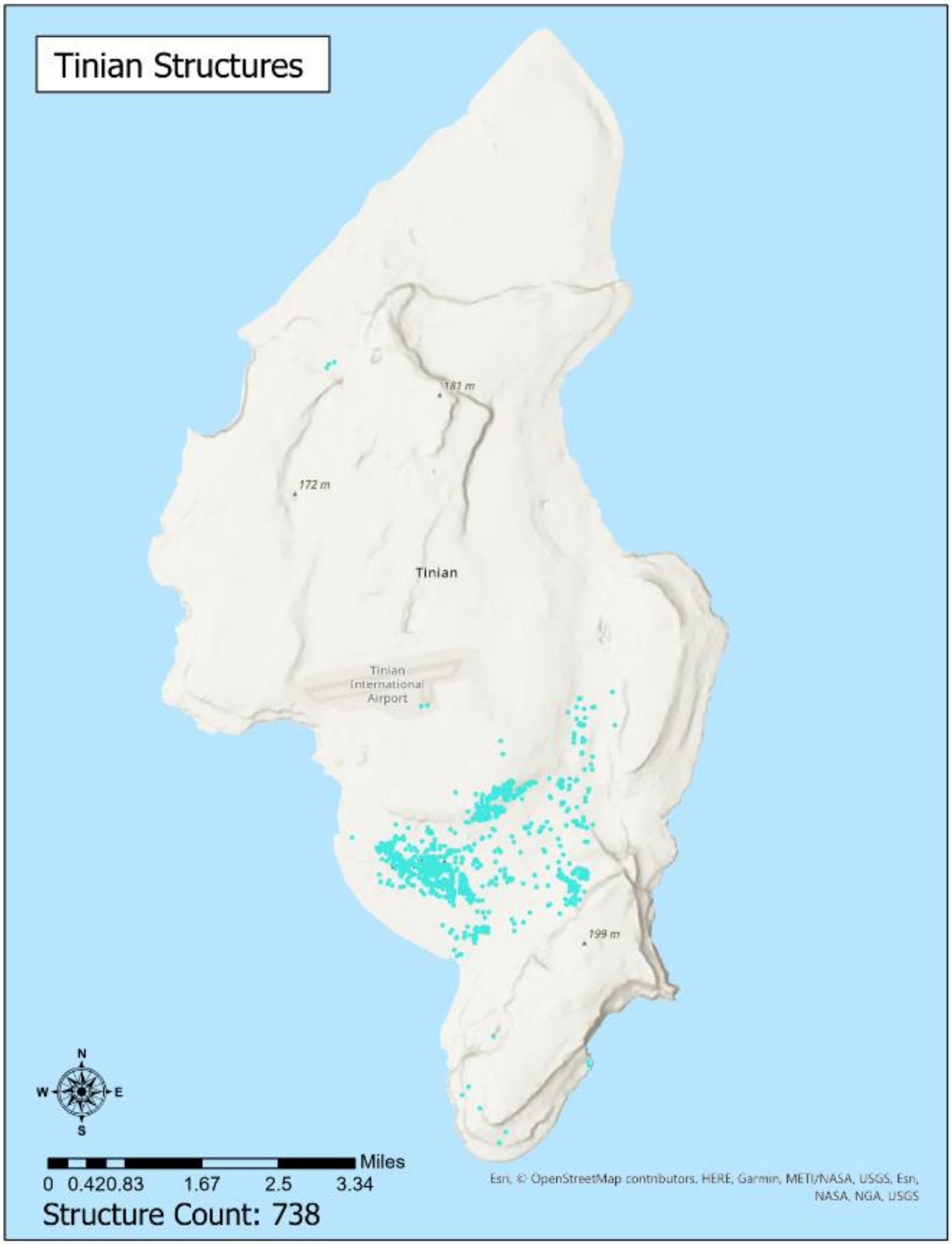

Figure 1-5: Tinian structures.

1.3.2 Energy Infrastructure

According to the U.S. Energy Information Administration, CNMI currently meets its energy needs with imported petroleum products. Some imported petroleum goods include butane and propane used by businesses and households, and jet fuel and aviation gas for use at the airports. Electricity is provided by the Commonwealth Utilities Corporation (CUC) where electricity generation is fueled by diesel. Electricity is generated at five diesel-fueled power plants-three on Saipan and one on Rota and one on Tinian. Most electricity is consumed by the commercial sector and small industries followed by the residential sector, with government and utility use accounting for the least electricity consumed.

1.3.3 Healthcare Infrastructure

The Commonwealth Healthcare Corporation (CHCC) was established by Public Law 16-51 and signed into law by the Governor in 2009. The Strategic Plans (2015-2020) states that the CHCC be its own entity, separate from the government, requiring them to be independent and self-sufficient financially. The CHCC's focus is to deliver quality health care to the population of Saipan, Tinian, and Rota. The hospital in Saipan, known as the Commonwealth Health Center (CHC), has 86 beds. For mental health and substance abuse help, there is a Community Guidance Center (CGC), also located in Saipan. The CGC provides therapeutic services to the public such as support services to families, community outreach, prevention and education services, and education on other resources that are available within the community. According to the Commonwealth Health Center Corporation, there is a health center in Rota known as the Rota Health Center that serves about 2,527 people and offers various health services. In Tinian, there is only one medical facility known as the Tinian Health Center, built in 1987, where they also offer various health services. All three medical facilities are under the control of the CHCC, following the strategic plan set forth in 2015 (CHCC, 2015).

2 LifeSim Model

The economic analysis for the Post-Disaster Watershed Assessments will focus on direct, event-based impacts from flooding in an existing and future scenario with relative sea level change (RSLC). The Corps Institute of Water Resources, Risk Management Center's LifeSim 2.0.1 model (LifeSim) will be the analytical tool used to estimate structure damages, road inundation, and areas with population at risk of flooding (PAR), and exposed PAR (additional detail of PAR is found in Section 3.2.1). 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 outputs highlighting areas vulnerable to existing and future conditions and aided in the prioritization of measures to help identify and reduce future risk. LifeSim will analyze storm surge of existing and future conditions that incorporate RSLC based on the USACE RSLC curves.

2.1 Economic Uncertainty

The Watershed Assessment is meant to be a screening level analysis to broadly show the changes to economic damages and 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 will be utilizing standard functions within the LifeSim model. All life safety and evacuation calculations such as warning issuance delay, first alert, and protective action initiation will be 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.

2.2 Analysis Years

The analysis year for the existing condition will be defined as the current calendar year (2022). The FWOP 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. Currently, this will be an existing condition year of 2022, and a FWOP year of 2072. Additional data and visualizations describing the adaptation of the 100-year RSLC curve can be found in Engineering Appendix C.

2.3 LifeSim Engineering Inputs

For the CNMI inundation inputs, 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. The cross sections extended from the MSL point to the 1% annual chance exceedance (ACE) inundation boundary high point digital elevation map (DEM). DEM values were then subtracted to produce depths.

2.4 Structure Inventory

There are currently no comprehensive structure inventories for The Commonwealth that were able to be acquired for the purposes of the watershed studies. For the purposes of the watershed assessment, the team developed a GIS-based synthetic 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 the Commonwealth and other Pacific Islands.

2.5 Synthetic Inventory Construction

As stated previously, the NSI2.0 structure inventory for Maui, HI was used to generate attributes for the structures of the watershed study. 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 watershed study, and use of the LifeSim outputs as a planning guide and not for rigorous assessment of damages as a test for feasibility or alternatives or life loss for project evaluation, the level of accuracy from this synthetic inventory was seen as appropriate to identify areas of generalized 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 synthetic 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 synthetic inventory:

Table 2-1: Occupancy type distribution.

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%
Entertainment & Recreation (COM8)	2.03%
Theaters (COM9)	0.03%
Heavy Industry (IND1)	2.00%
Agriculture (AGR1)	0.42%
Church/Non-Profit (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: Attribute types.

Attribute	Label	Type of Calculation
Foundation Type	Found_Type	Randomly Generated from Maui NSI2 Distribution using @Risk assuming normal distribution
Foundation Height	Found_Ht	Randomly Generated from Maui NSI2 Distribution using @Risk assuming normal distribution
Year Built	YrBuilt	Randomly Generated from Maui NSI2 Distribution using @Risk assuming normal distribution
Building Type (Construction Class)	BldgType	Randomly Generated from Maui NSI2 Distribution using @Risk assuming normal distribution
Number of Stories	Num_Story	Randomly Generated from Maui NSI2 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
Structure Value	Val_Struc	Generated via the Excel random number generator and descriptive statistics of the attribute in the Maui NSI2
Population (Day)	Day_Pop	Calculated using Hazus formulas for population per square foot

Attribute	Label	Type of Calculation
Population (Night)	Night_Pop	Calculated using Hazus formulas for population per square foot

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	13	1	12	3
COM1	10	1	9	1
COM2	15	1	14	1
HOS	3	0	3	2
MED	15	1	14	1
REST	35	1	34	2
COM9	2	1	1	1
IND1	5	1	4	1
AG	4	1	3	1
REL1	3	1	2	1
GOV1	15	1	14	2
GOV2	2	1	1	1
EDU1	7	1	6	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	3
MFR1	8	1	7	4
MFR2	8	1	7	5
COM1	8	1	7	4
COM2	8	1	7	4
HOS	1	1	0	1
MED	8	1	7	3
REST	8	1	7	4
COM9	7	1	6	3
IND1	8	1	7	3

AG	8	1	7	3
REL1	8	1	7	3
GOV1	8	1	7	3
GOV2	7	1	6	2
EDU1	8	1	7	3
EDU2	1	1	0	1

Table 2-5: Summary of values for year built.

Year Built			
Max	**Min**	**Range**	**Average**
2016	0	2016	1977
2015	0	2015	1988
2008	1920	88	1978
2010	1920	90	1979
2015	1900	115	1977
2015	1918	97	1978
2001	1986	15	1994
2014	1931	83	1975
2015	1914	101	1977
1983	1914	69	1953
2015	1914	101	1978
2015	1914	101	1977
2015	1914	101	1976
2015	1914	101	1977
1997	1914	83	1968
2013	1914	99	1974
1983	1914	69	1953

Table 2-6: Summary of values for square feet of structure.

Sq Ft			
Max	**Min**	**Range**	**Average**
1,613	950	663	1,251
3,933	842	3,091	2,634
8,407	1,339	7,067	3,720
157,703	285	157,418	13,701
117,755	92	117,663	5,310
128,595	10	128,584	3,100
8,856	681	8,175	4,769
23,280	90	23,189	2,575
308,076	79	307,997	9,611

6,128	316	5,812	2,933
196,353	14	196,338	4,594
99,159	9	99,150	3,979
137,678	30	137,648	5,493
147,592	23	147,570	6,010
20,857	91	20,766	7,762
59,355	31	59,324	5,110
3,399	15	3,383	1,337

Table 2-7: Summary of values for structure value.

Type	Structure Value			
	Max	Min	Range	Average
SFR1	$368,899	$79,799	$289,099	$169,367
SFR2	$849,873	$173,901	$675,973	$367,704
MFR1	$1,859,130	$103,001	$1,756,129	$449,157
MFR2	$59,016,145	$39,157	$58,976,988	$2,450,282
COM1	$22,006,367	$7,880	$21,998,487	$688,809
COM2	$19,189,526	$2,687	$19,186,839	$431,164
HOS	$2,574,942	$3,257	$2,571,685	$1,289,100
MED	$24,195,144	$8,002	$24,187,142	$928,658
REST	$71,442,507	$18,156	$71,424,351	$2,219,634
COM9	$1,049,823	$54,097	$995,727	$502,533
IND1	$25,274,244	$1,503	$25,272,741	$561,709
AG	$10,809,653	$1,018	$10,808,635	$433,291
REL1	$25,672,684	$5,411	$25,667,273	$1,018,515
GOV1	$20,603,659	$3,182	$20,600,477	$840,530
GOV2	$4,977,218	$21,614	$4,955,605	$1,852,366
EDU1	$10,625,156	$5,516	$10,619,640	$912,672
EDU2	$672,397	$3,030	$669,367	$264,439

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.

Due to the large range of values the @Risk method produced negative values for square feet and structure value attributes. To avoid generating structure values and square feet as negatives, the values were first converted to natural log and descriptive statistics were calculated for these attributes. Then, using the random number generation feature within Excel, the values were randomly generated and distributed within the respective occupancy type. Once the values were generated and distributed, the values were converted back from natural log.

3 Coastal Flooding Impacts Existing Scenario

To assist in the planning process, the LifeSim model was used to identify areas of risk within the coastal flooding areas under the Existing Scenarios. The synthetic structure inventory developed for this study and FEMA 1% ACE depth grids were used to show rough order of magnitude impacts along the coast of Saipan, Tinian, and Rota.

3.1 Vulnerability of Critical Facilities

The 2018 update of the Standard State Mitigation Plan (SSMP) identifies the critical/essential facilities within the CNMI, however there has not been any reports regarding the vulnerability of those facilities to coastal storm hazards. The SSMP identifies over 70 critical facilities throughout the islands of Saipan, Tinian, and Rota, and contains maps of the critical facility locations. Due to the rough nature of the underlaying data used for this analysis, the critical facilities were not explicitly input into the LifeSim model. To avoid miscommunication of potential risk, data from the SSMP should be used as a reference to the potentially vulnerable critical and essential facilities of the Commonwealth.

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 to the applicability of the underlaying data, such as the structure inventory and the FEMA based inundation data which is a rough estimate of the potential coastal flooding, all results must be viewed as very rough order 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 NSI 2.0 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.

Due to the inability of the model 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 2022 to 2072, 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. Values for population and structures were held constant within the model framework across scenarios.

As seen in Table 3-1 and Figure 3-1, the western villages of Garapan, Tanapag, Susupe, and San Antonio have the highest numbers of exposed population on the island of Saipan under the existing scenario. The island of Tinian does not show any exposed PAR under the existing scenario, and the island of Rota sees exposed PAR concentrated in the village of Songsong, which due to its low elevation and peninsular geography contribute to its vulnerability to coastal storm risk.

Table 3-1: Risk to the CNMI under the existing scenario. (Source: USACE, 2021)

Island/Village	PAR - Existing	PAR - Future	Additional PAR in Future
Rota			
- Liyu	x		
- Songsong	x		
- Annex F	x		
- Ugis			
- Taimama	x		
Saipan			
- San Antonio	x		
- San Roque	x		
- Chalan Piao	x		
- Chalan Kanoa II	x		
- Lower Base	x		
- San Jose (Oleai)	x		
- China Town	x		
- Garapan	x		
- Susupe	x		
- Puerto Rico	x		
- American Memorial Park	x		
- As Palacios	x		
- Achugao	x		
- Tanapag	x		

Table 3-2: Structures inundated under the existing scenario. (Source: USACE, 2021)

Island/Village	Structures Impacted Existing
Rota	
- Liyu	1
- Songsong	64
- Annex F	1
- Ugis	-
- Taimama	1
Total - Rota	**67**
Saipan	
- San Antonio	9
- San Roque	20
- Chalan Piao	1
- Chalan Kanoa II	2
- Lower Base	30
- San Jose (Oleai)	6
- China Town	1
- Garapan	257
- Susupe	16
- Puerto Rico	15
- American Memorial Park	7
- As Palacios	1
- Achugao	12
- Tanapag	56
Total - Saipan	**433**
Total - All	**500**

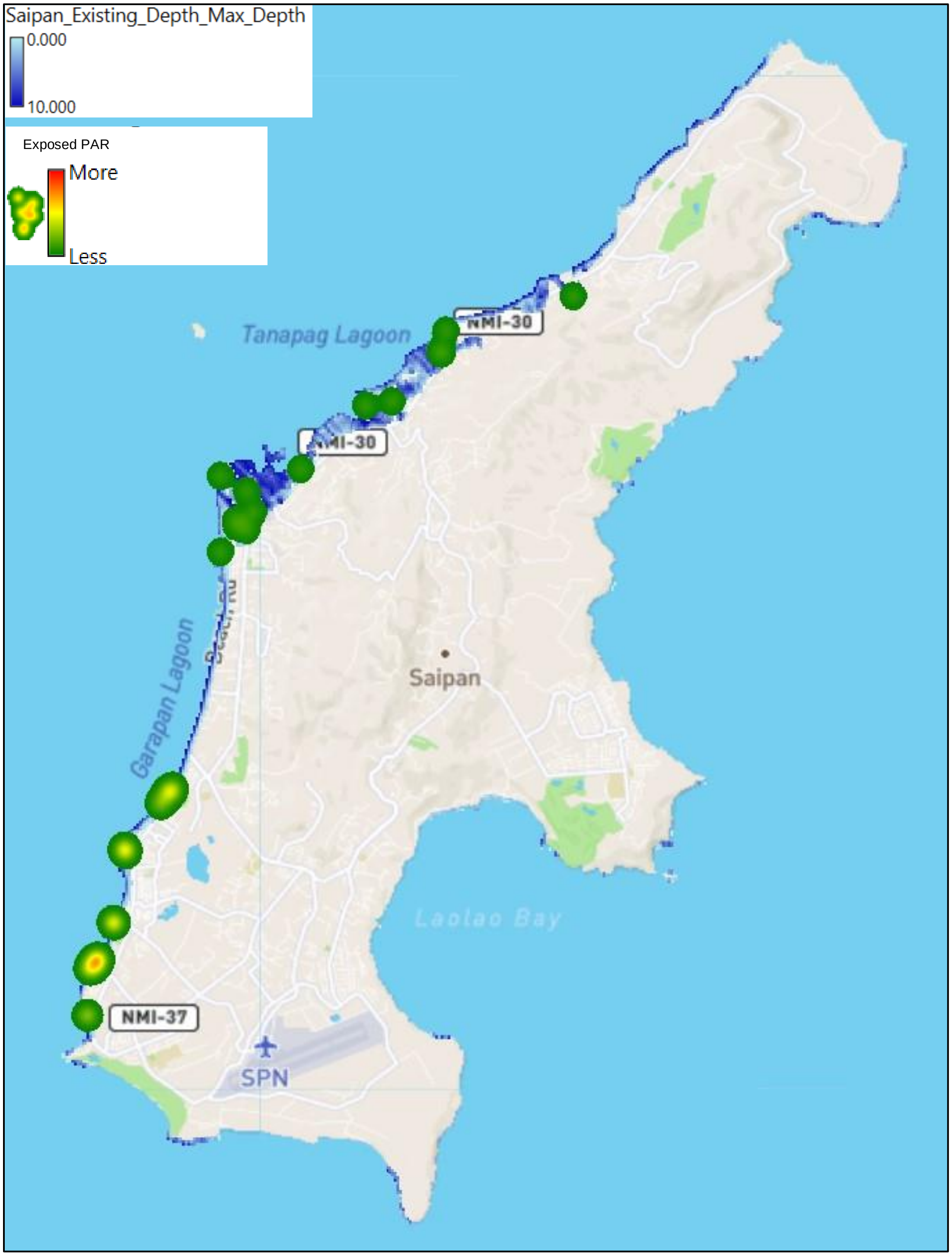

Figure 3-1: Heat map of areas with exposure of the PAR to flooding on the island of Saipan.

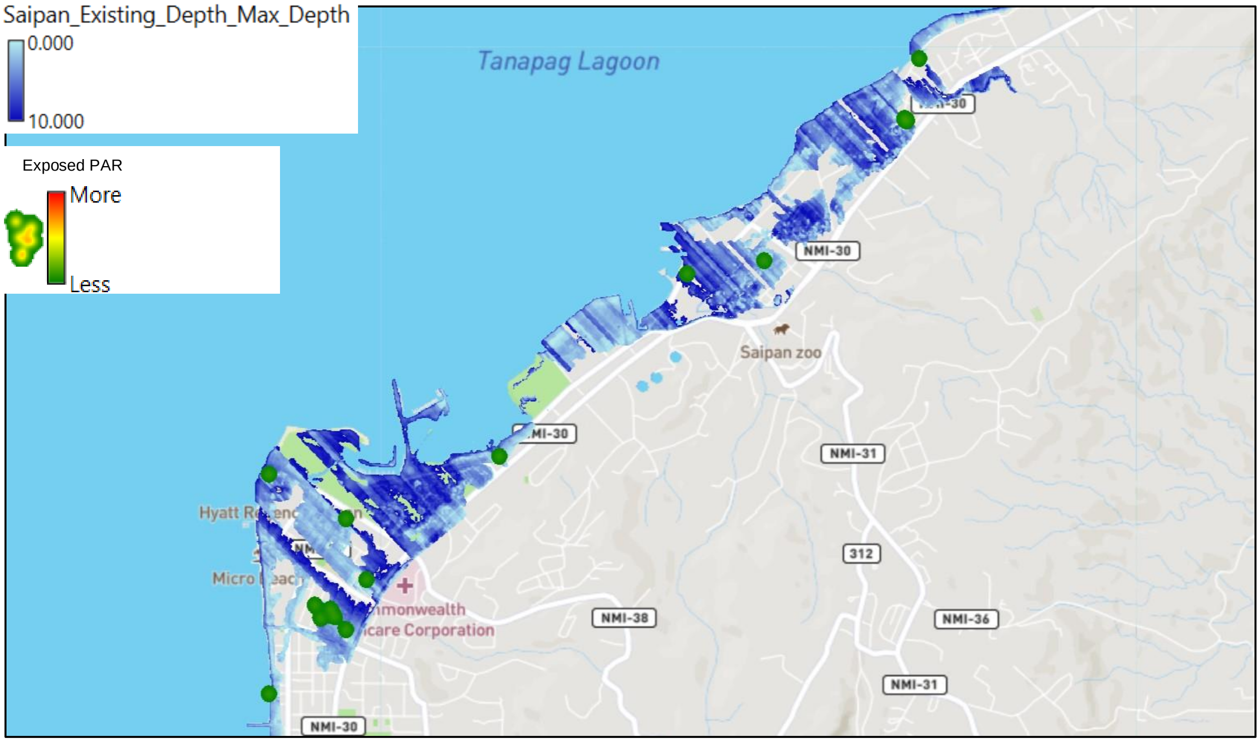

Figure 3-2: Heat map of the exposed PAR within the villages of Garapan and Tanapag under the existing scenario.

Figure 3-3: Heat map of areas of the island of Tinian with exposed PAR. There was no PAR shown within the LifeSim model for the existing scenario.

Figure 3-4: Heat map of the island of Rota with exposure of the PAR to coastal flooding under the existing scenario.

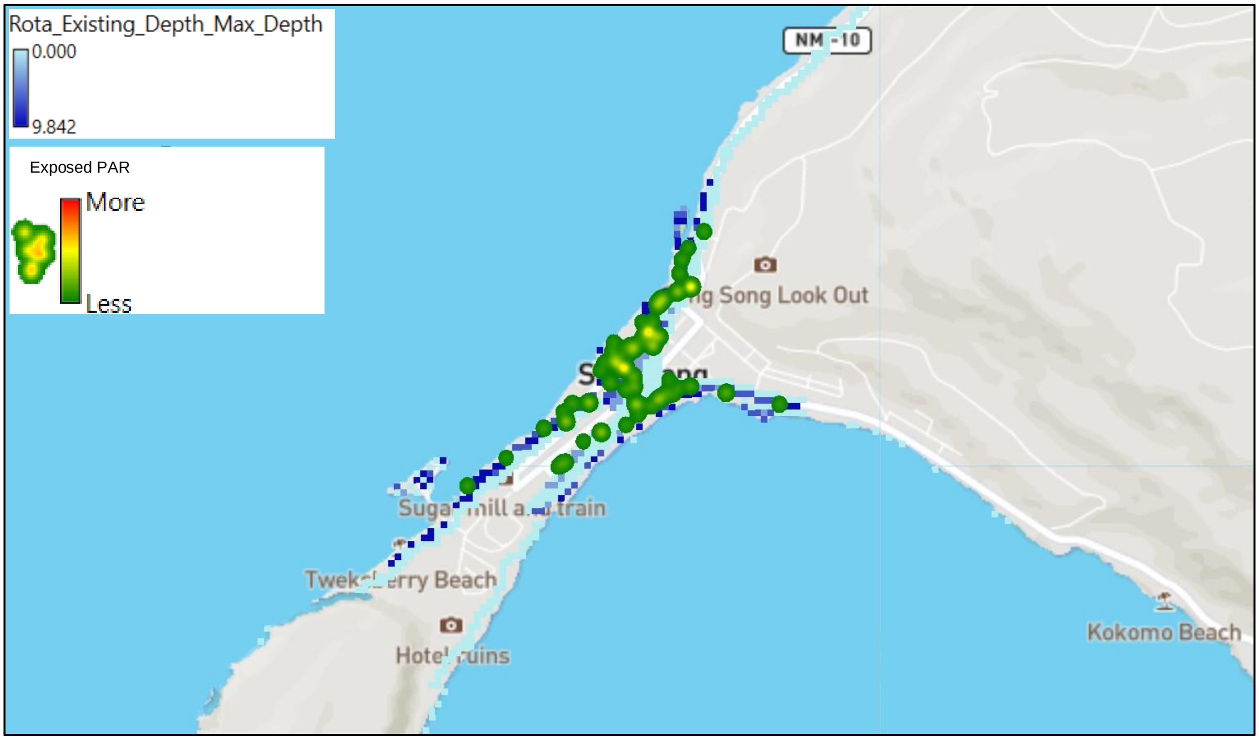

Figure 3-5: Heat map of the village of Songsong with exposure of the PAR to coastal flooding under the existing scenario.

3.2.2 Existing Exposed Road Infrastructure

The following figures show many of the primary routes on the island of Saipan have been built within close proximity to the shoreline leading to high levels of exposure to coastal flooding (see Figure 3-6). Most of Middle Road, Route 30, and Beach Road experience inundation between 1 and 10 feet under the existing scenario causing some areas such as Garapan to be at risk of becoming isolated from other areas of Saipan. The island of Tinian shows no inundated roads, and the island of Rota experiences flooding of nearly 10 feet along Route 10 between the Rota Resort, and the village of Songsong. The village of Songsong experiences flooding on nearly all roads with depths of nearly 10 feet.

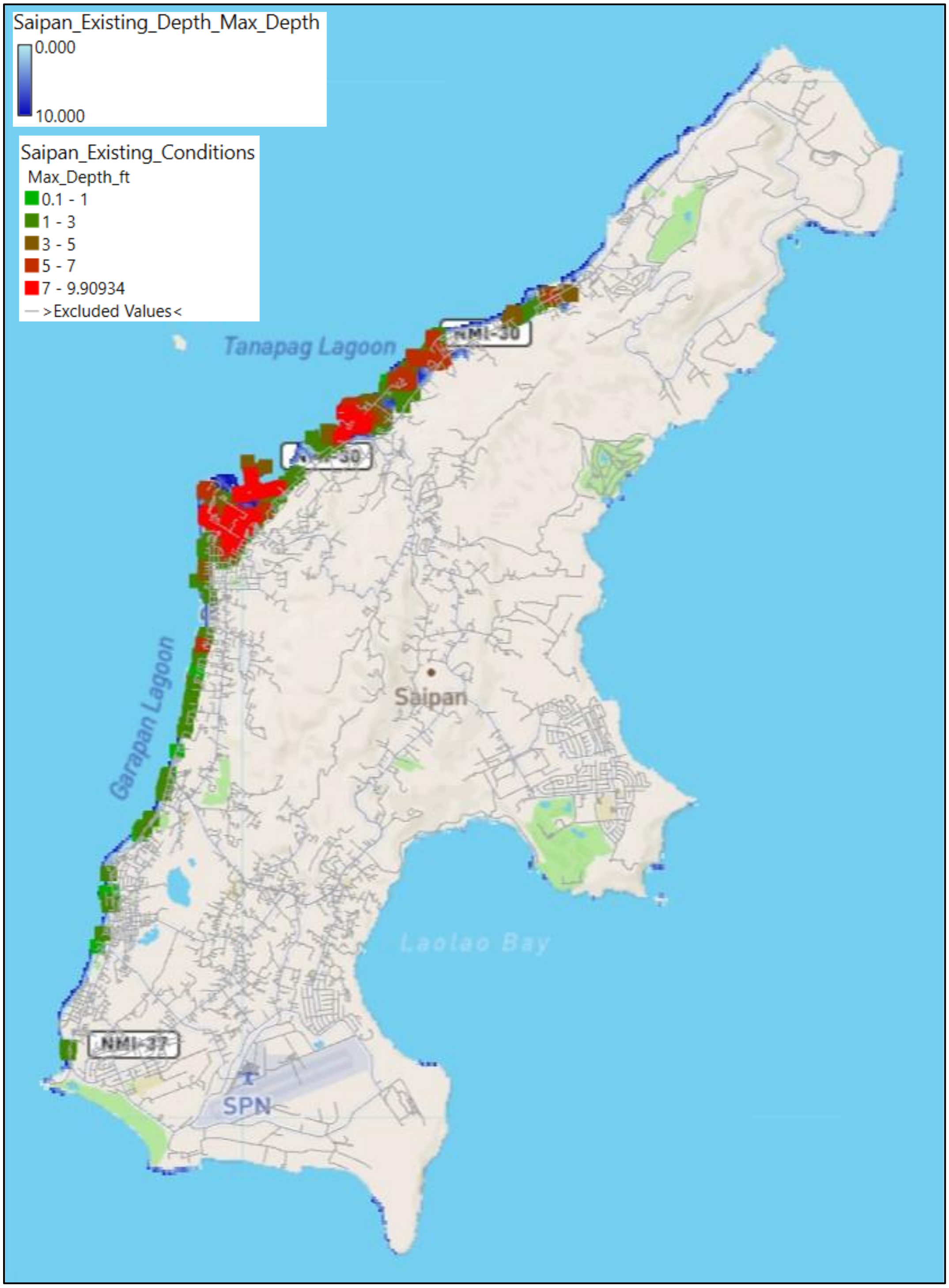

Figure 3-6: Map of existing scenario inundation hazard on Saipan's roads under the NOAA MEOW Storm Surge event.

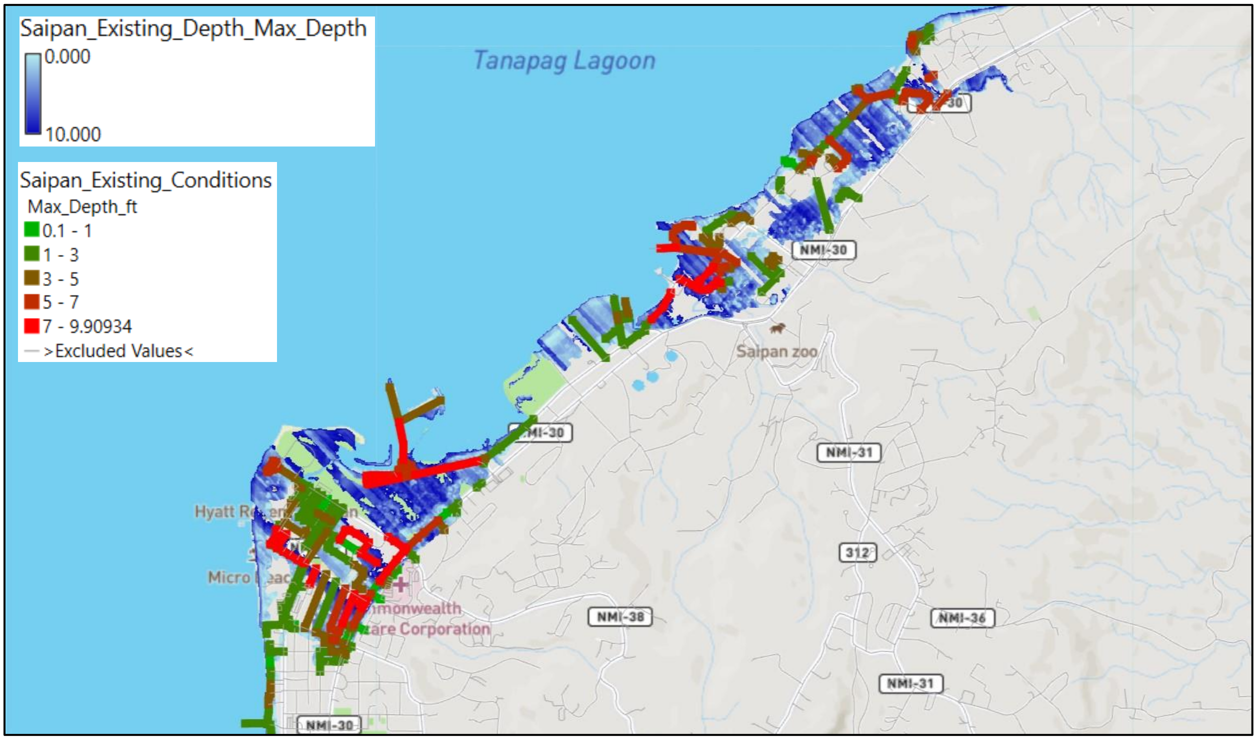

Figure 3-7: Map of existing scenario inundation hazard on Saipan's (Garapan) roads under the NOAA MEOW Storm Surge event.

Figure 3-8: Map of existing scenario inundation hazard on Tinian's roads under the NOAA MEOW Storm Surge event.

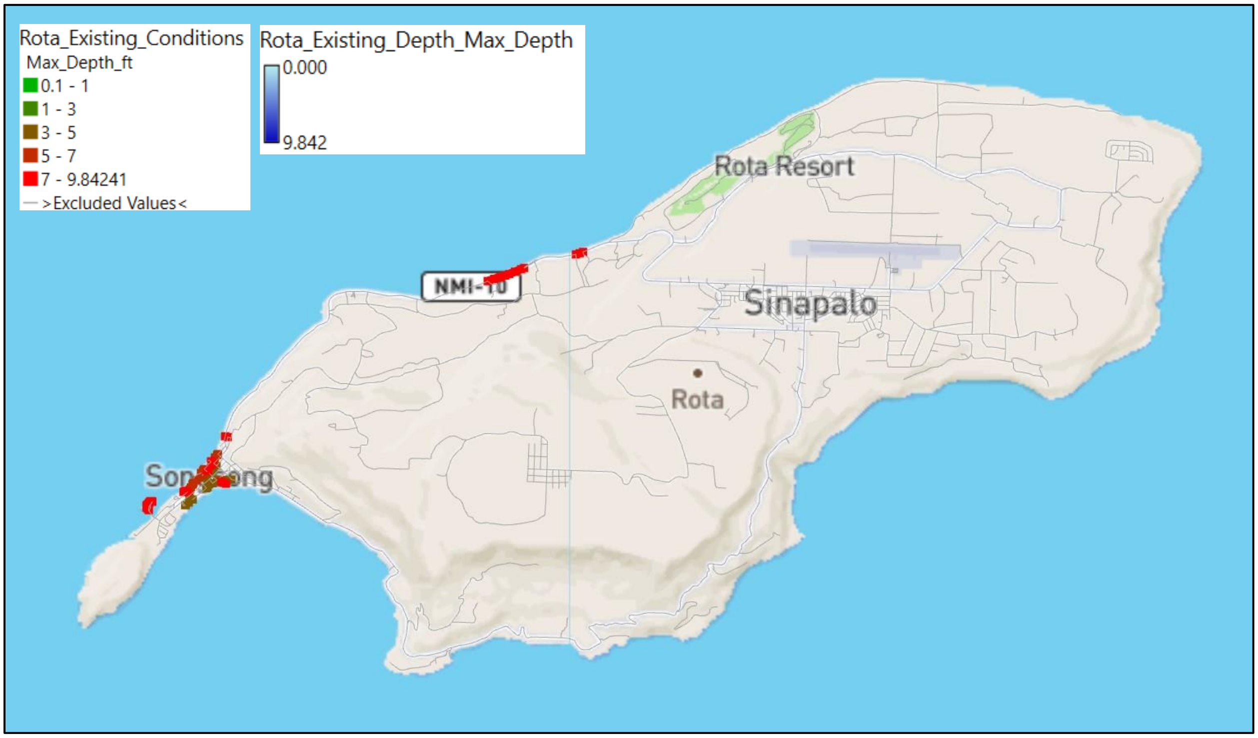

Figure 3-9: Map of existing scenario inundation hazard on Rota's roads under the NOAA MEOW Storm Surge event.

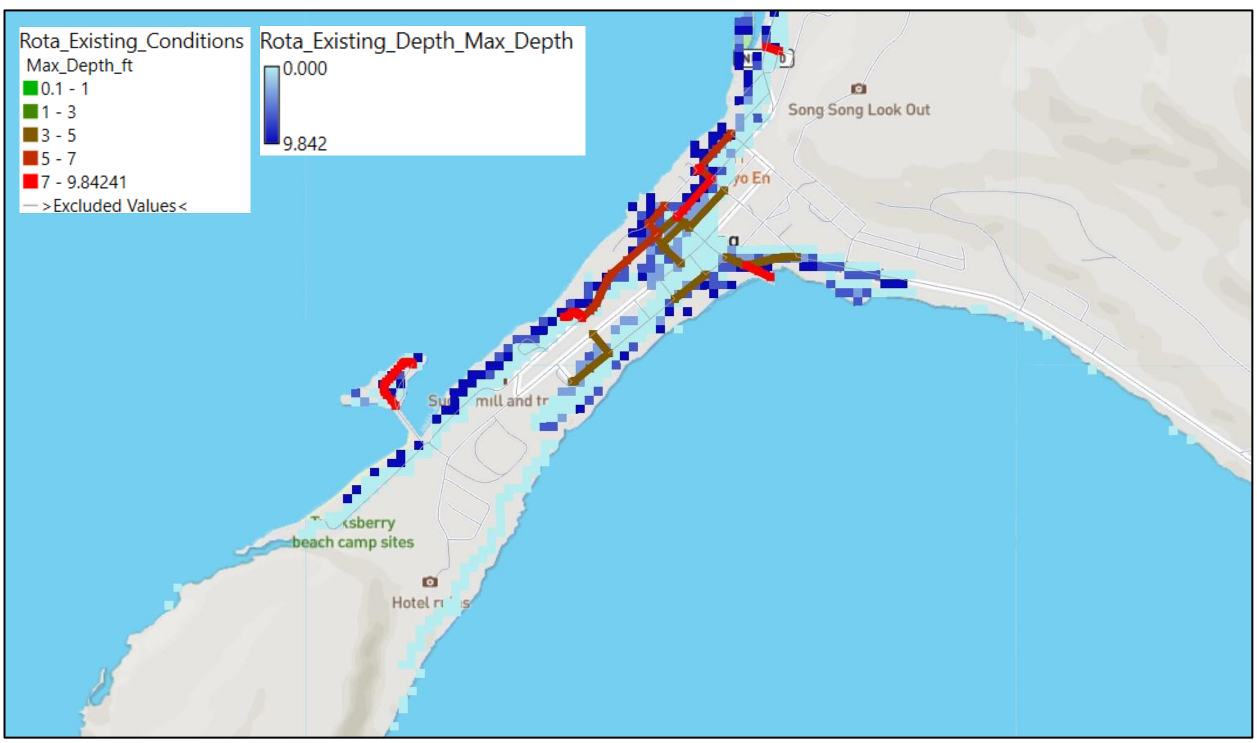

Figure 3-10: Map of Existing Scenario inundation hazard on Rota's roads (Song Song) under the NOAA MEOW Storm Surge event.

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 synthetic 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 year 2022 Scenario to the Future year 2072 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 CNMI to storm surge inundation increasing due to RSLC.

4.1 Population at Risk and Inundation of Structures

Figure 4-1 through Figure 4-6 show heat maps of the risk areas for the islands of Saipan, Tinian, and Rota under the future scenarios with RSLC. On Saipan, San Roque, the Lower Base area, Garapan, the American Memorial Park, and Tanapag show additional PAR from RSLC. In the future scenario, the island of Saipan experiences an 11% increase in the PAR to coastal flooding due to RSLC (Table 4-1). In both the existing and future scenario, the island of Tinian shows no PAR to coastal flooding. The PAR on the island of Rota increases within the village of Liyu while the village of Ugis, which has no PAR in the existing scenario, shows an entirely new area at risk to coastal flooding in the future scenario (Table 4-1). The village of Liyu displays a very large percentage change, however, this is due to the small (<10) PAR estimate within the existing condition. Overall, the island of Rota experiences a 23% increase in the PAR to coastal flooding. The village of Songsong, doesn’t experience increases in the PAR, however, the village is nearly completely inundated under both the existing and future scenarios due to its acutely vulnerable nature. The Commonwealth as a whole experiences a 16% increase in PAR in the future scenario attributable exclusively to RSLC.

Table 4-1: Areas and PAR vulnerable to RSLC in the future scenario.

Place	PAR - Existing	PAR - Future	Additional PAR in Future
Rota			
- Liyu	x	x	232%
- Songsong	x	x	
- Annex F	x	x	
- Ugis		x	**New PAR**
- Taimama	x	x	
Total - Rota	**x**	**x**	**23%**
Saipan			
- San Antonio	x	x	
- San Roque	x	x	30%
- Chalan Piao	x	x	
- Chalan Kanoa II	x	x	
- Lower Base	x	x	10%
- San Jose (Oleai)	x	x	
- China Town	x	x	
- Garapan	x	x	16%
- Susupe	x	x	
- Puerto Rico	x	x	
- American Memorial Park	x	x	14%
- As Palacios	x	x	
- Achugao	x	x	
- Tanapag	x	x	21%
Total - Saipan	**x**	**x**	**11%**
Total	**x**	**x**	**16%**

Table 4-2: Structures Inundated under existing and future scenarios.

Island/Village	Structures Inundated Existing	Structures Inundated Future	Additional Structures Inundated in Future	Percent Change in Future
Rota				
- Liyu	1	3	2	200%
- Songsong	64	64		
- Annex F	1	1		
- Ugis		1	1	**New Impacts**
- Taimama	1	1		
Total - Rota	**67**	**70**	**3**	**4%**
Saipan				
- San Antonio	9	9		
- San Roque	20	26	6	30%
- Chalan Piao	1	1		
- Chalan Kanoa II	2	2		
- Lower Base	30	33	3	10%
- San Jose (Oleai)	6	6		
- China Town	1	1		
- Garapan	257	297	40	16%
- Susupe	16	16		
- Puerto Rico	15	15		
- American Memorial Park	7	8	1	14%
- As Palacios	1	1		
- Achugao	12	12		
- Tanapag	56	68	12	21%
Total - Saipan	**433**	**495**	**62**	**14%**
CNMI Total	**500**	**565**	**65**	**13%**

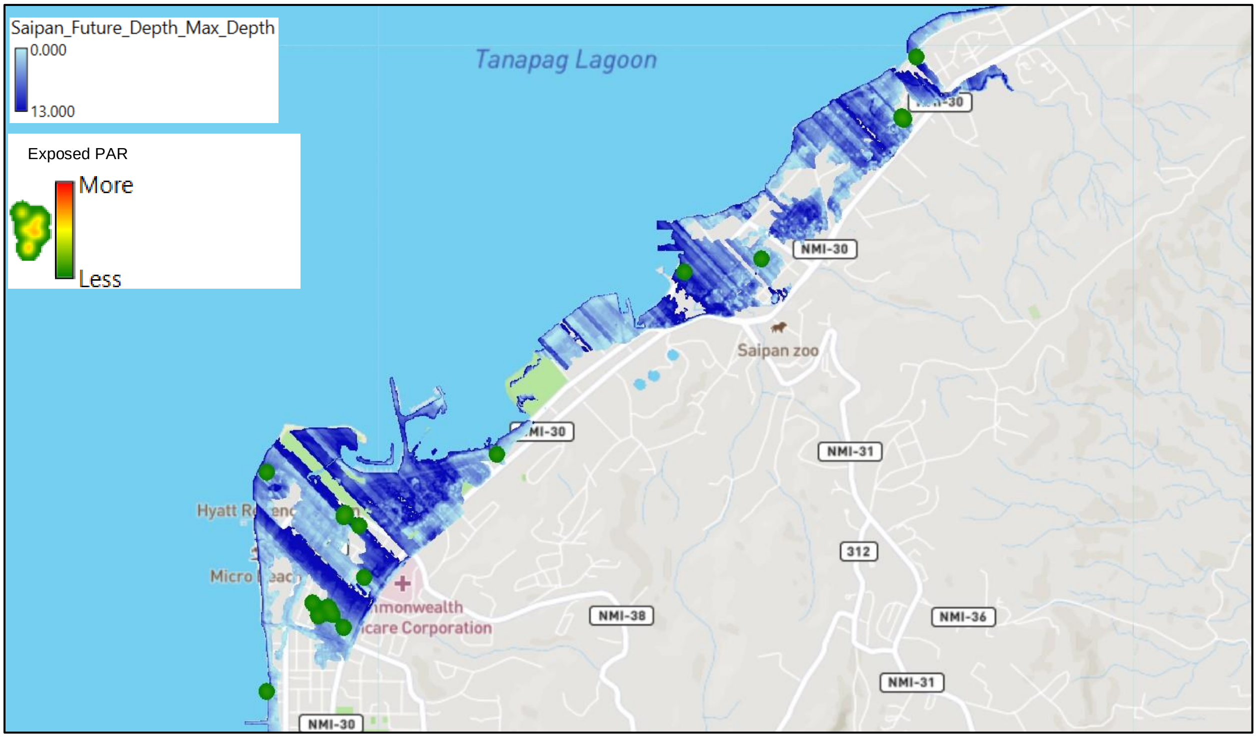

Figure 4-1: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Saipan (Garapan) under the MEOW Storm Surge event with future scenario RSLC.

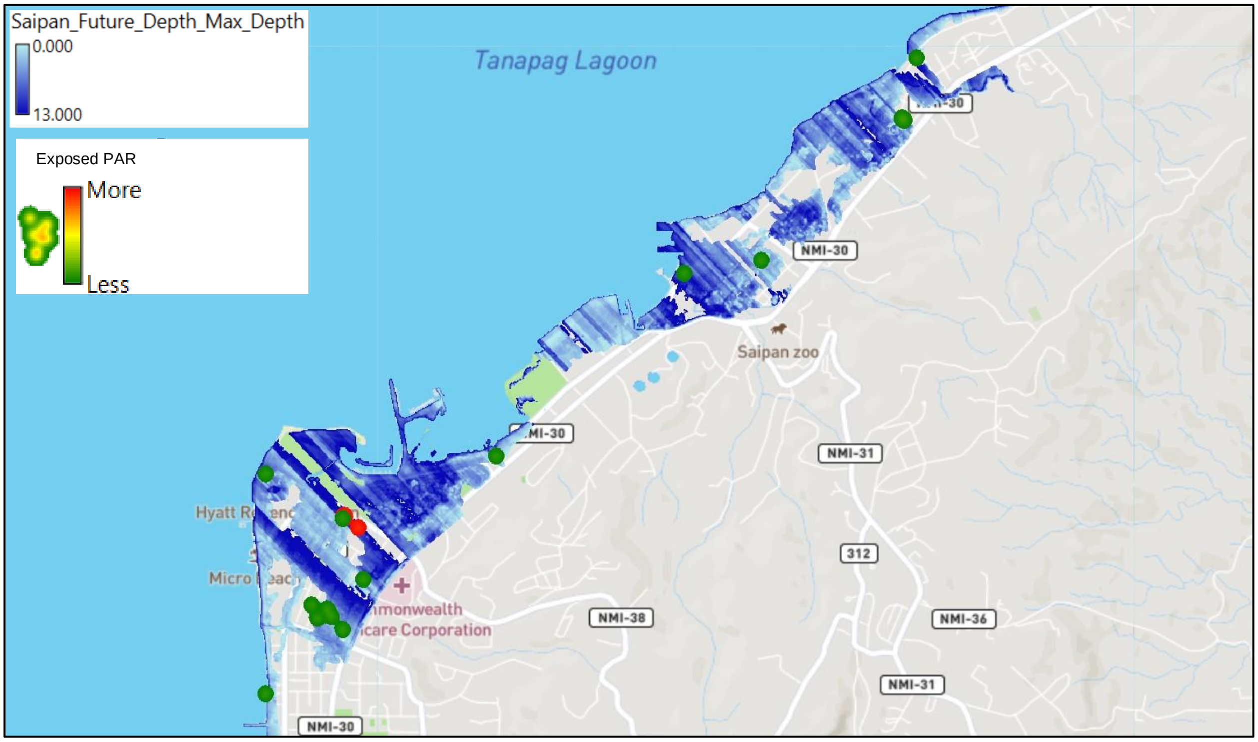

Figure 4-2: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Saipan (Garapan) under the MEOW Storm Surge event with future scenario RSLC. Solid red indicates new exposure in the future scenarios.

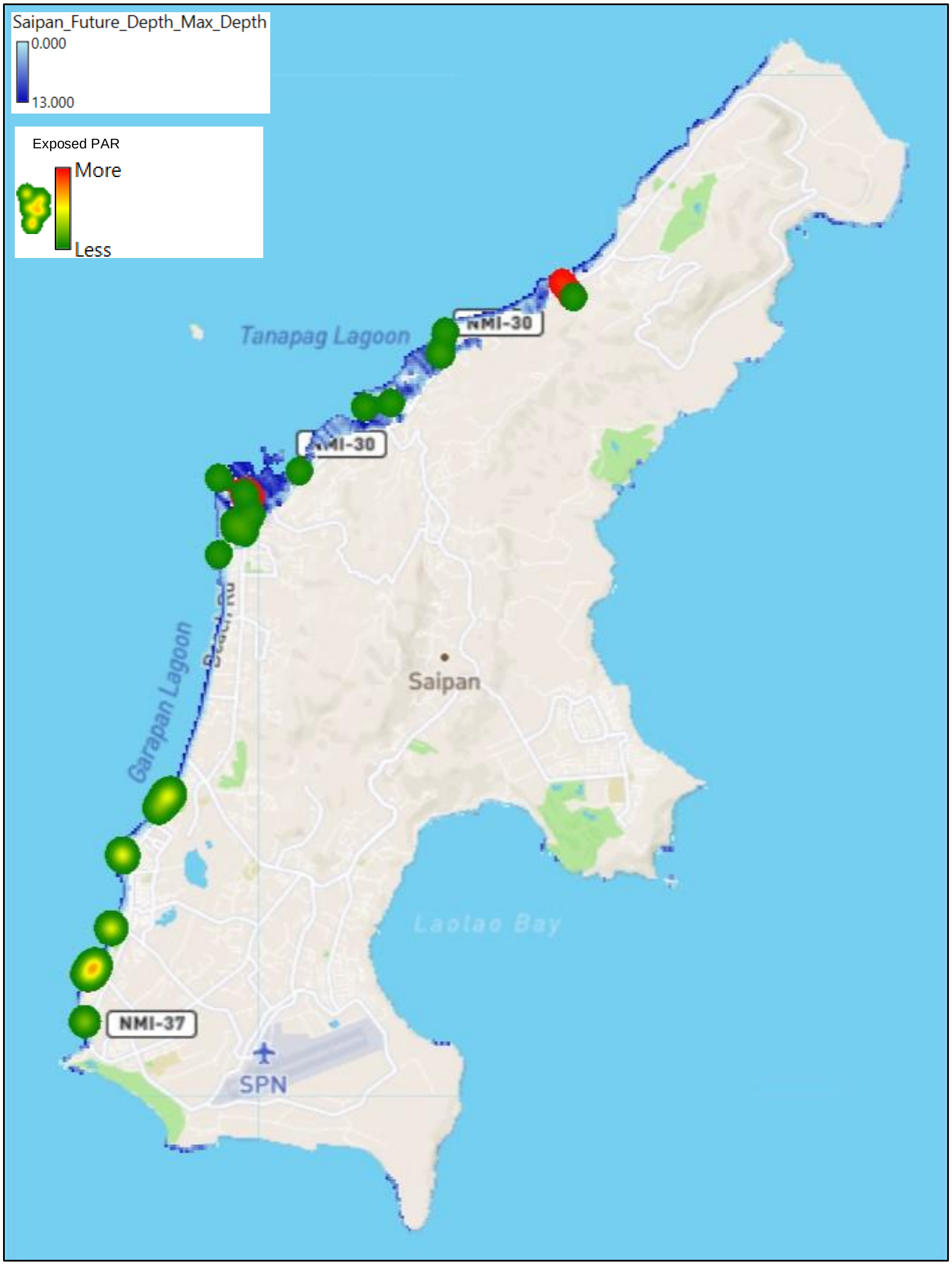

Figure 4-3: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Saipan under the MEOW Storm Surge event with future scenario RSLC. Solid red indicates new exposure in the future scenarios.

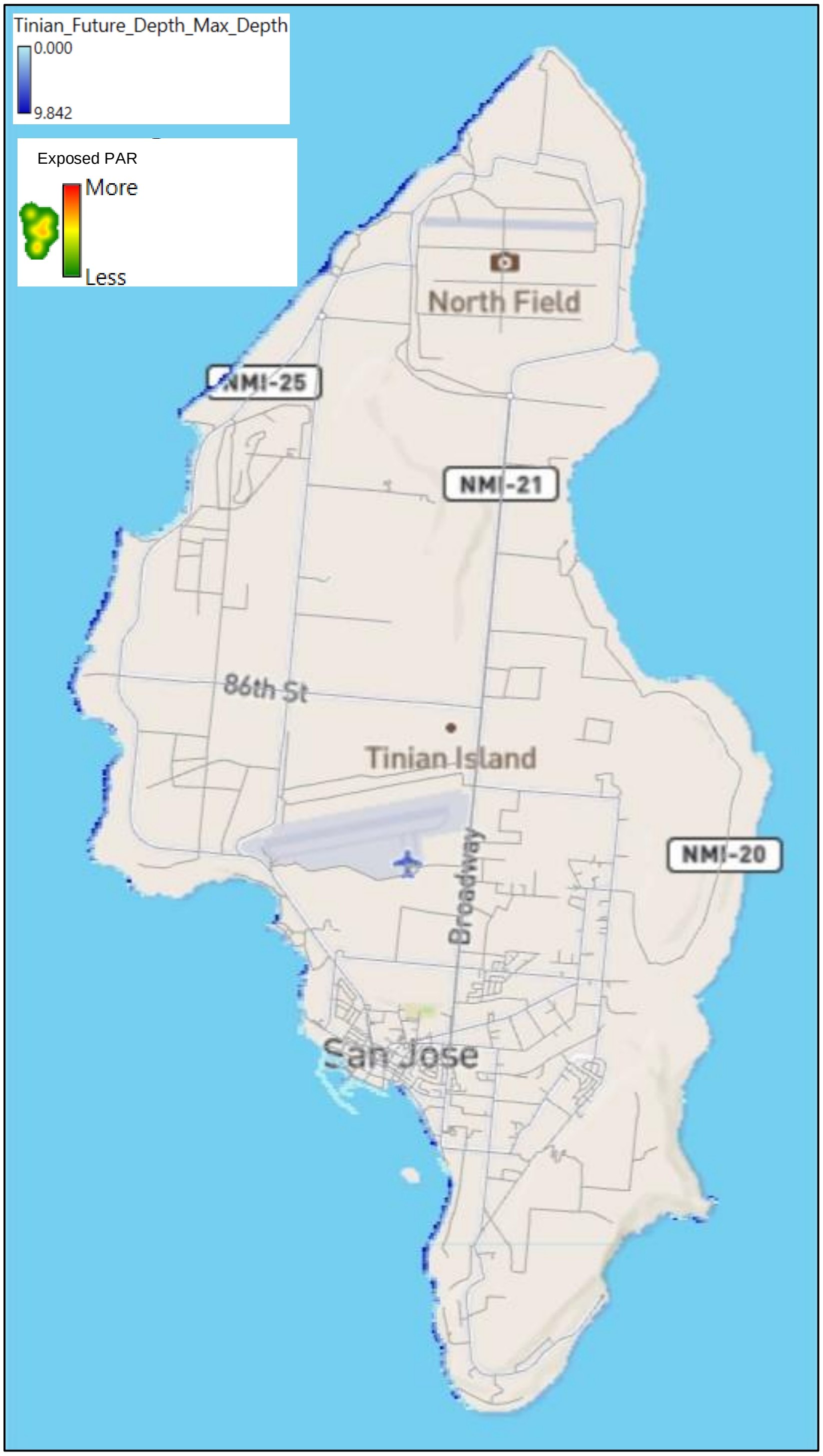

Figure 4-4: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Tinian under the MEOW Storm Surge event with future scenario RSLC.

Figure 4-5: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Rota under the MEOW Storm Surge event with future scenario RSLC.

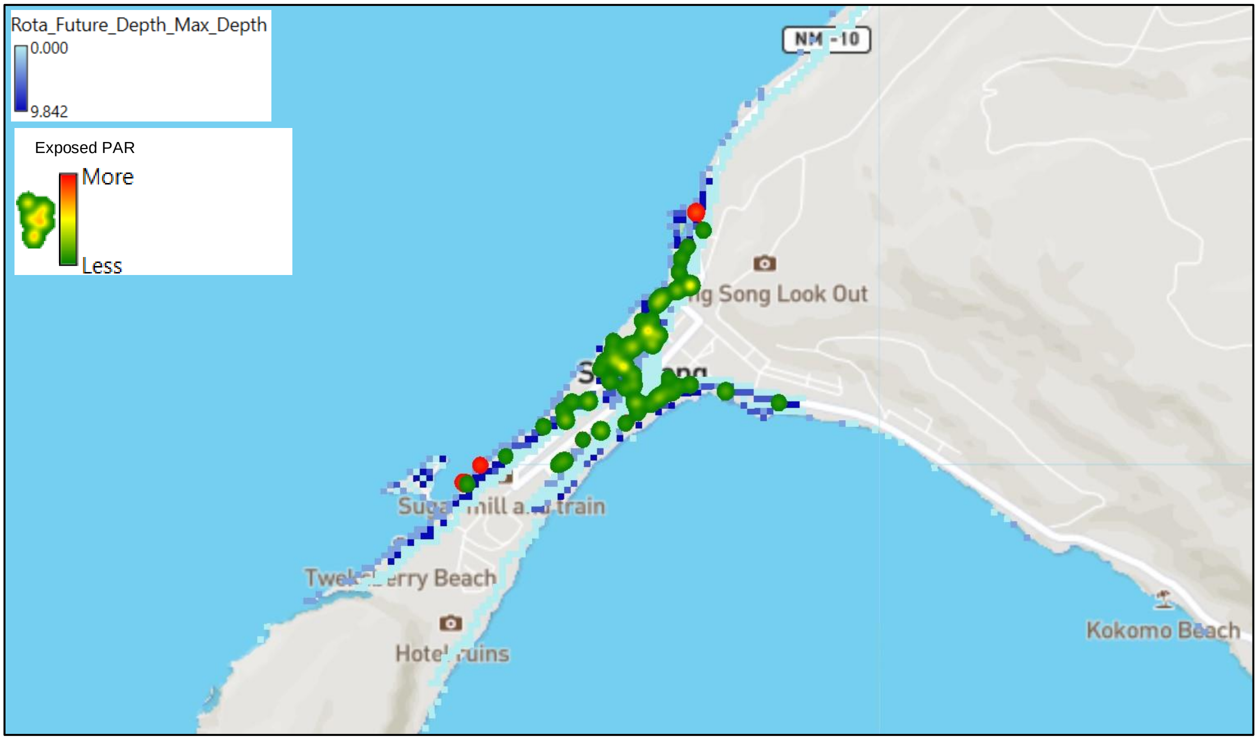

Figure 4-6: Inundation Extent of Future Scenario with RSLC with Heat map of risk areas for Rota (Song Song) under the MEOW Storm Surge event with future scenario RSLC. Solid red indicates new exposure in the future scenarios.

4.2 Exposed Road Infrastructure Future Scenarios

Exposed road infrastructure in the future scenario sees both a broadening of the number of roads exposed, as well as an increase of depth from the future scenario, leading to the inundated routs from the existing scenario, such as Middle Road, Route 30, and Beach Road to become even more dangerous for people attempting to travel. Tinian continues to benefit from the island's higher elevation geography in comparison to the island of Rota. Tinian does not see inundation on its roads in either the existing scenario nor the future scenario, whereas Rota sees increased depths, and inundation at an additional section of Route 10 between Songsong and the Rota resort.

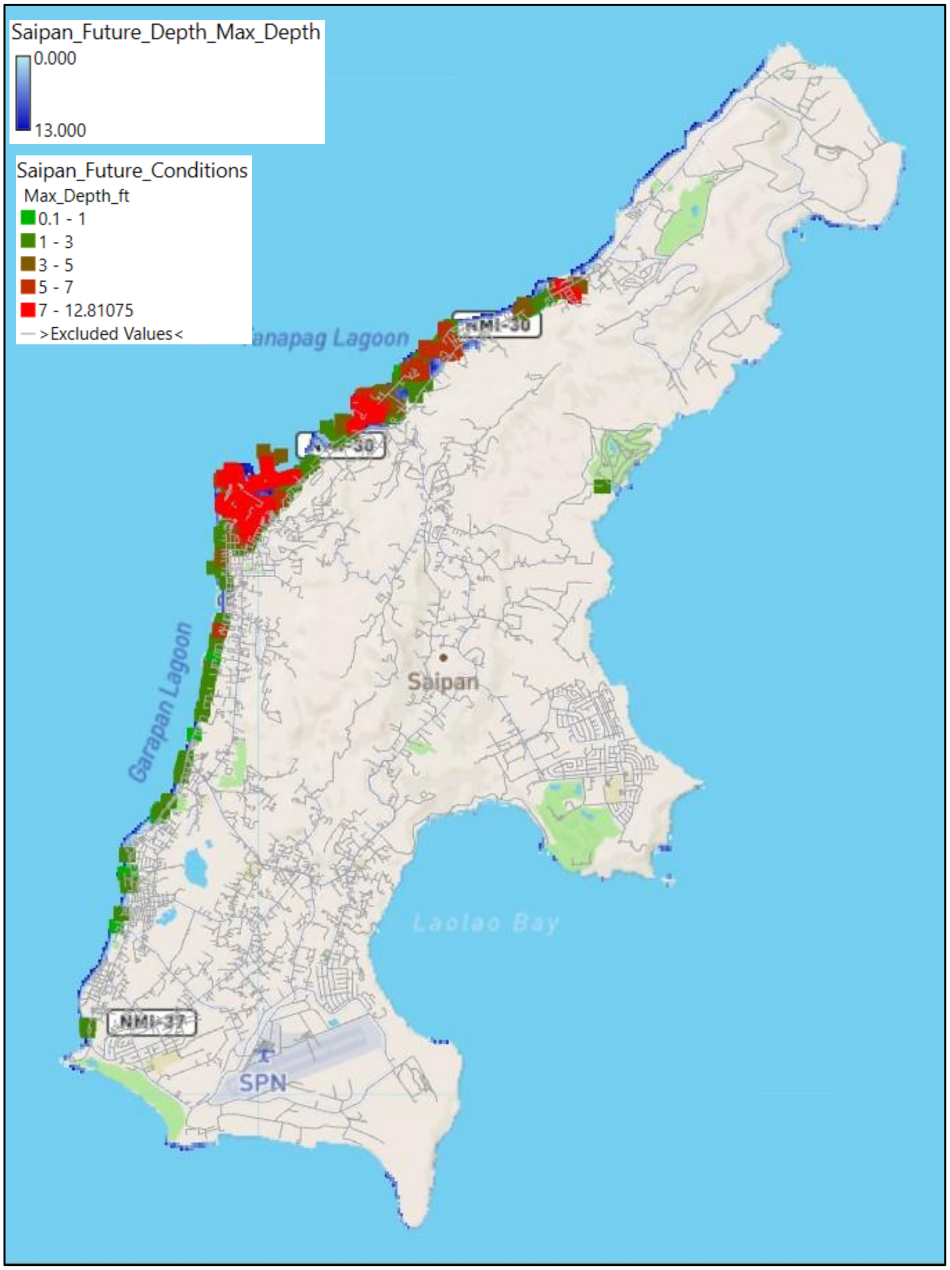

Figure 4-7: Inundation Extent of Future Scenario with RSLC with Map of risk on Saipan roads under the future MEOW Storm Surge scenario with RSLC.

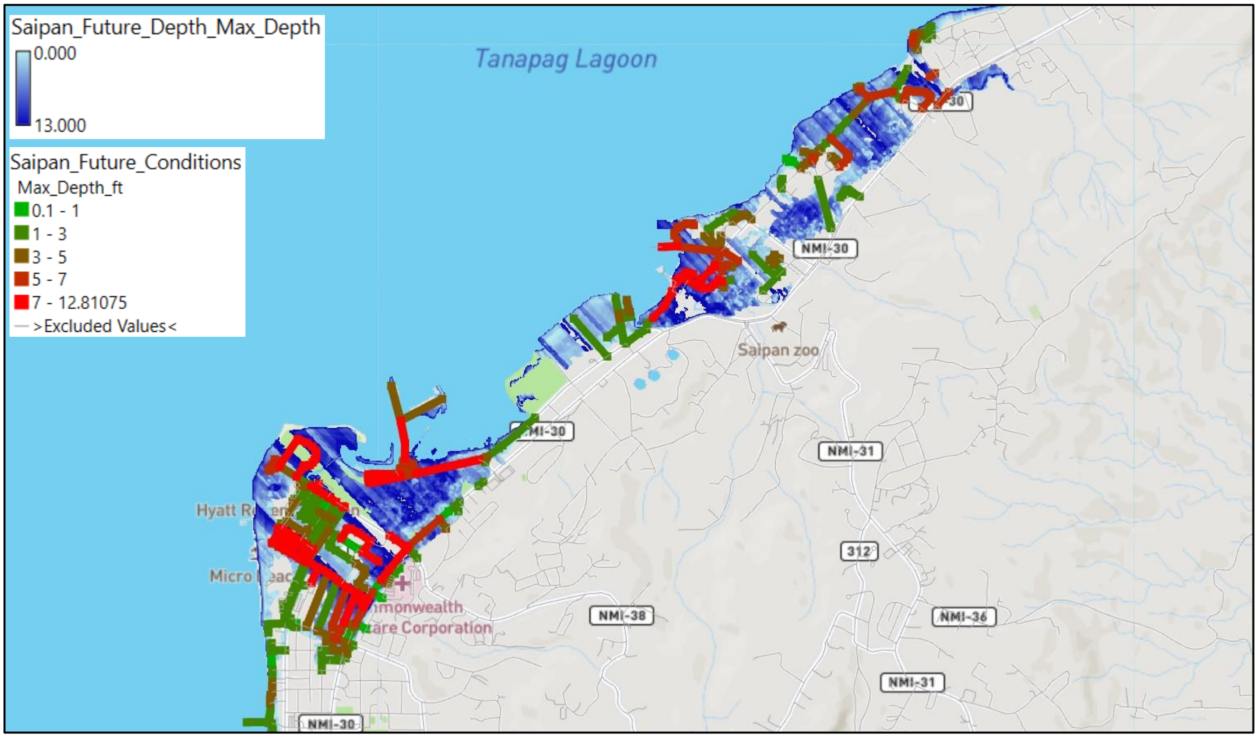

Figure 4-8: Inundation Extent of Future Scenario with RSLC with Map of risk on Saipan (Garapan) roads under the future MEOW Storm Surge scenario with RSLC.

Figure 4-9: Inundation Extent of Future Scenario with RSLC with Map of risk on Tinian roads under the future MEOW Storm Surge scenario with RSLC.

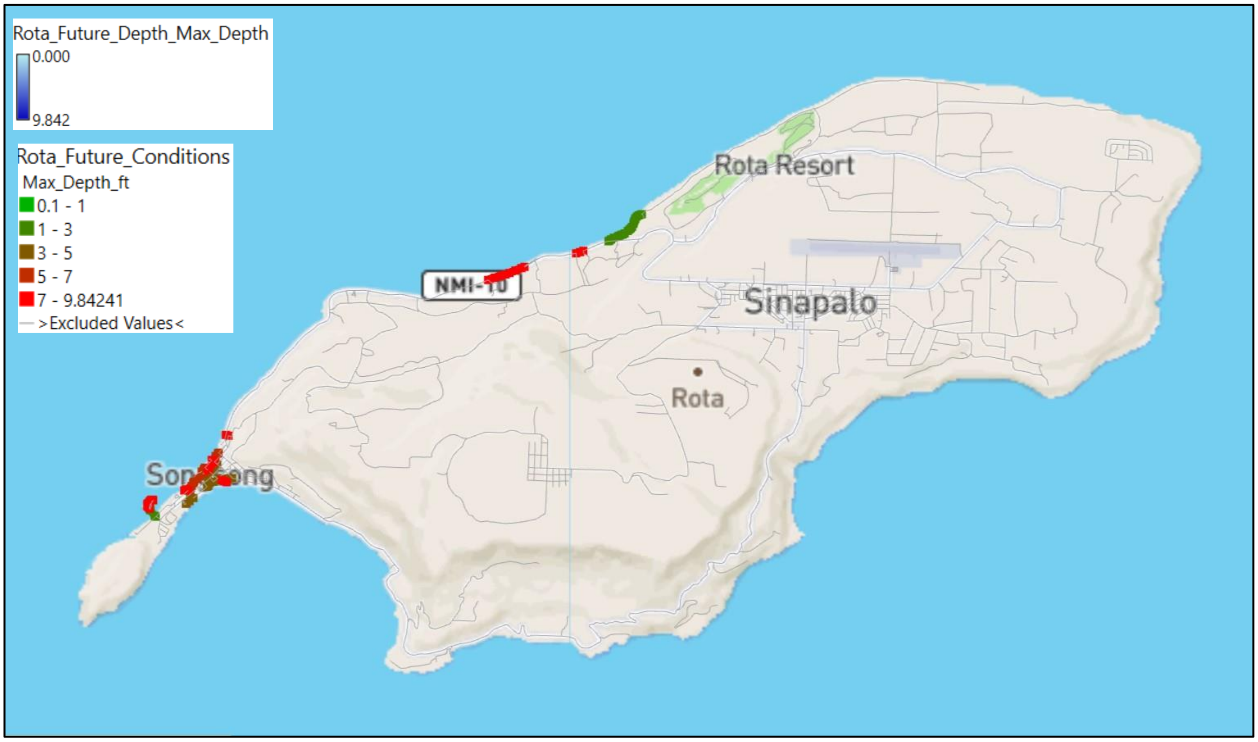

Figure 4-10: Inundation Extent of Future Scenario with RSLC with Map of risk on Rota roads under the future MEOW Storm Surge scenario with RSLC.

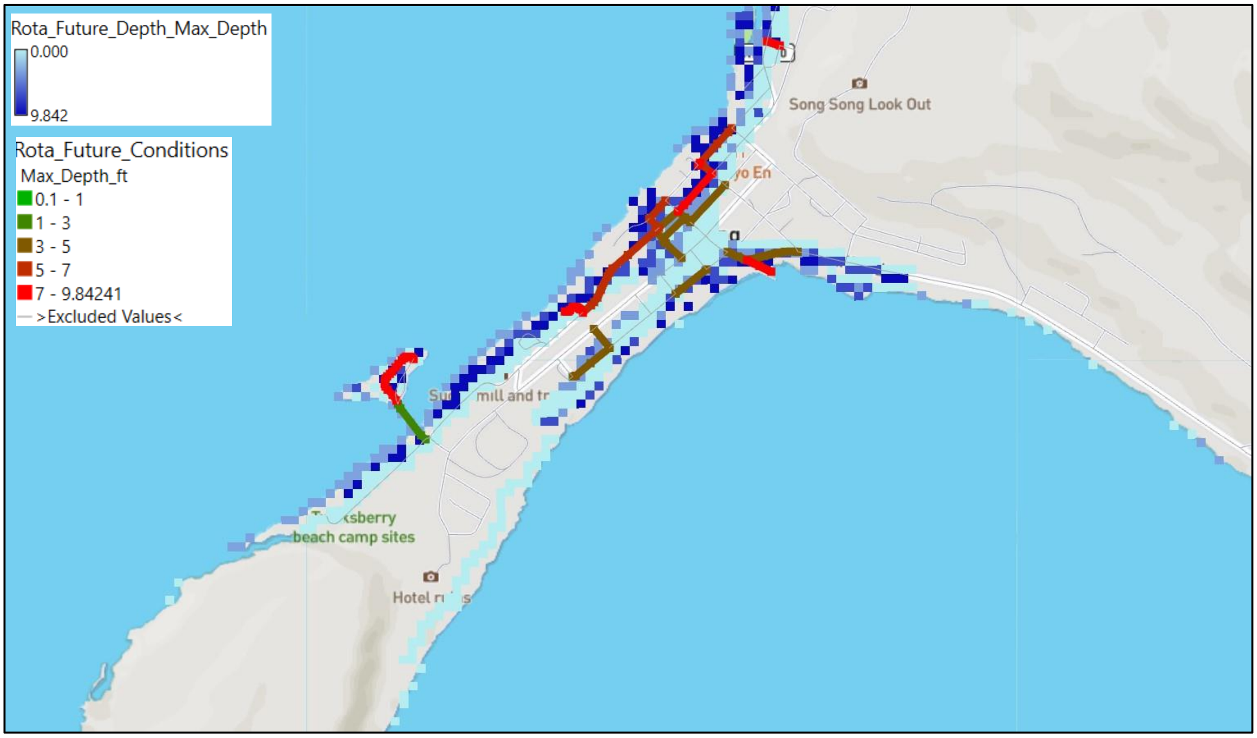

Figure 4-11: Inundation Extent of Future Scenario with RSLC with Map of risk on Rota (Song Song) roads under the future MEOW Storm Surge scenario with RSLC.

4.3 Findings and Discussion

As described in Section 4.1, The CNMI sees increases to estimated PAR, number of structures inundated and structure damages under the future scenario. Within the Commonwealth, new or increased PAR in the future scenario is estimated to occur in 7 villages. One of which, Ugis, on Rota is not estimated to occur until the future scenario. On Saipan, the largest increase in estimated PAR is the village of San Roque. The island of Tinian does not show existing or future estimated PAR, however it is only regarding coastal storm surge inundation and not risk to Tinian from other consequences that are known to occur during coastal storm events such as inland flooding from rainfall. Overall, there is an estimated 16% increase to PAR due to RSLC within CNMI.

Increases of structure impacts are seen on the islands of Rota and Saipan as well. New risk is seen on Rota in the village of Ugis, and Saipan shows several dozen new structures impacted due to RSLC. Overall, there is a 13% increase in the number of structures impacted from the existing to future scenario as shown in Table 4-2.

The LifeSim modeling also shows an increase in inundation of the road networks within the Commonwealth. The majority of inundation of roads is estimated to occur along the western coast of Saipan, with the greatest depths (over 12 feet) expected within and between the villages of Garapan and Tanapag. On Rota, the village of Songsong also sees increases of road depths with nearly all of the village’s roads experiencing segments flooded with depths of at least a foot. Of the 16,240 road segments within Saipan and Rota identified via OpenSreetMap, 359 road segments experience inundation under the existing scenario, with an additional 35 road segments in the future scenario (394 in total).

Increased elevation of coastal flooding in the future scenario due to RSLC could increase the amount of damages to structures within the commonwealth by 25%, with the areas of San Roque, Garapan, and Tanapag experiencing the largest increases as shown in Table 4-4.

Table 4-3: PAR in existing and future conditions.

Place	PAR - Existing	PAR - Future	Additional PAR in Future
Rota			
- Liyu	x	x	232%
- Songsong	x	x	
- Annex F	x	x	
- Ugis		x	**New PAR**
- Taimama	x	x	
Total - Rota	**x**	**x**	**23%**
Saipan			
- San Antonio	x	x	
- San Roque	x	x	30%
- Chalan Piao	x	x	
- Chalan Kanoa II	x	x	
- Lower Base	x	x	10%
- San Jose (Oleai)	x	x	
- China Town	x	x	
- Garapan	x	x	16%
- Susupe	x	x	
- Puerto Rico	x	x	
- American Memorial Park	x	x	14%
- As Palacios	x	x	
- Achugao	x	x	
- Tanapag	x	x	21%
Total - Saipan	**x**	**x**	**11%**
CNMI Total	**x**	**x**	**16%**

Table 4-4: CNMI structure damages.

CNMI Structure Damages	
Village	**Percent Change Future**
Rota	
- Liyu	5.26%
- Songsong	0.00%
- Annex F	0.00%
- Taimama	0.00%
Rota Total	**0.39%**
Saipan	
- San Antonio	0%
- San Roque	73%
- Lower Base	26%
- San Jose (Oleai)	0%
- Garapan	55%
- Susupe	0%
- Puerto Rico	0%
- American Memorial Park	28%
- Achugao	0%
- Tanapag	68%
Saipan Total	**53%**
CNMI Total	**25%**

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