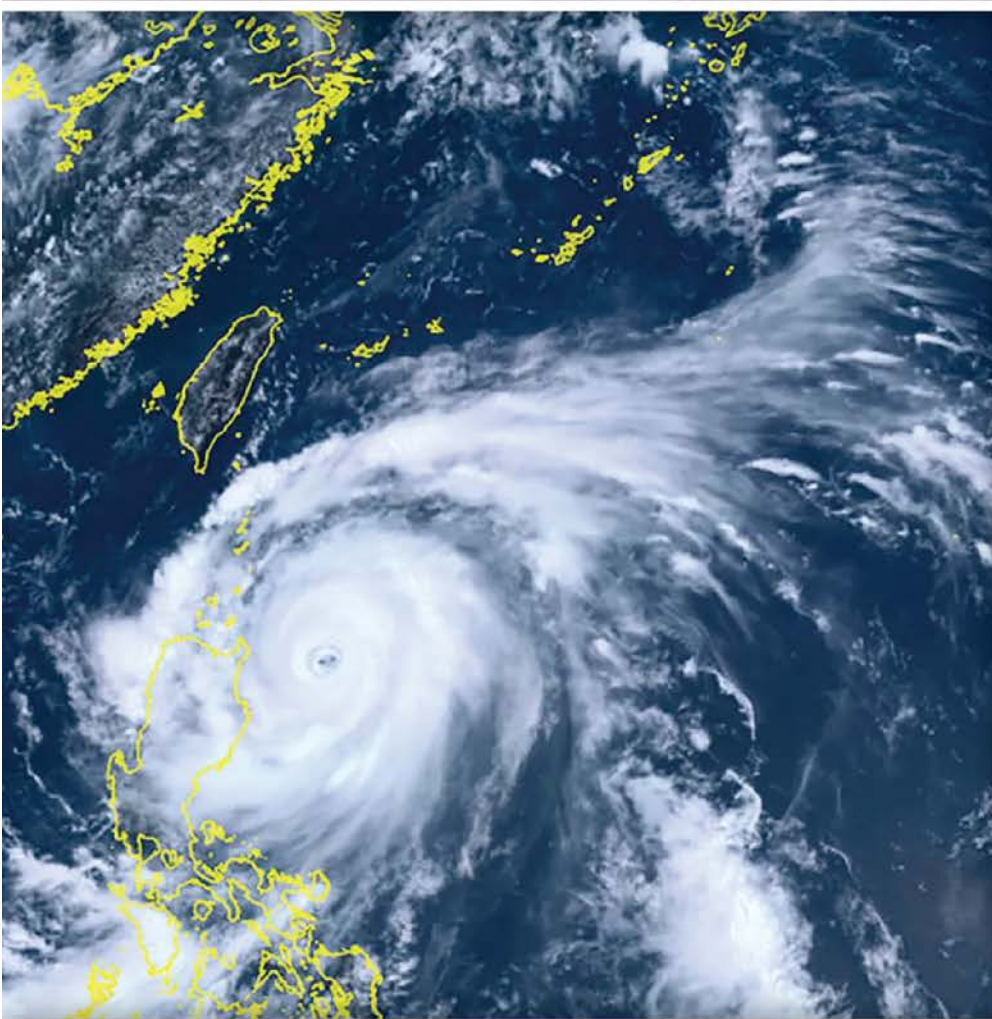


2024

GUAM HAZARD MITIGATION PLAN

JUNE 2024



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ACKNOWLEDGEMENTS

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Lieutenant Governor of Guam

Honorable Joshua F. Tenorio

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ACRONYMS AND ABBREVIATIONS

#

°F degrees Fahrenheit

A

ANA Administration for Native Americans
APHIS Animal and Plant Health Inspection Service
ASCE American Society of Civil Engineers

B

BBMR Bureau of Budget and Management Research
BRFSS Behavioral Risk Factor Surveillance System
BRIC Building Resilient Infrastructure and Communities
BSP Bureau of Statistics and Plans
BZPP Buffer Zone Protection Program

C

CDBG Community Development Block Grant (Program)
CDC Centers for Disease Control and Prevention
CERCLIS Comprehensive Environmental Response, Compensation, and Liability
 Information System
C.F.R. Code of Federal Regulations
CIP Capital Improvement Project
CNMI Commonwealth of the Northern Mariana Islands
COVID-19 Coronavirus Disease 2019
CRB coconut rhinoceros beetle
CZMP Coastal Zone Management Program

D

DFIRM Digital Flood Insurance Rate Map
DLM Guam Department of Land Management
DMA 2000 Disaster Mitigation Act of 2000
DoAg Guam Department of Agriculture
DoD Department of Defense
DPHSS Guam Department of Public Health and Social Services
DPW Guam Department of Public Works

ACRONYMS AND ABBREVIATIONS

E

EFMUTS	Essential Facilities, Major Utilities, and Transportation Systems
ENSO	El Niño–Southern Oscillation
E.O.	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act ER Emergency Relief (Program)
ERP	Emergency Response Plan
ESF	Emergency Support Function
ESG	Emergency Shelter Grant

F

FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance (Program)
FY	fiscal year

G

g	the vertical acceleration force due to gravity
GAR	Governor’s Authorized Representative
GBS	General Building Stock
G.C.A.	Guam Code Annotated
GEDA	Guam Economic Development Authority
GEPA	Guam Environmental Protection Agency
GHMGP	Guam Hazard Mitigation Grant Program
GHS	Guam Office of Homeland Security
GHURA	Guam Housing and Urban Renewal Authority
GIAA	Guam International Airport Authority
GIS	Geographic Information System
GMH	Guam Memorial Hospital
GMHA	Guam Memorial Hospital Authority
GPA	Guam Power Authority
GSHAP	Global Seismic Hazard Assessment Program
GWA	Guam Waterworks Authority

ACRONYMS AND ABBREVIATIONS

H

HAZMAT	Hazardous Material
HAZUS	Hazards United States
HAZUS-MH	Hazards United States Multi-Hazard
HMAC	Hazard Mitigation Advisory Committee
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HMWG	Hazard Mitigation Working Group
DHS	U.S. Department of Homeland Security
HS GP	Homeland Security Grant Program
HUD	U.S. Department of Housing and Urban Development
HURISK	Hurricane Risk model

I

IA	Individual Assistance
IBC	International Building Code
IOF	Initial Operating Facility
IRC	International Residential Code

M

M	magnitude
MM	Modified Mercalli (Intensity Scale)
mph	miles per hour
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
MSAW	minimum safe altitude warning

N

NCDC	National Climatic Data Center
NCTS	Naval Computer and Telecommunications Station
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTSB	National Transportation Safety Board
NWS-WFO	National Weather Service–Weather Forecast Office

O

OCD	Guam Office of Civil Defense
OIE	Office International des Epizooties

ACRONYMS AND ABBREVIATIONS

P

PA	Public Assistance (Program)
PAG	Port Authority of Guam
PDM	Pre-Disaster Mitigation
PGA	peak ground acceleration
PIRCA	Pacific Islands Regional Climate Assessment
PMEL	Pacific Marine Environmental Laboratory
PSC	Pacific Services Center
PSGP	Port Security Grant Program

R

RAC	Response Activity Coordinator
RCO	Recovery Coordination Office
RFC	Repetitive Flood Claim (Program)
RL	Repetitive Loss

S

SAFER	Staffing for Adequate Fire and Emergency Response
SBA	Small Business Administration
SEDS	Social and Economic Development Strategies
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SPR	Stakeholder Preparedness Review
SRL	Severe Repetitive Loss (Program)
Stafford Act	Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988
SVI	Social Vulnerability Index

T

THIRA	Threat and Hazard Identification and Risk Assessment

U

USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
U.S.	United States
USGS	U.S. Geological Survey

V

VS	Veterinary Services

W

WERI	Water and Environmental Research Institute of the Western Pacific, University of Guam

SECTION 1 – ADOPTION AND ASSURANCES

1.1 PURPOSE

The purpose of this section is to provide the Federal Emergency Management Agency (FEMA) required adoption and assurances for the 2024 Guam Hazard Mitigation Plan (HMP).

1.2 ADOPTION



S19. Did the state provide documentation that the plan has been formally adopted? [44 CFR § 201.4(c)(6)]

The Territory of Guam adopted the plan on Month, DD, YYYY through E.O. On Month, DD, YYYY, FEMA R9 notified GHS-OCD that the HMP was formally approved.

The 2024 Guam HMP meets the requirements of Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (Stafford Act) and FEMA's State Mitigation Planning Policy Guide (2022) requirements, including the requirement that the Government of Guam adopt the plan.¹

The Guam Offices of Homeland Security and Civil Defense (GHS-OCD) prepared the 2024 Guam HMP for promulgation and adoption by the Governor and the Lieutenant Governor of Guam through the issuance of Executive Order ## dated Month DD, YYYY [Refer to **Appendix A** (Adoption Resolution)].

1.3 ASSURANCES



S20. Did the state provide assurances? [44 CFR § 201.4(c)(7)]

The section assures that the Territory of Guam will manage and administer grant funding IAW CFR and that the HMP will be updated as necessary.

Per 44 CFR 201.4(c)(7), the Territory assures that it will manage and administer FEMA funding. These efforts will comply with the following:

- 2 CFR Part 200—Office of Management and Budget Guidance: Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
- 2 CFR Part 3002—Department of Homeland Security adoption of the Office of Management and Budget Guidance listed in 2 CFR Part 200, giving regulatory effect to the guidance and supplementing the guidance as needed for the Department of Homeland Security

¹ Federal Emergency Management Agency, "State Mitigation Planning Policy Guide" (Washington, D.C.: Federal Emergency Management Agency, April 19, 2022), https://www.fema.gov/sites/default/files/documents/fema_state-mitigation-planning-policy-guide_042022.pdf.

SECTION 1

PREREQUISITES

The Territory assures it will amend Guam's HMP as required by 44 CFR 201.4(c)(7) whenever necessary to reflect changes in Territory or Federal statutes and regulations.²

² 44 CFR 201.4

SECTION 2 – BACKGROUND

2.1 PURPOSE

The purpose of this section is to provide an overview of the 2024 Guam HMP, a discussion of the authority under which the plan was prepared and adopted, and a disclaimer regarding the HMP and HMP update process.

2.2 OVERVIEW

To receive federal disaster mitigation funds, the 2024 Guam HMP must meet the requirements of Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and FEMA's State Mitigation Planning Policy Guide.

Significant provisions of the Stafford Act include funding for pre-disaster mitigation activities, developing multi-hazard maps to understand risk better, establishing state and local government infrastructure mitigation planning requirements, defining how states can assume more responsibility in managing the Hazard Mitigation Grant Program (HMGP), and adjusting how project management costs are funded.

FEMA prepared further guidance to assist state, local, and tribal governments to meet the new 2022 State Mitigation Planning Policy Guide. The document has three guiding principles:

- Focus on Risk-Informed Mitigation Strategies.
- Foster Cooperative Relationships and an Integrated State Planning Framework that Strengthens Connections between the Local and State Plans.
- Improve Mitigation Capabilities.³

Integrating the Stafford Act with the 2022 State Mitigation Planning Policy Guide is indispensable for the 2024 Guam Hazard Mitigation Plan. The Stafford Act provides a foundational legal framework outlining the federal disaster relief protocols and eligibility for funding, which is essential for unincorporated territories such as Guam with unique environmental and logistical challenges. The Stafford Act mandates that Guam develop and maintain an approved hazard mitigation plan to qualify for federal assistance, stressing the importance of proactive disaster preparedness and recovery strategies.⁴ Meanwhile, the 2022 State Mitigation Planning Policy Guide offers comprehensive guidelines to meet Guam's specific risks, identified in **Appendix B** (Planning Review Tool). This guide assists in identifying local hazards, assessing vulnerabilities, and prioritizing mitigation strategies that are both effective and feasible. Also, it incorporates the latest risk assessment and planning methodologies, ensuring mitigation efforts are grounded in current best practices and technologies.

³ State Mitigation Planning Policy Guide, 4.

⁴ "Robert T. Stafford Disaster Relief and Emergency Assistance Act, P.L. 93-288 as Amended," 322 § (2024), <https://www.govinfo.gov/content/pkg/COMPS-2977/pdf/COMPS-2977.pdf>.

By aligning Guam's hazard mitigation planning with the strategic and financial support outlined in the Stafford Act and the detailed, actionable steps provided by the 2022 Policy Guide, the 2024 Guam Hazard Mitigation Plan will meet federal requirements and establish a robust framework for reducing disaster risks. This integrated approach ensures that mitigation efforts are comprehensive, well-coordinated, and effectively implemented, significantly enhancing Guam's resilience to natural disasters and minimizing potential impacts on its population and infrastructure.

2.3 AUTHORITY

The plan is a living document updated every five (5) years. During the five years before an update, the plan should be implemented as much as possible to create an increasingly strong "all-hazards" mitigation environment and a sustainable "all-hazards" mitigation community in Guam.

GHS-OCD prepared the plan. The State Hazard Mitigation Officer (SHMO) led the effort, with significant assistance from numerous Government of Guam agencies, other interested parties within the Hazard Mitigation Advisory Committee (HMAC) and Hazard Mitigation Working Group (HMWG). FEMA Region IX provided technical assistance to GHS-OCD and HMWG during the update process.

The 2024 Guam HMP is authorized by the Guam Civil Defense Act of 1951⁵, as amended by Public Law 24-298 (included in the original Government Code of Guam enacted by Public Law 1-88, 1952), and Executive Order 97-18 relative to establishing a Civil Defense Advisory Council and the HMAC. Public Law 20-147, Chapter II of Title LXV (Comprehensive Planning), also supports the Government of Guam's hazard mitigation activities.

The 2024 Guam HMP is promulgated and adopted by the Governor of Guam through executive order.

2.4 DISCLAIMER

It is important to note that the 2024 Guam HMP was prepared using the best available data at the time of preparation. Significant time and resources were expended to involve all relevant parties, gather all available information, review and rectify data, conduct and interpret analyses, discuss findings, and reach consensus.

However, numerous and sometimes significant hurdles were encountered during plan preparation. Some of these issues were resolved, but some must be addressed before or during the next five-year plan update.

⁵ 10 G.C.A. 65101

The analyses and associated maps in the 2024 Guam HMP indicate potential exposure (susceptibility) to the hazards but do not indicate the probability or magnitude of all hazard events due to limited data. The maps and analyses in this report are not intended to be relied on as the sole source of information regarding potential exposure (susceptibility) to hazard events, and these maps and analyses should not be used to predict the probability or magnitude of specific hazard events or the potential damage from a hazard event at a particular location.

The 2024 Guam HMP is designed as an instrument of mitigation, primarily for natural disasters and other environmentally-related events. Although some human involvement is implied with many of the hazards profiled herein, this document does not address the prevention or mitigation of the possible impacts of terrorist activity. The term terrorism encompasses intentional, criminal, or malicious acts involving weapons of mass destruction, including biological, chemical, nuclear, and radiological weapons; arson, incendiary, explosive, and armed attacks; industrial sabotage and intentional hazardous material (HAZMAT) releases; and cyber terrorism (attacks through the computers). Therefore, the 2024 Guam HMP does not intend to pre-emptively address these specific events. Definitions of the key terms found throughout this document are provided in **Appendix C** (Definitions).

SECTION 3 – PLANNING PROCESS

3.1 PURPOSE

This section describes the process of preparing the 2024 Guam HMP. Specifically, it discusses documentation of the planning process of the State Mitigation Planning Policy Guide requirements, coordination among agencies, and plan integration.

3.2 DOCUMENTATION OF PLANNING PROCESS

The State Mitigation Planning Policy Guide requirements for the planning process hyper-focus on the 2024 Guam HMP's development and update process. The 2024 Guam HMP update process and development history are shown below to build upon the most recent update period, ensuring a continuous improvement cycle.



S1. Does the plan include a description of the process used to develop the plan? [44 CFR §§ 201.4(b) and 201.4(c)(1)]

Section 3.2.1 addresses this requirement, including the process, its preparation, the schedule, specific milestones and activities, and the agencies and stakeholders involved.

3.2.1 2024 GUAM HMP UPDATE PROCESS

Although the 2024 Guam HMP updating process was disrupted by the Coronavirus Disease 2019 (COVID-19) pandemic (2020 to 2022) and Typhoon Mawar (2023), there is an ideal update process. Explicitly, the process that should have happened to update the Guam 2024 HMP is in three phases spanning two years. The three phases are (1) the Planning Phase, (2) the Development Phase, and (3) the Approval and Implementation Phase. The Planning Phase is as follows: (1) Month 1-3: Conduct initial meetings with stakeholders to establish goals, governance, and the plan's scope; (2) Month 4-6: Engage the public and start data collection and risk assessment processes, and (3) Month 7-9: Develop risk profiles for each significant hazard and formulate mitigation strategies. The Development Phase is as follows: (1) Month 10-12: Draft the mitigation strategies and action plans. Conduct review sessions with key stakeholders and revise strategies based on feedback, and (2) Month 13-15: Finalize and submit the 2024 Guam HMP draft for public review. Incorporate public input and prepare the final document. The Approval and Implementation Phase is Months 16-24: Submit the plan to the appropriate and relevant government authorities of Guam and FEMA for approval. Once approved, begin implementing prioritized mitigation actions.

Planning Phase: Months 1 - 3

The Hazard Mitigation Grants Council Meeting marked the initial planning phase on June 8, 2022. This pivotal event, held at the Governor's Large Conference Room in Adelup, served as a platform for presenting and evaluating submission applications related to DR-4495 COVID-19. Stakeholders from the government of Guam agencies represented various disciplines, such as planning, finances, grants, economy, and infrastructure. The discussions and decisions from this meeting played a crucial role in shaping the foundational strategies of the 2024 Guam HMP, ensuring the mitigation strategies were well-aligned with current needs and available resources. Establishing

SECTION 3

PLANNING PROCESS

key stakeholders was a key topic of discussion, and preliminary schedules were presented, depending on the funding awarded for the plan development. This early prioritization of projects set a robust framework for the subsequent phases of the plan's development, underlining the importance of stakeholder collaboration in our collective success.

Planning Phase: Months 4 – 6

The focus expanded to public engagement and data collection, highlighted by the meeting with the Guam Waterworks Authority (GWA) on July 7, 2022. This meeting addressed challenges in water and power services—common and life-line concerns during disasters. The action plans and mitigation strategies discussed were vital for enhancing the risk assessment processes within the HMP. By integrating scenarios involving utility disruptions into the plan, GWA stakeholders aimed to strengthen the resilience of critical infrastructure, thereby enhancing the island community's ability to withstand such disruptions. The thoroughness of our data collection resources and studies, initiated in January 2022 and continued, including reviews of the THIRA/SPR for identifying hazardous threats, the Integrated Preparedness Plan, and various watershed studies conducted by USACE, among others, should inspire confidence in the effectiveness of our risk assessment process.

Planning Phase: Months 7- 9

In the final segment of the planning phase, stakeholders participated in a Benefit-Cost Analysis (BCA) Training from February 7 to 10, 2023. The stakeholders who attended were PAG, GCC, GMHA, MCOG, GFD, GDOE, BSP, and DYA, demonstrating participation in multiple fields, such as education, local governments (villages), health, emergency services, planning, transportation, and public safety. This training was essential in helping stakeholders evaluate the cost-effectiveness of proposed mitigation actions. Using the BCA Toolkit, participants assessed the long-term benefits of mitigation strategies against their initial costs. This approach was crucial for developing economically viable and effective mitigation strategies integral to the HMP.

Development Phase: Months 10 – 12

The Development Phase, spanning months ten to twelve, was a testament to stakeholders' collaborative and collective efforts. The Local Mitigation Planning Workshop marked the phase, held virtually from June 13 to 16, 2023. This workshop provided essential knowledge on mitigation planning, risk assessment, and strategy development. The insights gained were instrumental as stakeholders drafted informed and practical action plans. The inclusion of CNMI emergency and hazard professionals, who shared their experiences and recommendations, further underscored the collaborative nature of this phase. It was a collective effort to synthesize the earlier collected input and data into a coherent draft of the 2024 Guam HMP, emphasizing the shared responsibility and teamwork that underpins our approach.

Development Phase: Months 13 – 15

In the subsequent months, the draft underwent a critical refinement process during the Guam Mitigation Consultation and Plan to Action (P2A) from August 14 to 18, 2023,

held at the UOG Building 12. This consultation was a comprehensive planning session with local partners and FEMA, allowing for an in-depth review and refinement of the 2024 Guam HMP. The session was based on a thorough understanding of local and federal resources and priorities, ensuring the draft plan accurately reflected the mitigation needs and strategies suitable for addressing the unique challenges faced by Guam. The September 12-13, 2023 Hazard Mitigation Grant Section hosted a Hazard Mitigation Kick-off Workshop for Typhoon Mawar at the GHS-OCD Initial Operating Facility (IOF), further enhancing the collaborative efforts.

Approval and Implementation Phase: Months 16 - 24

The approval and implementation phase marked the culmination of the planning efforts, beginning with the HMP Update Kick-Off Meeting on January 18, 2024, at GCC Building 300. This meeting was crucial for reviewing the draft plan comprehensively and gathering the final inputs needed for the revisions before its submission for approval. Also, it signified the transition from planning to actionable steps toward mitigating hazard impacts. Following this, the ESF/RAC Workshop on April 10, 2024, provided updates on grant management and public assistance processes, aligning the 2024 Guam HMP with the existing financial and emergency management frameworks.

The stakeholder engagement continued with a focused discussion on May 3, 2024, with the GPA and GWA. This meeting addressed the status and updates of projects listed in the 2019 HMP, facilitating their integration or modification in the 2024 update. Lastly, the FEMA Mitigation Consultation and P2A on May 6-7, 2024, at GHS-OCD

IOF prepared stakeholders for post-approval mitigation actions, emphasizing planning tools to assess risks and develop appropriate strategies. This sequence of events ensured that the 2024 Guam HMP was comprehensive, reflective of the latest risks, and set the groundwork for effective mitigation strategies. Additionally, expedited stakeholder engagements through phone conversations and quick in-person meetings in May 2024 ensured updates and inclusions were made to the plan and mitigation actions, culminating in a resilient and thorough Hazard Mitigation Plan for Guam. Stakeholders who participated in the expedited process were DOAG, PAG, GPD, NWS, MCOG, USACE, BSP, and DPW. This integrated and detailed approach, involving extensive stakeholder collaboration and data-driven risk assessments, has laid the foundation for a robust and effective 2024 Guam HMP.

3.2.2 PLAN INTEGRATION

The 2024 Guam HMP is a comprehensive effort integrating various strategic documents and reports to ensure mitigation planning aligns with broader state planning initiatives. This alignment is crucial for maximizing the HMP's efficacy and relevance, as it leverages existing frameworks and insights to bolster Guam's resilience to natural hazards. For instance, critical documents integrated into the HMP are the Guam Comprehensive Economic Development Strategy and the Guam Comprehensive Emergency Management Plan. These plans provide a macroeconomic and emergency response framework, guiding the 2024 Guam HMP's strategies to mitigate hazards and enhance economic stability and emergency readiness. This integration ensures that the financial implications of disaster risks are considered in the planning process, facilitating

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a holistic approach to disaster mitigation that supports economic growth and development.

PAG's Modernization Plan and the GWA Capital Improvement Plan address specific infrastructure and environmental considerations. These plans detail critical infrastructure upgrades and improvements essential for reducing disaster vulnerability. By aligning the 2024 Guam HMP with these capital improvement plans, the mitigation strategies can directly contribute to strengthening critical infrastructure and enhancing its resilience against natural disasters.

Further, integration is seen with the University of Guam Water and Environmental Research Institute (WERI) Plan and the Guam Integrated Preparedness Plan. The WERI Plan offers research-based insights into water resource management and environmental protection, which are critical in disaster mitigation, especially for an island community such as Guam. The Preparedness Plan, on the other hand, provides a framework for readiness activities, ensuring that mitigation strategies are not only about prevention but are also prepared for effective response when disasters occur.

The Typhoon Mawar Resilience Report, conducted by FEMA, is another pivotal document that informs the HMP. This report provides a detailed analysis of the recent impacts of Typhoon Mawar, offering valuable lessons and recommendations incorporated into the HMP to address specific vulnerabilities and enhance resilience against similar future events. Therefore, by integrating these diverse plans and reports, the 2024 Guam HMP ensures that the mitigation planning process is not isolated but closely aligned with other state planning efforts. This integration maximizes resource utilization, ensures consistency across different planning frameworks, and enhances the overall effectiveness of disaster mitigation strategies, demonstrating a comprehensive and unified approach to hazard mitigation.

3.2.3 HAZARD MITIGATION WORKING GROUP

Table 1 identifies the twenty-three (23) Government of Guam departments/agencies, advisory councils and commissions, private sector partners, and Federal agencies that made up the HMWG for the 2024 Guam HMP update process.

Table 1. Hazard Mitigation Working Group

Entity	Sector	Community Lifelines
Office of the Governor	Territorial Government	
Office of Civil Defense	Emergency Management	Safety and Security
Guam Homeland Security	Public Safety (Homeland Security)	Safety and Security
Guam National Guard	Public Safety (Domestic Operations)	Safety and Security
Guam Police Department	Public Safety (Policing)	Safety and Security
Guam Fire Department	Public Safety (Fire and EMS)	Safety and Security
Port Authority of Guam	Infrastructure	Transportation

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Guam International Airport Authority	Infrastructure	Transportation
Guam Power Authority	Infrastructure	Energy
Guam Waterworks Authority	Infrastructure	Food, Water, Shelter
Department of Public Works	Infrastructure	Transportation
Guam Memorial Hospital Authority	Health/Social Services	Health and Medical
Department of Public Health and Social Service	Health/Social Services	Health and Medical
Guam Climate Change Committee	Natural/Cultural Resources	
Bureau of Statistics and Plans	Natural/Cultural Resources; Land Use/Development	
Guam Housing Corporation	Housing	Food, Water, Shelter
Department of Land Management	Land Use/Development	Food, Water, Shelter
Guam Economic Development Authority	Economic Development	
Guam Community College	Higher Education	
University of Guam	Higher Education	
Guam Voluntary Organizations Active in Disaster	Non-Profit / Non-Governmental Organizations	Food, Water, Shelter
American Red Cross	Non-Profit / Non-Governmental Organizations	Food, Water, Shelter
Mayors' Council of Guam	Local Government	

3.3 COORDINATION AMONG AGENCIES



S1. Does the plan describe how the state coordinated with other agencies and stakeholders? [44 CFR §§ 201.4(b) and 201.4(c)(1)]

Section 3.3. satisfies this requirement by documenting coordination with agencies and stakeholders and how their input was utilized to inform the update.

The State Mitigation Planning Policy Guide requires a description of how the State coordinated with other state agencies, appropriate federal agencies, and other stakeholders and how they were involved in the development process of the 2024 Guam Hazard Mitigation Plan.

3.3.1 FEDERAL AND STATE AGENCY INVOLVEMENT AND COORDINATION

The 2024 Guam HMP update process exemplifies a collaborative effort between federal and Government of Guam agencies, ensuring a coordinated approach to disaster mitigation planning. Federal involvement is prominently led by the FEMA Mitigation Division, which is crucial in guiding the HMP's framework, providing regulatory compliance oversight, and facilitating funding for mitigation projects. FEMA's contributions are vital in aligning the 2024 Guam HMP with national disaster mitigation standards and practices. Alongside FEMA, various government agencies in Guam actively participate in the update process see **Table 1**. These local agencies are

instrumental in implementing the 2024 Guam HMP's strategies, addressing specific local needs, and ensuring that the mitigation measures are effectively integrated across all levels of government. This extensive collaboration fosters a unified approach that enhances Guam's resilience to natural hazards, leveraging federal support and local knowledge to develop a robust and comprehensive mitigation plan.

3.3.2 STAKEHOLDERS ENGAGEMENT

The SMHO, Guam's HM Team, and GHS-OCD HM designee conducted numerous stakeholder engagement events and meetings throughout the 2024 Guam HMP update process, demonstrated in Section 3.2.1 with stakeholder listing in **Table 1**. Notably, they engaged stakeholders across several critical sectors: emergency management, economic development, land use and development, housing, health and social services, infrastructure, and natural and cultural resources.

- Engagement with emergency management stakeholders was pivotal, beginning with the Hazard Mitigation Grants Council Meeting on June 8, 2022. Attended by GHS-OCD, FEMA, DPW, BSP, and DLM, this meeting laid the groundwork for prioritizing projects under the DR-4495 COVID-19 disaster grant.
- The Benefit-Cost Analysis (BCA) Training held from February 7-10, 2023, further involved GHS-OCD and FEMA, providing stakeholders with essential skills to evaluate the cost-effectiveness of proposed mitigation actions.
- The Local Mitigation Planning Workshop, held from June 13 to 16, 2023, included GHS-OCD, FEMA, ESF 2, and GCC, enhancing stakeholders' understanding of risk assessment and strategy development.
- The Guam Mitigation Consultation and P2A followed this from August 14-18, 2023, when GHS-OCD, FEMA, ESF 2, ARC, and DPW reviewed and refined the HMP draft.
- The Hazard Mitigation Kick-off Workshop for Typhoon Mawar on September 12-13, 2023, and the HMP Update Kick-Off Meeting on January 18, 2024, both continued this trend of comprehensive stakeholder involvement.
- The FEMA Mitigation Consultation and P2A on May 6-7, 2024, at GHS-OCD IOF, provided a final opportunity for collaboration and review.

Economic development stakeholders played a crucial role in shaping the HMP. The Local Mitigation Planning Workshop in June 2023 included GEDA, focusing on integrating economic resilience into the mitigation strategies. This involvement continued through the Guam Mitigation Consultation and P2A in August 2023 and the Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023, ensuring that Guam's economic considerations were embedded in the plan. GEDA's participation in the HMP Update Kick-Off Meeting in January 2024 and the FEMA Mitigation Consultation and P2A in May 2024 further solidified the integration of economic development perspectives.

Land use and development stakeholders were BSP and DLM, who actively engaged in the Hazard Mitigation Grants Council Meeting in June 2022. Their participation extended through critical events, including the Local Mitigation Planning Workshop in June 2023 and the Guam Mitigation Consultation and P2A in August 2023. Their insights were crucial to aligning the 2024 Guam HMP with land use planning and regulatory frameworks. Their continued involvement in the Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023, the HMP Update Kick-Off Meeting in January 2024, and the FEMA Mitigation Consultation and P2A in May 2024 ensured that land use and development priorities were well integrated and showcased areas of

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improvement for the following update process, such as building code and land zoning policy updates.

Housing stakeholders, particularly GHURA, were integral to the HMP update. Their involvement in the Local Mitigation Planning Workshop in June 2023 helped address housing vulnerabilities. GHURA's continued engagement through the Guam Mitigation Consultation and P2A in August 2023 and the Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023 ensured that housing strategies were a core component of the HMP. Their participation in the HMP Update Kick-Off Meeting in January 2024 and the FEMA Mitigation Consultation and P2A in May 2024 further refined housing mitigation actions. However, GHURA did not participate in the 2024 Guam HMP update process. Without GHURA's participation, as it is the primary organization in Guam that is hyper-focused on constructing affordable homes and increasing housing inventory, there are insignificant data-driven mitigation strategies that can support the housing element in Guam.

Stakeholders from health and social services, including GMHA and DPHSS, were engaged in the Local Mitigation Planning Workshop in June 2023. This collaboration was essential in integrating public health and social service considerations into the HMP. Their active participation continued through the Guam Mitigation Consultation and P2A in August 2023, the Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023, and the HMP Update Kick-Off Meeting in January 2024. The FEMA Mitigation Consultation and P2A in May 2024 allowed for final adjustments and enhancements to health-related mitigation strategies.

Infrastructure stakeholders, notably DPW, GWA, and GPA, were crucial throughout the HMP update process. Starting with a dedicated meeting on July 7, 2022, these stakeholders addressed critical water and power services issues. Their involvement in the BCA Training in February 2023, the Local Mitigation Planning Workshop in June 2023, and the Guam Mitigation Consultation and P2A in August 2023 ensured that infrastructure resilience was a priority. The Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023 and the HMP Update Kick-Off Meeting in January 2024 continued this focus. The FEMA Mitigation Consultation and P2A in May 2024 further integrated infrastructure considerations into the final HMP.

The natural and cultural resources stakeholder was DOAG, which participated in the Local Mitigation Planning Workshop in June 2023. Their insights were vital for incorporating environmental and cultural preservation into the HMP. DoAg's continued engagement in the Guam Mitigation Consultation and P2A in August 2023, the Hazard Mitigation Kick-off Workshop for Typhoon Mawar in September 2023, and the HMP Update Kick-Off Meeting in January 2024 ensured these elements were thoroughly addressed. The FEMA Mitigation Consultation and P2A in May 2024 provided the final opportunity to align these strategies with overall mitigation efforts. Although DOAG engaged in the 2024 Guam HMP update process, DPR, specifically DPR's Guam Historical Resources Division, did not participate. DPR's role is to provide a holistic approach to protecting and maintaining Guam's historical, cultural, and natural

resources. Therefore, the absence of DPR's participation is a stakeholder engagement issue that will not be overlooked in the following HMP update process.

3.4 PROGRAM INTEGRATION



S1. Does the plan include a description of the process used to develop the plan? [44 CFR §§ 201.4(b) and 201.4(c)(1)]
Section 3.4 describes integration with other territory planning efforts.

The updated efforts of the 2024 Guam HMP inform existing and emerging territorial and agency-level plans. These efforts have been updated for the 2024 Guam HMP and include the following:

- Continued integration of the mitigation planning process of the 2024 Guam HMP relative to the identification of hazards/threats and assessment of risk addressed in the Threat and Hazard Identification and Risk Assessment (THIRA), Stakeholder Preparedness Review (SPR), National Incident Management System (NIMS) Implementation Self-Assessment and Community Preparedness Guide (CPG) 101 Assessments. The risk assessment of the Guam HMP identifies threats and hazards addressed in Guam's THIRA.
- Continued integration of the 2024 Guam HMP as an Annex of the Guam Comprehensive Emergency Management Plan (GCEMP). The GCEMP is due for the next update in 2029.
- Continued integration of the 2024 Guam HMP with the National Flood Insurance Program (NFIP) provisions by the Department of Public Works (DPW) Floodplain Administration and Building Permits Section during the review of building proposals. The risk assessment of the 2024 Guam HMP identifies the National Flood Insurance Program's (NFIP) Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties on Guam, and the mitigation strategy of the HMP includes mitigation actions to reduce or eliminate damage to these properties.
- Consideration of 2024 Guam HMP by Government of Guam agencies and programs, such as Bureau of Statistics and Plans (BSP) – Guam Coastal Management Program, Department of Agriculture (DoAg), Department of Land Management (DLM), Department of Public Health and Social Services (DPHSS), Department of Public Works (DPW), Department of Youth Affairs, Guam Community College (GCC), Guam Department of Education (GDOE), Guam Housing and Urban Renewal Authority (GHURA), Guam Memorial Hospital Authority (GMHA), Guam Power Authority (GPA), Guam Solid Waste Authority (GSWA), Guam Waterworks Authority (GWA), University of Guam (UOG), with capital improvement projects (CIPs), and relevant land and development master plans.
- Consideration of 2024 Guam HMP (notably, the high-priority mitigation actions identified in the 2024 Guam HMP) by GHMO and HMAAC for Hazard Mitigation Grant Program (HMGP), Building Resilient Infrastructure and Communities (BRIC) grant program, Pre-Disaster Mitigation (PDM) Grant, and Flood Mitigation Assistance (FMA) mitigation projects.

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- Consideration of 2024 Guam HMP with the following Federal planning efforts: NOAA Office of Coastal Management Natural Hazards element as developed and applied to Guam's coastal zone, USGS Rigorously Valuing the Role of US Coral Reefs in Coastal Hazard Risk Reduction.
- The 2024 Guam HMP can inform the Guam Disaster Recovery Plan, which is currently in draft form.

SECTION 4 – BACKGROUND

4.1 PURPOSE

This section provides basic background information on the island of Guam. It includes general information concerning geography, climate, government, population, economy, tourism, assets, and planning and development.

4.2 GEOGRAPHY

Located in the western North Pacific Ocean, Guam is the largest and farthest-South Island of the chain of volcanic islands that constitute the Mariana Archipelago. The elongated, peanut-shaped island is oriented northeast-southwest, covers an area of 209 square miles, and has approximately 100 miles of coastline. Major features of the island (e.g., major roads, village boundaries) are shown in **Figure D-1**.⁶

Guam can be divided into two primary ecoregions: the southern mountainous part of the island and the northern, relatively flat, with a marine-terrace plateau. Guam is divided into 19 villages. The southern ecoregion contains nine villages: *Agat, Asan/Maina, Inarajan, Merizo, Piti, Santa Rita, Talofofo, Umatac, and Yona*. The northern ecoregion contains the other ten villages: *Agana Heights (Passan), Hagatna (Agana), Barrigada, Chalan Pago-Ordot, Dededo, Mangilao, Mongmong-Toto-Maite, Sinajana, Tamuning/Tumon, and Yigo*.

The southern ecoregion is mountainous, with 11 peaks rising to 1,000 feet or more that form a discontinuous ridge extending along the island's southwestern part. Mount *Lam Lam* is the tallest point on the island, with an elevation of 1,332 feet.

The western coast of this ecoregion contains a narrow stretch of lowlands, and the eastern coastline contains limestone cliffs. The ecoregion's volcanic rock has formed clay-sand residuum-type, inherently unstable soils. **Figure D-2** presents the various soils of Guam, and **Figure D-3** shows the geology of Guam.

Slopes in the southern ecoregion are often very steep. Nonriverine areas either lack vegetation or are covered with a savanna grass community primarily consisting of swordgrass and mission grass. The volcanic terrain contains numerous streams. The four most significant streams are the *Ylig, Talofofo-Ugum, Inarajan, and the Pago-Lonfit*. Riverine areas contain forests with native tropical plants such as *nunu*, sea-hibiscus, and *aggag*. Vegetation is mapped in **Figure D-4**.

The western section of the southern ecoregion has a large natural bay. This area has been developed into Apra Harbor, Guam's only seaward port of entry. Fena Reservoir, a primary source of potable water for Guam, is also in this region. The U.S. Navy operates a large portion of Apra Harbor, and a naval magazine is present roughly in the center of this region.

⁶ All figures are provided in Appendix D (Figures).

The northern ecoregion is a relatively flat coralline limestone plateau, with steep coastal cliffs and narrow coastal plains dominating the island's northern part. The topography of this plateau gently undulates with elevations that vary between 200 to 600 feet. The limestone geology has high permeability, and no substantial streams or rivers exist, but Guam's largest aquifer and primary source of freshwater is beneath this region. The area's limestone also contains sinkholes, which are natural depressions in the ground caused by weathering processes. However, sinkholes also occur in the southern portion of the island.

Five main vegetation types are associated with the limestone soils of the area. Breadfruit and banyan forests are generally widespread throughout the area; a mammea forest occurs in the eastern escarpment of the northern limestone plateau; a *Cordia* scrub-type forest dominates many steep slopes and cliffs of the area; another forest type is dominated by tall *nunu*; and a final forest type is dominated by *aggag*. The northern section of this ecoregion is operated as Andersen Air Force Base.

Living coral reefs surround the island of Guam, which has very deep waters; the Marianas Trench, the deepest part of the world's oceans, is directly east of Guam. Low-lying vegetated beaches are found in the island's northern and southern ecoregions. Small swamps, mangroves, and marsh areas are also found along the coastal areas of Guam.

4.3 CLIMATE

Guam has a tropical maritime climate with year-round warm weather, wet and dry seasons, moderate to high humidity, and wind speed and direction that vary with its two primary seasons.

4.3.1 Temperature

Seasonal temperatures vary approximately 5 degrees Fahrenheit (°F) from one another. The annual average maximum temperature is 86°F, and the annual average minimum temperature is 76°F. The temperature range between day and night is approximately 15 to 20 °F and is larger than the difference between January and July temperatures.

4.3.2 Dry Season

Dry season winds are known as "trade winds," which usually blow from the northeast or east. The trade winds can, and often do, occur for some time every month of the year.

4.3.3 Wet Season

The wet season generally lasts from July through December, and the season is characterized by a high annual average relative humidity of around 86 percent and relatively weak winds ranging in direction from southeasterly to southerly. The dry season generally lasts from January through June, and a low annual average relative humidity of around 71 percent characterizes this season.

Average annual rainfall varies from about 80 inches in the central and coastal lowlands to 110 inches in the more mountainous areas of southern Guam. A wide variation in rainfall can occur from year to year. 1997, for example, the island recorded around 165 inches of rain. In contrast 1998, the island recorded around 55 inches of rain. The contrast from one year to the next, which differed by a factor of three or 300%, vividly demonstrates Guam's vast range of natural rainfall variability. 1997, a strong El Niño year (wet), and the subsequent post-El Niño year (dry) in 1998 serve as prime examples. The shift in official rainfall measurement from the 1950s to the mid-1990s, from *Finegayan* in northwest Guam—a wetter island area, the international airport—to a drier area account for the majority of the difference between early rainfall averages of around 100 inches yearly and a more current average of around 86 inches annually. This shift in measurement location is crucial in understanding Guam's rainfall patterns.

During the wet season, a monsoon weather pattern can surge from the vicinity of the Philippines across the western North Pacific, affecting Guam with sustained western and southwestern winds ranging from 10 mph up to 45 miles per hour (mph) and lasting from a few days to a few weeks. Rainy conditions often accompany these winds. However, the wet season in Guam is not just about monsoons. It is also punctuated by the arrival of tropical cyclones, which can pass near or over Guam, bringing a new level of weather intensity and potential hazards.

4.3.4 Tropical Cyclones

Tropical cyclone is a generic term that includes tropical depressions, tropical storms, typhoons, and super typhoons. Typhoons, the most severe of these cyclones, can produce destructive winds with sustained winds over 150 mph and gusts over 180 mph. Various hazards, including powerful storm surges, torrential rains and flooding, wind shear and mechanical turbulence, rough seas and hazardous surf, tornadoes, sea salt deposition, coastal erosion and pollution, and slope failures, including mudslides, accompany these conditions. The strength of a typhoon as it passes over Guam is primarily influenced by the relative location of the seasonal monsoon weather pattern. For instance, typically from September to November, the axis of the monsoon weather pattern continually migrates southward and eastward, taking a position east or southeast of Guam. Therefore, the typhoons that develop during this time tend to move southeast of Guam and toward the island. They have more time to develop and intensify than typhoons that develop closer to Guam when the typical monsoon pattern is focused closer to the island. However, it is essential to note that typhoons can affect Guam any month of the year, posing a constant threat to the island's safety and infrastructure.

4.3.5 El Niño—Southern Oscillation

The El Niño—Southern Oscillation (ENSO) is a phenomenon that involves the east-west oscillation of warm and cold ocean waters along the equatorial Pacific and the east-west oscillation of wet and dry atmospheric weather patterns along the equatorial Pacific. It involves three major phases: El Niño, the warm phase; La Niña, the cold phase; and ENSO-neutral, the intermediate phase that separates the other two phases. El Niño involves the eastward redistribution of warm equatorial oceanic waters to the Central

and Eastern Pacific. It usually has a wet phase that generally results in more rainfall and stronger monsoon-related westerly winds on Guam and a dry phase that usually results in a persistent regional drought. Weak El Niño events occur every 3-5 years, moderate events every 7-12 years, and vital events every 20-30 years. During El Niño events, intense tropical cyclones can develop southwest of Hawaii and travel to Guam.

Super Typhoon Paka, which devastated Guam in 1997, is an example of a super typhoon during such conditions. The year after an intense El Niño event can be exceptionally dry. For example, rainfall for Guam was around 40 percent of normal from January to June 1998, six months after the 1997 El Niño.

Another aperiodic climatic event that involves colder-than-normal ocean temperatures in the equatorial central Pacific Ocean is known as La Niña. This event can result in drier-than-normal conditions in Guam during the typical wet season and wetter-than-normal conditions during the usual dry season. During La Niña, the monsoon trough becomes reverse-oriented, stretching northeast to southwest. As a result, storms tend to develop to the north and west of Guam, making tropical cyclone activity minimal for Guam. Other more subtle climate patterns can affect the weather in Guam, usually resulting in upper-level systems that cause increased thunderstorm activity over the island.

ENSO-neutral refers to the intermediate phase between El Niño and La Niña phases. With ENSO-neutral, tropical cyclone activity is less than during an El Niño event but greater than during a La Niña event. Rainfall is closer to average in the wet season and the dry season. Sea level stabilizes toward average elevations from lower values in El Niño events and higher values in La Niña events.

4.3.6 Climate Change

Changes in the earth's atmosphere will likely alter several aspects of life in Guam in the coming decades. The air and ocean are warming, sea levels are rising, and the ocean is becoming more acidic.

These changes are likely to damage or destroy much of Guam's coral reef ecosystems, increase damages from flooding and typhoons, reduce the availability of fresh water during the dry season, and make air temperatures uncomfortably hot more often than they are today.

Our planet is warming, and the climate is changing. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of the earth by about one degree (F) during the last 50 years. Evaporation increases as the atmosphere warms, increasing humidity, average rainfall, and the frequency of heavy rainstorms in many places, but it contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic.

Worldwide, the ocean's surface has warmed about one degree during the last 80 years. Mountain glaciers are retreating, and even the great ice sheets on Greenland and Antarctica are shrinking. Thus, the sea is rising at an increasing rate.

Indicators of Climate Change on Guam

Below is a summary of climate change indicators from the Climate Change in Guam report. The Pacific Islands Regional Climate Assessment (PIRCA) developed Indicators and Considerations for Key Sectors, as seen in **Table 2**.⁷ These indicators and future projections show that Guam's vulnerability to weather-related natural hazards will likely increase.

Table 2. PIRCA Consolidated Assessments

Climate Category	Indicator	How has it changed?	Projected future change
Air Temperature	Hot days	↑	↑
	Cool nights	↓	↓
	Average air temperature	↑	↑
Rainfall	Average rainfall	No change	↓
	Rainy season average rainfall	No change	↓
	Dry season average rainfall	No change	↑
	Extreme rainfall frequency	No change	↑
	Frequency of drought	Unk	↑
	Streamflow	Unk	↓
Typhoons and storms	Tropical cyclone intensity	No change	↑
	Tropical cyclone frequency	No change	↓
Sea Level	Sea level	↑	↑
	High water frequency	↑	↑
Ocean changes	Sea surface temperature	↑	↑
	Frequency and intensity of heat stress on coral	↑	↑
	Ocean acidification	↑	↑

Climate Change and Coral Loss

Warming waters are likely to damage much of the coral around Guam. Average water temperatures around Guam have risen more than one degree over the last century, in addition to the year-to-year changes associated with the El Niño-Southern Oscillation ("El Niño"). Rising water temperatures harm the algae that live inside corals and provide food for them. The loss of algae weakens corals and can eventually kill them. This process is commonly known as "coral bleaching" because the loss of the algae also causes the corals to turn white. Coral bleaching is becoming more common around Guam, including record-breaking bleaching throughout the western Pacific since 2013. In 2017, severe coral bleaching was observed as deep as 120 feet below the sea

⁷ X Grecni et al., "Climate Change in Guam: Indicators & Considerations for Key Sectors," 2020, <https://doi.org/10.5281/zenodo.4037481>.

surface, and live coral cover declined by 54% between 2017 and 2018. Elevated water temperatures also cause outbreaks of diseases that can harm or kill corals, as well as other ecologically important reef-associated organisms like sea cucumbers and sea urchins. Warming ocean temperatures may also negatively impact fish and coral larvae, creating long-term changes in fish and coral populations' survival, dispersal, and growth. Increasing ocean acidity, caused by increased absorption of carbon dioxide gas, also damages corals. By changing the balance of minerals in seawater, higher acidity decreases the ability of corals to produce calcium carbonate, which is the primary component of their skeletons. The Pacific Ocean has become about 25 percent more acidic in the past three centuries, and acidity is likely to increase another 40 to 50 percent by 2100.

Over the next 50 to 60 years, warming and acidification will likely harm coral reefs around Guam and throughout the world, and widespread coral loss is expected. Increasing acidity would also reduce shellfish populations and other organisms that depend on minerals in the water to build their skeletons and shells. Warming and acidification could result in widespread damage to marine ecosystems and disruptions to the ecosystem services they provide to human populations. Guam is home to many fish species, many of which are harvested for food and are culturally significant. Sharks, rays, grouper, snapper, and hundreds of other fish species rely on healthy coral reefs for habitat. Reefs also protect nearshore fish nurseries and feeding grounds. A significant fraction of reef-dwelling fish and invertebrates will likely lose their habitats by 2100.

Tropical Storms

As the climate changes, typhoons may cause more damage. Guam is one of the world's most active regions for tropical storms. In 2023, Typhoon *Mawar* caused approximately \$300 million in damages, destroyed an estimated 600 homes, left the island without power, and left many without water. In 2002, Typhoon *Pongsona* caused \$700 million in damages, destroyed 1,300 homes, and left the island without power. In just the last few years, neighboring islands have suffered from some of the strongest and most damaging tropical cyclones ever recorded, including Super Typhoons *Haiyan* (2013), *Maysak* (2015), and *Soudelor* (2015).

Although the frequency of tropical cyclones is projected to decrease, wind speeds and rainfall rates during typhoons are likely to increase as the climate continues to warm, increasing the intensity of tropical cyclones that will land on Guam.

Rising Sea Level, Coastal Flooding, and Coastal Erosion

The sea level has risen by about four inches relative to Guam's shoreline since 1993. If the oceans and atmosphere continue to warm, the sea level around Guam will increase by one to three feet in the next century. Sea rise submerges low-lying areas, erodes beaches, and exacerbates coastal flooding from typhoons and tsunamis. Coastal homes and infrastructure will flood more often as sea level rises because storm surges will also increase. Homes, businesses, roads, and the Port of Guam are vulnerable to the impacts of storms and sea level rise.

The loss of coral reefs compounds this problem because the structural complexity of live coral reefs reduces wave energy, helping to protect the shore from erosion by waves and storm damage. As reefs die, they lose their structural integrity and provide less protection to the shore. If more giant waves strike the shore, beaches will erode more rapidly, and infrastructure (including homes, businesses, and public services) may be damaged by flooding. Coral reef restoration activities began in Guam in 2015 as a response to severe losses in live coral due to bleaching, with efforts focusing on the highly rugose staghorn *Acropora* corals on reef flats on the western side of the island. In 2024, reef restoration efforts will be significantly expanded by constructing three new coral nurseries. These efforts will focus on restoring high-priority areas to conserve species diversity, expand live coral cover, and increase reef complexity for shoreline protection.

Rainfall and Water Supplies

Guam's wet season may become wetter, while dry periods may become drier. Although Guam recorded the second-highest amount of rainfall in 2023, Guam is expected to become drier overall in the long term, with a projected island-wide decrease in rainy season precipitation.

Warmer temperatures tend to intensify rainstorms and droughts. Moreover, Guam's climate tends to be dry during El Niño years and wet during La Niña years, and scientists generally expect the differences between El Niño and La Niña years to become more significant in most places.

Wildfire and Drought

Drought conditions in Guam are conducive to wildfire ignition and spread. They are also associated with water stress for crops and ecosystems. Drought conditions will likely be more frequent in the future. Under the high scenario, drought conditions (defined here as more than 20% below mean annual historic rainfall) are projected to occur in 4 out of 10 years on average in 2080–2099. This is an increase in drought frequency from the historical rate of 1.6 years out of 10 years on average.⁸

Any future changes in ENSO will likely affect the frequency and intensity of drought. Recent studies show that the frequency of strong El Niño events has increased in the past 30 years compared to previous centuries.⁹

⁸ Stephen B. Gingerich et al., "Water Resources on Guam—Potential Impacts of and Adaptive Response to Climate Change," *Scientific Investigations Report*, January 1, 2019, <https://doi.org/10.3133/sir20195095>.

⁹ Thomas A. Schroeder et al., "The Role of the Pacific ENSO Applications Climate Center in Reducing Vulnerability to Climate Hazards: Experience from the U.S.-Affiliated Pacific Islands," *Bulletin of the American Meteorological Society* 93, no. 7 (July 2012): 1003–15, <https://doi.org/10.1175/bams-d-11-00109.1>.

Human Health and Social Vulnerability

Hot days can be unhealthy—even dangerous. Rising temperatures will increase the frequency of hot days and warm nights. High air temperatures can cause heat stroke and dehydration and affect people’s cardiovascular and nervous systems. Warm nights are perilous because they prevent the human body from cooling off after a hot day. Certain people are especially vulnerable, including children, the older population, the sick, and the poor.

Climate change is expected to disrupt many aspects of Guam, and socially vulnerable groups will be disproportionately affected.

Application of Climate Change on Guam to the 2024 Guam HMP Hazards

Climate change applies to all Hazards in the 2024 Guam HMP except Earthquakes, Non-Seismic Ground Failure, and Terrorism. Two of these hazards are unrelated to climate, as two apply to Guam’s geology, and the other is man-made.

4.4 GOVERNMENT

Guam is an unincorporated territory of the United States; policy relations between Guam and the United States are under the jurisdiction of the Office of Insular Affairs, United States Department of the Interior. Guam was acquired by the United States from Spain in 1898 after the Spanish-American War under the Treaty of Paris. Under the Organic Act of 1950, citizens of Guam are required to follow the laws and the Constitution of the United States. Guam citizens are citizens of the United States but do not have the right to vote for the President of the United States. Guam elects one nonvoting delegate to the United States House of Representatives.

Guam has an elected Governor, a Lieutenant Governor, and a 15-seat unicameral Legislature. It also has a cabinet of executive departments whose heads are appointed by the Governor with the consent of the Legislature. Guam has a Federal District Court, with a judge appointed by the President; a Territorial Superior Court, with judges appointed for 8-year terms by the Governor with the consent of the Legislature; and a Territorial Supreme Court, with justices appointed by the Governor with the consent of the Legislature.

As noted earlier, Guam is divided into 19 villages: *Agana Heights (Passan), Agat, Asan/Maina, Barrigada, Chalan Pago-Ordot, Dededo, Hagatna (Agana), Inarajan, Mangilao, Merizo, Mongmong-Toto-Maite, Piti, Santa Rita, Sinajana, Talofofo, Tamuning/Tumon, Umatac, Yigo, and Yona. Hagatna (formerly Agana)* is the capital of the island. Each village has an elected mayor, and all village Mayors sit on the Mayors’ Council of Guam.

The government of Guam currently operates most of the island’s services and utilities. These include the Guam Fire Department (GFD), Guam Memorial Hospital Authority (GMHA), Guam Police Department (GPD), Guam Power Authority (GPA), and Guam Waterworks Authority (GWA). The Guam Telephone Authority (GTA), the island’s

principal provider of telecommunications services, was acquired and privatized in January 2005 by TeleGuam Holdings, LLC, doing business as GTA TeleGuam.

Several U.S. military bases or installations are found on Guam, including the Andersen Air Force Base in Yigo, Camp Blas in *Dededo*, and numerous U.S. Navy facilities, including Apra Harbor Naval Complex; Naval Activities in Santa Rita; Naval Information, Computer, and Tele-Communications Area Master Station (NCTS) *Finegayan* in *Dededo*; NCTS in *Barrigada*; Tiyan; *Orote* Point; Nimitz Hill in *Asan/Maina*; and the Ordnance Annex. The Army National Guard also has military installations in *Barrigada*. The Government of Guam has no authority in these areas, which occupy approximately 26 percent of the island's total land area.

The U.S. Department of Defense has developed the Guam Military Buildup Program, which will involve the movement of forces and equipment of the U.S. Army, Air Force, Marines, and Navy from other areas to Guam. The program was initiated in May 2006, and construction, which will take place at military sites throughout the island, was initially expected to be completed in 2014. However, the scale of construction has increased, and previously authorized construction has still been delayed. A majority of Camp Blas is expected to be completed in 2025. There will still be 1.5 to 2 billion dollars in construction between 2025-2029. This does not consider the 2024 and 2025 NDAA authorizations, as those project schedules are not currently available and are pending procurement. Once completed, the program will increase the number of active-duty military personnel from 6,420 to 18,930 (see Section 4.9.2 [Military Buildup] for additional information).

4.5 POPULATION

The 2020 population in Guam was 153,836. According to the U.S. Census, between 2000 and 2010, Guam underwent a 3.5 percent population decrease. Likely, the 2020 Census did not capture the total population, as the response rates were low due to the COVID-19 lockdown that was in place during the enumeration. Based on the most recent estimates when this 2024 HMP was updated, it is estimated that Guam has a current population of 169,532.

Dededo, which is geographically one of the largest villages, has the largest population. **Figure D-5** shows the locations of several densely populated areas. *Agana* Heights, *Barrigada*, *Mangilao*, *Mongmong-Toto-Maite*, *Sinajana*, and *Tamuning/Tumon* have areas of dense populations. Most island populations are centered on a geographically narrow point in the approximate center of the island, which is also the largest urbanized area of Guam.

Table 3. Population of Guam, 2010–2020¹⁰

	Population	Change (2020 less 2010)

¹⁰ US Census Bureau, "2020 Island Areas Censuses: Guam," Census.gov, October 20, 2020, <https://www.census.gov/data/tables/2020/dec/2020-guam.html>.

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Geographic area	2010	2020	Number	Percent
Guam	159,358	153,836	-5,522	-3.5
Agana Heights municipality	3,808	3,673	-135	-3.5
Agat municipality	4,917	4,515	-402	-8.2
Asan municipality	2,137	2,011	-126	-5.9
Barrigada municipality	8,875	7,956	-919	-10.4
Chalan Pago-Ordot municipality	6,822	7,064	242	3.5
Dededo municipality	44,943	44,908	-35	-0.1
Hagåtña municipality	1,051	943	-108	-10.3
Inarajan municipality	2,273	2,317	44	1.9
Mangilao municipality	15,191	13,476	-1,715	-11.3
Merizo municipality	1,850	1,604	-246	-13.3
Mongmong-Toto-Maite municipality	6,825	6,380	-445	-6.5
Piti municipality	1,454	1,585	131	9.0
Santa Rita municipality	6,084	6,470	386	6.3
Sinajana municipality	2,592	2,611	19	0.7
Talofofo municipality	3,050	3,550	500	16.4
Tamuning municipality	19,685	18,489	-1,196	-6.1
Umatac municipality	782	647	-135	-17.3
Yigo municipality	20,539	19,339	-1,200	-5.8
Yona municipality	6,480	6,298	-182	-2.8

In 2020, Guam was the only island area with military housing and the only location where military enumeration was conducted. During military enumeration, the 2020 IAC collected person-level data of respondents in housing units, barracks/dormitories, military treatment facilities with assigned patients at the naval hospital, and TLs located inside the military installations of Joint Base Marianas (Naval Base Guam and Andersen Air Force Base). For this enumeration, only basic demographic questions were asked of each eligible person (name, age, date of birth, Hispanic or Latino origin, race, relationship, and sex). Detailed information on person-level characteristics and housing units was not collected. As a result, data tables for these detailed characteristics will not include the population living on the military installations.

In 2020, other changes impacted the Guam Census. These included cells in data tables will display the letter “N” when those data are not statistically reliable. A list of the geographic areas and data tables that will not have data displayed due to data quality concerns can be found in Chapter 5 of the IAC Demographic Profile Summary File Technical Documentation.

There is no data on the economic, housing, and social characteristics of the Tamuning, Hagatna, and Umatac villages. *Tamuning* does contain 2 Census Designated Places where the data for these characteristics was unreliable, making the entire village data set unreliable. The *Tamuning* CDP does have data, so amounts from that CDP will serve as the amounts for the entire village.

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Young children, older populations, and people living below the poverty level are typically more vulnerable to the effects of hazards. Thus, as of 2020, 10,626 people on Guam, or 6.9 percent of the total population, are five years old or younger; 17,190 people, or 11.2 percent of the total population, are 65 years old or older; and 29,408 people, or 19.1 percent of the total population, live below the poverty level. As shown in **Table 4**, *Mongmong-Toto-Maite* has the highest population (8.98 percent) of people under five years of any village, while *Agana Heights*, *Mangilao*, and *Tamuning/Tumon* have the lowest percentage of their total populations are five years or younger of all the villages on Guam (6.3, 6.11, and 5.12 percent respectively). *Hagatna* has the highest percentage of 65 years or older (9.5 percent), and *Umatac* has the lowest percentage (2.3 percent). *Mongmong-Toto-Maite* and *Umatac* have the highest proportion of persons living below the poverty level of any village in Guam (29.7 and 28.8 percent, respectively). *Santa Rita* has the lowest proportion of people living below the poverty line (12.9 percent).

Table 4. Populations Potentially Vulnerable to Hazards on Guam¹¹

Village	Population			
	Totals	Under 5 years	65+ years	Below the 2019 Poverty Level (Excluding Military Households)
Agana Heights	3,673	233	465	553
Agat	4,515	392	587	1,304
Asan/Maina	2,011	144	276	332
Barrigada	7,956	553	971	1,207
Chalan Pago-Ordot	7,064	435	733	1,056
Dededo	44,908	3,101	5,204	9,829
Hagatna	943	60	138	N
Inarajan	2,317	191	218	506
Mangilao	13,476	824	1,558	2,305
Merizo	1,604	120	180	433
Mongmong-Toto-Maite	6,380	573	634	1,722
Piti	1,585	128	176	261
Santa Rita	6,470	506	529	452
Sinajana	2,611	195	327	503
Talofofo	3,550	248	352	592
Tamuning/Tumon/Harmon	18,489	947	2,391	788*
Umatac	647	49	46	N
Yigo	19,339	1,430	1,708	3,434
Yona	6,298	497	697	1,305
Total	153,836	10,626	17,190	29,410

¹¹ 2020 Island Areas Censuses.

Renters and those living in older homes are typically more vulnerable to the effects of hazards. As shown in **Table 5**, renters occupy nearly the same number of homes in Guam than do homeowners. This ratio fluctuates among the different villages. More than twice the number of homes in *Hagatna* is owner-occupied than renter-occupied, but in *Mongmong-Toto-Maite*, about two times as many renters occupy many homes as homeowners. **Table 5** also shows that most housing units in Guam were built after 1979, with approximately 26.9 percent of the units built before 1979. This ratio also varies by village; only 7.28 percent of the homes in *Tamuning* were built before 1979, and nearly 60 percent of the homes in *Piti* were built during this same time.

Table 5. Dwelling Units Potentially Vulnerable to Hazards on Guam: Owners/Renters (Excluding Military Households)^{12,13,14}

Village	Occupied Housing		Housing Units	
	Owner-Occupied	Renter-Occupied	Total	Built <1979
Agana Heights	598	480	1,210	691
Agat	667	567	1,472	627
Asan/Maina	393	206	714	312
Barrigada	1,378	686	2,533	970
Chalan Pago-Ordot	1,396	633	2,129	456
Dededo	6,390	5,186	13,651	4,074
Hagatna	94	250	407	0
Inarajan	418	150	605	154
Mangilao	2,210	1,689	4,656	1,404
Merizo	280	135	471	188
Mongmong-Toto-Maite	728	1,127	2,277	1,005
Piti	257	206	578	347
Santa Rita	704	917	1,956	543
Sinajana	439	332	836	479
Talofofo	656	276	988	281
Tamuning/Tumon/Tumon	1,907	5,275	8,692	633
Umatac	121	32	177	N
Yigo	2,733	2,158	6,360	986
Yona	1,176	531	1,843	724
Guam (Total)	22,545	20,836	51,555	13,874

4.5.1 Social Vulnerability Index for Guam

The U.S. Centers for Disease Control and Prevention (CDC) produces social vulnerability index (SVI) maps and estimates for all states. The CDC also provides SVI and maps for Puerto Rico. However, the SVI remains to be constructed for Guam, a U.S. territory in the western Pacific. To narrow this gap, the local government and the University took it upon themselves to calculate the SVI for the municipalities and census-designated places (CDPs) in Guam and assess SVI associations with select health indicators among Guam residents.

The first SVI was calculated using data from the 2010 Guam census following the CDC methodology to rank and identify the most vulnerable communities in Guam. Fifteen

¹² 2020 Island Areas Censuses.

¹³ Homeownership represents homeowner-and renter-occupied units, but does not include vacant units. Total housing units represent all housing units, including unoccupied units.

¹⁴ Census 2020 data is used in the 2024 Guam Hazard Mitigation Plan (HMP) planning and development process. The next U.S. Census Bureau survey has been scheduled for 2030. This survey is a method of collecting and analyzing social, economic, and geographic data. It provides information about the conditions of the United States, states/territories, and counties.

variables reflecting socioeconomic status, household composition and disability, minority status and language, and housing transportation were applied to the SVI calculations. A second set of adjusted SVI was calculated using a CDC-modified method incorporating additional Guam-specific characteristics on housing structure, communication capacity, and other relevant indicators. It was ranked separately for the 19 municipalities and 57 CDPs in Guam. Lastly, the SVI was applied to a data set of health indicators acquired through the 2011 Guam Behavioral Risk Factor Surveillance System (BRFSS), and the relationship between BRFSS variables and the CDC SVI and between the BRFSS variables and adjusted SVI was assessed.

For the 2024 HMP, the Guam SVI population used the current Guam SVI and the 2020 Census populations. The following tables include the variables used to calculate the SVI for Guam, the SVI by village, and the SVI by Census Designated Place.

Table 6. Census Variables Used to Describe Themes Reflective of the Social Vulnerability Index, Guam

Theme	Variable
Theme 1: Socioeconomic status	Below poverty level Unemployment Income No high school diploma
Theme 2: Household composition & disability	Aged 65 or older Aged 17 or younger Older than 5 with a disability Single-parent households
Theme 3: Minority status and language	Minority Speaks no English
Theme 4: Adjusted minority status and language	Modified minority variable (not <i>CHamoru</i> or Filipino)* Speaks no English
Theme 4: Housing type and transportation	Multi-unit structures Mobile homes Crowding No vehicle Group quarters
Theme 5: Housing	No public water No public sewer No concrete wall No concrete roof No concrete foundation No plumbing No kitchen No telephone services
Theme 6: Communication	No battery-operated radio No computer or laptop No internet services
Theme 7: Other indicators	Not U.S. citizen Foreign-born Send remittances abroad No health insurance

Notes:

* Adjusted for Guam definition of minority (neither *CHamoru* nor Filipino) and additional Guam-specific variables on housing, connection, and other minority indicators.

Table 7. Variables Included in the Guam-Specific Themes Used to Adjust Calculations of the Social Vulnerability Index, Guam¹⁵

Theme	Variable	Percent
Minority status and language**	Modified minority (not Chamorro or Filipino)	33.6
	Speaks no English	0.39
Housing*	No public water	0.61
	No public sewer	32.5
	No concrete wall	6.65
	No concrete roof	11.3
	No concrete foundation	1.76
	No plumbing	12.1
	No kitchen	11.5
	No telephone services	4.15
Communication*	No battery-operated radio (2010 only)	22.3
	No computer or laptop	25.3
	No internet services	7.06
Other indicators	Not U.S. citizen**	12.8
	Foreign-born**	20.4
	Send remittances abroad*	27.6
	No health insurance**	17.1

Notes:

* Adjusted for Guam definition of minority (neither CHamoru nor Filipino) and additional Guam-specific variables on housing, connection, and other minority indicators.

** Significant at 0.05 level.

Table 8. Social Vulnerability Index (SVI) and Percentile Rank for the 19 Municipalities in Guam Stratified by Methodology¹⁶

CDC Methodology			Adjusted Methodology*		
Rank	SVI	Municipality	Rank	SVI	Municipality
1	1.00	Agat	1	1.00	Agat
2	0.94	Merizo	2	0.94	Dededo
3	0.89	Hagatna	3	0.89	Yigo
4	0.83	Mongmong-Toto-Maite	4	0.83	Hagatna
5	0.78	Dededo	5	0.78	Umatac
6	0.72	Mangilao	6	0.72	Mangilao
7	0.67	Umatac	7	0.67	Merizo
8	0.61	Yigo	8	0.61	Mongmong-Toto-Maite
9	0.56	Sinajana	9	0.56	Inarajan
10	0.50	Yona	10	0.50	Chalan Pago-Ordot
11	0.44	Barrigada	11	0.44	Barrigada
12	0.39	Inarajan	12	0.39	Yona
13	0.33	Chalan Pago-Ordot	13	0.33	Sinajana
14	0.28	Agana Heights	14	0.28	Talofofo

¹⁵ 2020 Island Areas Censuses.

¹⁶ 2010 U.S. Census

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15	0.22	Talofofo
16	0.17	Tamuning
17	0.11	Asan-Maina
18	0.06	Santa Rita
19	0.00	Piti

15	0.22	Tamuning
16	0.17	Agana Heights
17	0.11	Asan-Maina
18	0.06	Santa Rita
19	0.00	Piti

* Adjusted for Guam definition of minority (neither CHamoru nor Filipino) and additional Guam-specific variables on housing, connection, and other minority indicators.

Table 9. Social Vulnerability Index (SVI) and Percentile Rank for the 57 Census Designated Places (CDPs) in Guam Stratified by Methodology¹⁷

CDC Methodology			Adjusted Methodology*		
Rank	SVI	CDP	Rank	SVI	CDP
1	1.00	Ukudu	1	1.00	Ukudu
2	0.98	Astumbo	2	0.98	Chaguian
3	0.96	Y Sengsong	3	0.96	Y Sengsong
4	0.95	Pagat	4	0.95	Pagat
5	0.93	Toto	5	0.93	Astumbo
6	0.91	Machanao	6	0.91	Macheche
7	0.89	Chaguian	7	0.89	Machananao East
8	0.88	Merizo CDP	8	0.88	Hagatna CDP
9	0.86	Macheche	9	0.86	Anao
10	0.84	Yona CDP	10	0.84	Machanao
11	0.82	Hagatna CDP	11	0.82	Machananao West
12	0.80	Machananao East	12	0.80	Mataguac
13	0.79	Agat CDP	13	0.79	Toto
14	0.77	Mataguac	14	0.77	Dededo CDP
15	0.75	Dededo CDP	15	0.75	Wusstig
16	0.73	Machananao West	16	0.73	North Gayinero
17	0.71	Santa Rita CDP	17	0.71	Agat CDP
18	0.70	Mongmong	18	0.70	Yona CDP
19	0.68	Umatac CDP	19	0.68	Umatac CDP
20	0.66	Mangilao CDP	20	0.66	Ordot
21	0.64	University of Guam	21	0.64	Harmon Industrial Park
22	0.63	Harmon Industrial Park	22	0.63	Merizo CDP
23	0.61	Wusstig	23	0.61	Mongmong
24	0.59	Talofofo CDP	24	0.59	Talofofo CDP
25	0.57	Anao	25	0.57	Mangilao CDP
26	0.55	Ordot	26	0.55	Mogfog
27	0.54	Upper Tumon	27	0.54	Malojloj
28	0.52	North Gayinero	28	0.52	Inarajan CDP
29	0.50	Malojloj	29	0.50	Liguan
30	0.48	Mogfog	30	0.48	Adacao
31	0.46	Liguan	31	0.46	Upper Tumon
32	0.45	Sinajana CDP	32	0.45	University of Guam
33	0.43	Barrigada CDP	33	0.43	Santa Rita CDP
34	0.41	Tamuning CDP	34	0.41	South Gayinero
35	0.39	Afame	35	0.39	Piti CDP
36	0.38	South Gayinero	36	0.38	Apotgan

¹⁷ 2010 U.S. Census

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37	0.36	Agana Heights CDP	37	0.36	Tamuning CDP
38	0.34	Inarajan CDP	38	0.34	Afame
39	0.32	Piti CDP	39	0.32	Barrigada CDP
40	0.30	Adacao	40	0.30	Barrigada Heights
41	0.29	Apotgan	41	0.29	Maite
42	0.27	Barrigada Heights	42	0.27	Agana Heights CDP
43	0.25	Maite	43	0.25	Chalan Pago
44	0.23	Asan	44	0.23	Sinajana CDP

* Adjusted for Guam definition of minority (neither CHamoru nor Filipino) and additional Guam-specific variables on housing, connection, and other minority indicators.

Table 10. Spearman's Rank Correlations Between the Social Vulnerability^{18,19}

BRFSS Variables	SVI CDC	SVI Adjusted*
Binge drinking	-0.571**	-0.496
Current asthma	0.318	0.354
Current smoker	-0.121	-0.271
Fair or poor general health	0.471	0.354
Obese	0.264	0.093

* Adjusted for Guam definition of minority (neither CHamoru nor Filipino) and additional Guam-specific variables on housing, connection, and other minority indicators.

** Significant at 0.05 level.

4.6 ECONOMY

According to the Guam Department of Labor's Current Employment Report for September 2023, were 66,520 civilians employed in Guam. As shown in **Table 11**, the largest industry (12,080) is the Private Sector. This industry will continue to grow to meet the demand for military construction. Other key industries in Guam include Services (16,180) and Retail Trade (12,110). The (16,150) Public Sector accounts for 24% of Guam's overall civilian labor force.²⁰

Table 11. Employment by Ownership and Industry²¹

Ownership and Industry	Employees on Payroll
PRIVATE SECTOR	50,370
AGRICULTURE	250
CONSTRUCTION	12,080
General Building Contractors	10,260
Heavy Construction, ex. Building	480
Special Trade Contractors	1,340
MANUFACTURING	1,480
All other manufacturing	860

¹⁸ 2010 U.S. Census

¹⁹ U.S. Centers for Disease Control and Prevention, "CDC - BRFSS - BRFSS 2011 Survey Data and Documentation," www.cdc.gov/brfss/annual_data/annual_2011.htm.

²⁰ Guam Department of Labor, "Current Employment Statistics – Bureau of Labor Statistics," Current Employment Statistics, September 2023, <https://bls.guam.gov/current-employment-statistics/>.

²¹ Ibid.

Food and kindred products	480
Printing and publishing	140
FINANCE, INSURANCE & REAL ESTATE	2,320
TRANSPORTATION & PUBLIC UTILITIES	3,720
WHOLESALE TRADE	2,230
RETAIL TRADE	12,110
SERVICES	16,180
All other services	10,380
Hotels and other lodging places	5,800
PUBLIC SECTOR	16,150
FEDERAL	4,110
GOVERNMENT OF GUAM	12,040
Total Paid Employees	66,520

4.7 TOURISM

Table 12 shows the annual number of tourists who arrived in Guam from 2000 to 2023. During this period, Guam averaged 1,255,896 tourists annually. Tourist arrivals were highest in 2016, 2017, and 2018. From 2000 to 2018, 98.17 percent of all tourists and military arrived in Guam by air. Civilian tourists typically come from Japan, the U.S. mainland, Hawaii, the Commonwealth of the Northern Mariana Islands (CNMI), Taiwan, the Philippines, Korea, Russia, and Hong Kong.

Table 12. Tourist Arrivals to Guam, 2000–2024²²

Year	Civilian					Military			Total
	Air			Sea Arrivals	Subtotal: Civilian Arrivals	Air Arrivals	Sea Arrivals	Subtotal: Military Arrivals	
	Domestic (U.S. Mainland & Hawaii)	Int'l Air Arrivals	Total Civilian Air Arrivals						
2000	41,075	1,243,566	1,284,641	5,987	1,290,628	589	1,577	2,166	1,292,794
2001	38,557	1,101,437	1,139,994	19,114	1,159,108	3,318	16,583	19,901	1,179,009
2002	33,233	1,025,391	1,058,624	5,022	1,063,646	8,288	22,521	30,809	1,094,455
2003	35,409	874,097	909,506	2,411	911,917	5,816	49,663	55,479	967,396
2004	40,563	1,064,086	1,104,649	5,982	1,110,631	7,582	37,986	45,568	1,156,199
2005	41,580	1,115,133	1,156,713	2,605	1,159,318	8,436	42,393	50,829	1,210,147
2006	39,576	1,143,715	1,183,291	2,341	1,185,632	6,600	24,879	31,479	1,217,111
2007	49,590	1,125,972	1,175,562	2,139	1,177,701	9,335	40,380	49,715	1,227,416
2008	52,797	1,031,728	1,084,525	3,203	1,087,728	10,999	32,462	43,461	1,131,189

²² Guam Visitors Bureau, "Visitor Arrival Statistics - Guam Visitors Bureau | GVB," www.guamvisitorsbureau.com, 2024, <https://www.guamvisitorsbureau.com/research/statistics/visitor-arrival-statistics>.

2009	55,525	978,883	1,034,408	7,264	1,041,672	10,083	1,116	11,199	1,052,871
2010	61,381	1,113,655	1,175,036	8,256	1,183,292	12,696	436	13,132	1,196,424
2011	49,562	1,073,359	1,122,921	7,937	1,130,858	15,502	774	16,276	1,147,134
2012	50,967	1,189,053	1,240,020	4,847	1,244,867	21,615	3,679	25,294	1,270,161
2013	47,058	1,266,218	1,313,276	6,846	1,320,122	17,211	332	17,543	1,337,665
2014	54,459	1,254,866	1,309,325	4,669	1,313,994	21,396	7,702	29,098	1,343,092
2015	58,531	1,324,337	1,382,868	5,284	1,388,152	17,529	3,369	20,898	1,409,050
2016	52,310	1,445,872	1,498,182	2,694	1,500,876	19,250	15,392	34,642	1,535,518
2017	55,625	1,451,781	1,507,406	5,633	1,513,039	14,945	17,408	32,353	1,545,392
2018	80,628	1,432,654	1,513,282	3,238	1,516,520	19,130	13,357	32,487	1,549,007
2019	81,461	1,559,434	3,238	7,942	1,648,837	14,775	3,053	17,828	17,828
2020	22,638	290,204	312,842	1,250	314,092	13,750	331	14,081	328,173
2021	33,677	24,112	57,789	530	58,319	20,680	390	21,070	79,389
2022	70,430	240,771	311,201	636	311,837	14,918	123	14,942	326,878
2023	76,656	567,132	643,788	3,652	647,440	9,054	24	9,078	656,518
*2024 YTD	19,838	194,396	214,234	6,991	221,225	3,322	14	3,336	224,561

4.8 ASSETS

Although the 2024 HMP is not utilizing the FEMA software Hazards United States (HAZUS), GIS mapping and the database for Essential Facilities, Major Utilities, and Transportation Systems use the same five major categories of critical infrastructure: Essential Facilities, Lifeline (Major) Utilities, Transportation Systems, High Potential Loss Facilities, and Hazardous Material Facilities. **Table 13** identifies the critical assets in this plan.

Table 13. Essential Facilities, Major Utilities, and Transportation Systems²³

Essential Facilities	Major Utilities	Transportation Systems
Fire Stations	Electric Power Utilities: - Facilities - Substations - Power Plants - Power Stations	Municipal Airports
Police Stations		Port Facilities
Senior Centers		Traffic Signals
Community Centers		Pedestrian Crossing Signals
Historic Sites		Bridges
Cemeteries and Burial Grounds	Potable Water Systems: - Production Wells - Enclosed Storage Facilities - Storage Basins - Pump Stations - Treatment Plants	Bus Sub-stations
Parks, Preserves, and Beaches		Major Roads
Recreation Facilities		
Governor's Complex		
Government of Guam Agencies and Departments		
Libraries	Wastewater Systems: Pump Stations	
Mayor's Councils of Guam Facilities		

²³ Federal Emergency Management Agency, "STEP 3: INVENTORY ASSETS 3-1," accessed June 4, 2024, https://www.fema.gov/pdf/plan/prevent/hazus/fema433_step3.pdf.

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Health Care Facilities and Clinics	• Treatment Plants	
Public Schools		
Resorts, Hotels, and Motels		

High Potential Loss Facilities, which include military facilities, nuclear facilities, and dams, are excluded from analysis for several reasons: the military bases are federal facilities and outside the jurisdiction of the Government of Guam; for security reasons, detailed information on military facilities is generally not available; and the only dam on Guam (Fena Dam) is also a federal facility and outside the jurisdiction of the Government of Guam. In addition, Hazardous Material Facilities that are excluded from this plan are not under the direct control of the Government of Guam. Also, to maintain the focus on critical infrastructure, only major roads (not minor roads) are considered in the 2019 Guam HMP (as was the case in the earlier versions of the HMP).

Despite these exceptions, 895 Essential Facilities, Major Utilities, and Transportation Systems (EFMUTS) owned and operated by the Government of Guam and the private sector were identified and geocoded for the 2019 and 2014 Guam HMP. The EFMUTS values were collected from various sources, including the 2023 Guam Real Property Tax Roll, 2022 Audited Financial Statements Capital Assets for GIAA and PAG, and insurer replacement cost estimates for GPA and GWA.

Appendix E (Essential Facilities, Major Utilities, and Transportation Systems) are geocoded and added to the EFMUTS list and available online at: <https://govguamgis.maps.arcgis.com/apps/mapviewer/index.html?webmap=f5004840eb65488496be185de44aa024>. **Table 14** is a breakdown of these EFMUTS by major category of Critical Buildings, Facilities, and Infrastructure in 2024:

Table 14. EFMUTS by Major Category of Critical Buildings, Facilities, and Infrastructure (2024)

			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	sq. mi.	Pop	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	1.03	3,940	7	8,473,449	4	11,973,307	11	212,070	170	24,247,736
Agat	10.62	5,656	22	68,393,275	9	48,942,614	33	4,083,603	1,578	211,786,394
Asan/Maina	5.67	2,090	6	15,094,389	10	47,323,525	18	12,543,922	504	75,888,753
Barrigada	8.5	8,652	24	44,706,404	17	23,874,499	54	902,046,000	4,672	982,437,954
Chalan Pago-Ordot	5.65	5,923	8	10,222,600	19	25,943,003	33	21,489,075	698	113,980,003
Dededo	30.25	42,980	37	63,720,712	96	864,949,321	150	50,927,342	14,199	3,374,695,451
Hagatna (Agana)	0.85	1,100	44	45,164,842	4	13,842,840	57	46,326,284	337	215,886,638
Inarajan	18.74	3,052	15	31,373,592	17	83,562,107	37	35,432,815	626	72,133,449
Mangilao	10.28	13,313	28	96,115,393	28	75,985,727	60	14,677,695	1,325	278,898,089
Merizo	6.12	2,163	10	6,508,381	16	27,164,258	27	9,549,497	381	43,949,231
Mongmong- Toto-Maite	1.82	5,845	7	12,883,761	7	9,150,463	15	3,694,629	389	115,575,092
Piti	7.35	1,666	19	19,060,835	11	561,920,374	41	927,385,084	523	111,933,654
Santa Rita	16.42	7,500	7	41,310,478	12	58,010,152	22	11,974,388	439	62,532,235
Sinajana	0.89	2,853	8	5,135,848	9	6,123,884	18	3,217,647	3,476	493,636,211
Talofofo	17.8	3,215	8	4,320,091	9	40,348,207	17	915,918	957	149,244,478

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Tamuning/Tumon	5.7	18,012	79	816,237,711	23	148,154,977	132	96,937,103	1,577	1,180,418,410
Umatac	6.09	887	9	4,888,457	19	93,942,131	30	17,862,514	139	14,567,811
Yigo	35.78	19,474	12	20,098,671	33	113,389,313	50	14,641,606	4,758	691,047,282
Yona	20.25	6,484	12	107,650,087	16	157,648,890	31	21,870,885	1,672	333,827,467
Total	209.81	154,805	362	1,421,358,974	359	2,412,249,591	836	2,195,788,078	38,420	8,546,686,338

Tables E-1, E-2, E-3, and E-4 (Appendix E [Essential Facilities, Major Utilities, and Transportation Systems]) identify specific EFMUTS, shown in **Figures D-6 through D-11**. These facilities and related data have been mapped using GIS and form the basis for the vulnerability analysis estimates.

4.9 MAJOR DEVELOPMENTS AND LAND USE

Land use and development are major risk factors for natural hazards. Major areas of concern are where the built environment intersects hazard areas. Understanding how past, current, and projected development has or is likely to increase or decrease risk in hazard areas is critical to understanding the state's overall risk to its hazards of concern. The following sections discuss changes in development since the 2019 HMP, current land use and development trends, and projected changes in development. Additional land use and development discussion can be found in Section 5 (Capability Assessment) of the 2024 HMP Update.

4.9.1 Major Developments

A method of determining the level of growth in the GBS is through an analysis of building permits. **Table 15** shows the number of new building permits issued, the total values of these buildings, the number of permits issued for additions to buildings, and the values for 2000 through 2023. From 2000 to 2023, the largest number of building permits for new structures was issued in 2018.

Most of the new construction permits issued were for *Dededo*, with 76 permits (28.0%) issued. The village with the second-highest number of permits issued for new construction in 2018 was *Yigo*, where 58 permits (21.3%) were issued. 2018 holds the record for most permits issued in a calendar year.

Table 15. Building Permits Issued by Year 2000–2023²⁴

CY	Number (New)	Value (\$)*	Number (Additions)	Value (\$)*
2000	345	\$45,527	200	\$26,913
2001	254	\$48,158	217	\$22,368
2002	247	\$25,617	268	\$24,677
2003	390	\$41,437	824	\$52,512
2004	255	\$55,989	268	\$25,735
2005	291	\$64,906	262	\$27,432
2006	344	\$84,893	232	\$38,851

²⁴ Guam Department of Public Works

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2007	390	\$222,733	262	\$32,081
2008	342	\$128,417	254	\$21,402
2009	337	\$148,766	253	\$26,571
2010	350	\$104,639	182	\$15,976
2011	272	\$75,606	182	\$14,912
2012	221	\$196,008	127	\$17,263
2013	366	\$202,827	148	\$25,272
2014	256	\$151,446	120	\$15,284
2015	335	\$88,093	120	\$25,883
2016	328	\$212,060	91	\$10,313
2017	375	\$87,361	103	\$13,681
2018	622	\$121,183	84	\$12,493
2019	301	\$186,896	76	\$10,723
2020	272	\$214,380	85	\$9,788
2021	301	\$121,304	144	\$8,554
2022	398	\$344,812	117	\$47,968
2023	325	\$66,945	78	\$9,422

Note:
 * Values do not include government, demolition, relocation, grading, signing, miscellaneous, or renewal permits.

Construction projects proceed through several phases: planning, funding, contracting or permitting, and construction and payment. Statistics are provided for the funding, often appropriations, bond or private financing, and contracting and permitting. Funding authorizations provide an advance indicator of upcoming construction, while building permits and contracts provide a more immediate leading indicator of construction that will likely commence soon. Employment reflects current construction activity.

Expenditures reflect payments for construction work that has been completed. Figures on these items reflect the stages of the construction activity and are included in this section.

Construction is expected to increase substantially from FY 2023 to FY 2024 and FY 2025. The recent acceleration of construction activity was substantial in FY 2023. Construction activity has increased dramatically through FY 2023 as measured by employment, H-2B Temporary Non-Agriculture Workers (H2), and gross receipts. Construction employment increased from 7,860 in September 2020 to 12,080 in September 2023. H2 workers increased from 1,527 in December 2020 to 5,065 in December 2023. As a measure of construction activity, Gross receipt taxes paid for construction increased from \$48.2 million in FY 2020 to \$70.7 million for FY 2023, an increase of 47% in three years.

The total value of building permits for civilian projects and Department of Defense (DoD) construction contracts increased substantially in 2021 through 2022 compared to prior

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years (**Table 16**). High levels of previously permitted and contracted projects are underway. Building permits and DOD construction contracts are solid indicators of plans backed by financial commitments to commence construction soon.

Federal appropriations for military construction projects, Government of Guam bond or other financing commitments, and announcements of private sector projects are strong indicators of future construction. Federal DOD construction appropriations have increased from \$248.7 million in FY 2017 to \$523.0 million in FY 2023 and just over \$1.0 Billion in FY 2024 (**Table 17**). The list of DOD projects currently under construction is also substantial at over \$2.2 billion project cost, with over \$1.1 billion in work remaining to be completed.

Table 16. DoD Construction by FY

Fiscal Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Building Permits	434,277	436,833	365,589	361,574	379,612	307,928	580,040	253,860		
US Military Construction Contracts	40,963	167,932	294,999	427,229	153,347	473,159	799,917	754,577		
Japan Funded Base Relocation Contracts	640	203,500	78,300	208,100	350,900	918,900	N/A	N/A		
TOTAL	475,880	808,265	738,888	996,903	883,859	1,699,987	1,341,257	1,008,437		

Table 17. Federal DoD Construction Appropriations by FY

Fiscal Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
US DoD Military Construction	133,680	272,268	248,658	354,654	448,500	470,638	571,205	761,217	522,994	1,018,925
DoD Civilian Guam Infrastructure		20,000								
Government of Japan (Revenues)	183,300	124,500	235,800	521,400	193,600	367,000	401,900	38,700*		
Combined:	316,980	416,768	484,458	876,054	642,100	837,638	973,105	799,917	522,994	1,018,925

Several major civilian projects have been recently completed or are ongoing. These include:

Table 18. Additions to Building Stock and EFMUTS

Category	Type	Development	Location	Status
Essential Facilities	Government	Guam Department of Education's Tiyan HQ	Barrigada	New Development
	School	iLearn Academy	Dededo	New Development
		SIFA Learning Academy	Barrigada	New Development
	Police Station	Sinajana Police Station	Sinajana	New Development
	Hotel	Tsubaki Tower Hotel	Tamuning	New Development
		The Village Kidney Care Center	Dededo	New Development

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	Health Care Facilities and Clinics	The Village Kidney Care Center	Sinajana	New Development
		Fresenius Kidney Care Usg - Tamuning	Tamuning	New Development
Major Utilities	Power Plants	Solar Farm	Yigo	New Development
	Power Plants	Ukudu Power Plant	Dededo	Under Development
	Treatment Plants	Northern Water Treatment Plant	Dededo	New Development
	Treatment Plants	Southern Water Treatment Plant	Merizo	New Development
Housing	Large Apartment Complex	Ironwood Delmar	Mongmong-Toto-Maite	New Development
	Housing Subdivision	Songsong Hills	Yigo	New Development
	Housing Subdivision	Summer Estates	Dededo	New Development
	Housing Subdivision	J524 Development LLC.	Yigo	Under Development
Retail and Services	Grocery	Don Don Donki	Tamuning	New Development
		American Grocery	Mongmong-Toto-Maite	Under Development
		Happy Mart	Tamuning	Under Development
	Banks	Community First	Hagatna	New Development
	Banks	Coast 360	Tamuning	New Development
	Banks	Bank of Hawaii	Tamuning	Under Development

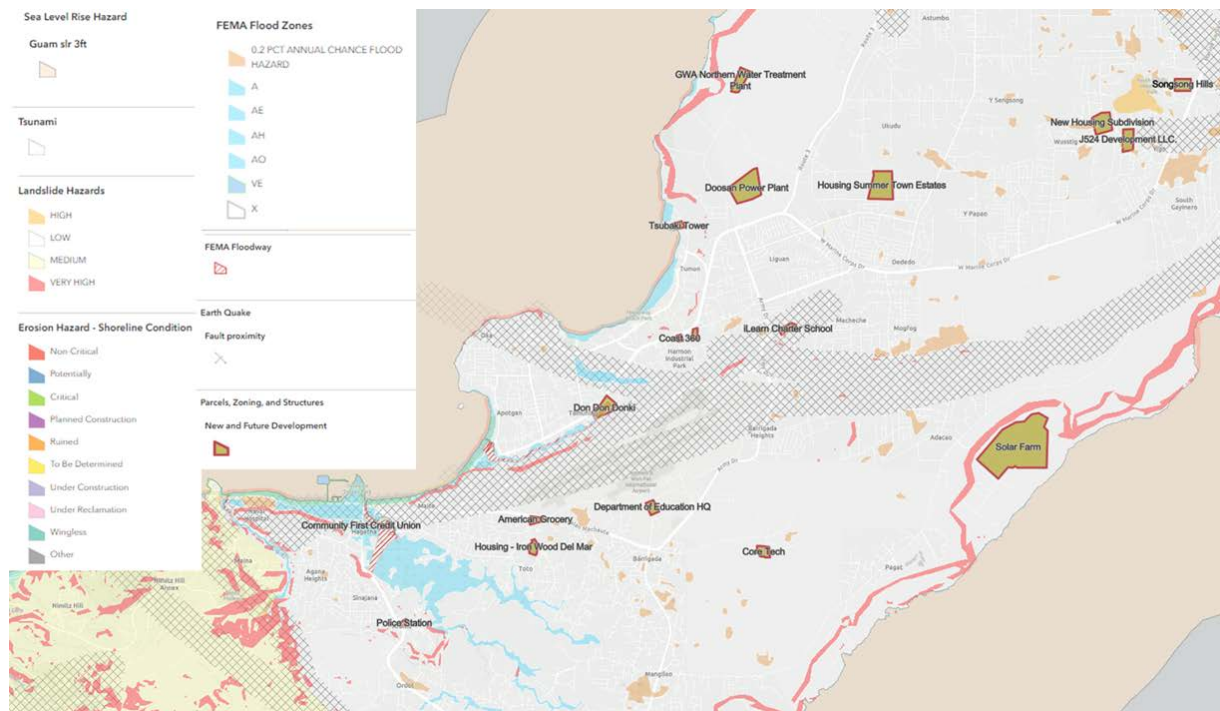
As depicted in **Table 19**, new major developments are located in areas where they are exposed to risk. These include the following developments and the hazards they are exposed to. Notes regarding mitigation to avoid or limit their exposure are also described.

Table 19. Vulnerability of New and Upcoming Major Developments on Guam

Type	Development	Location	Hazard	Mitigation
School	iLearn Academy	Dededo	Fault Proximity-Earth Quake	N/A
Grocery	Don Don Donki	Tamuning	.2 Annual Chance of Flood	Property raised above base flood elevation with major stormwater controls in place.
Banks	Community First	Hagatna	New Development	Structure raised above base flood elevation

The Ukudu Power Plant in Dededo is intended to replace Cabras 1 and 2 in Piti. Those two plants are in a coastal flood zone, and the new location is not directly exposed to land-based hazards.

Figure 1. Ukudu Power Plant



4.9.2 Land Use Changes

The two northern subdivisions listed in section 4.9 required a zone change from agricultural to residential. Both developments are not directly exposed to any hazards included in this plan. All other major developments listed were consistent with the zoning for those properties as of 2019.

4.9.3 General Building Stock

Guam has 42,663 mapped residential and non-residential buildings. Except for a few new significant developments in 2023 and 2022, data on building stock or building values were used for the 2024 HMP. This represents an increase of 2,594 structures compared to those mapped and reported in the 2019 HMP.

For the 2024 Guam HMP, 2023 property tax values were obtained for each village's appraised building value (in \$/building) of structures. The total assessed value of buildings outside the military bases was 8.6 billion dollars. The average building values for Guam's GBS varied from a low of \$104,809/building in *Umatac* to a high of \$748,521/building in *Tamuning/Tumon*. The average value of a building (residential and non-residential) in Guam is \$222,454.

The tax appraised value is estimated to be much lower than the market value of these buildings. The appraisal value is only updated during the mass property re-appraisal or when a new building is built, sold, or improved. The last mass tax reappraisal was done in 2015. Since then, the median home price for sale has increased by \$250,000 or 119%, and the cost of building has tripled.

As shown in **Figure D-12** and listed by the village in **Tables F-1** and **F-2**, the highest numbers of buildings, in descending order, are found in the villages of *Dededo*, *Yigo*, and *Tamuning/Tumon/Tumon*. In descending order, the highest concentrations of building values are found in the villages of *Dededo*, *Tamuning/Tumon/Tumon*, and *Yigo*.

Guam structures have been mapped using GIS, forming the basis for the exposure analysis estimates. However, additional information that would have contributed considerably to the vulnerability analysis results was not comprehensively available with the time and resources available for this update. Helpful information for plan updates would include the age/year built, primary building material, roofing material, general condition, mitigation upgrades (e.g., seismic retrofit, wind shutters), and prior hazard damage.

4.9.4 Military Buildup

The effect of the ongoing Marine Corps Relocation projects on Guam's economy in FY 2025 will primarily be associated with substantial increases in construction activity. Despite the acceleration in construction, delays related to labor shortages, the pandemic, and other causes, the realignment of forces to Guam was extended again to FY 2028, as noted in the Inspector General's Realignment report covering FY 2020. These economic increases and impacts are interrelated and discussed in this report's construction and federal expenditures sections. This section focuses on realignment issues specifically.

The Record of Decision released in August 2015 substantially downsized and lengthened the time frame from the initial 2010 plan. The realignment cost is capped at \$8.7 billion, of which about \$3 billion will come from the Government of Japan. The plan was to relocate about 5,000 Marines and their dependents from Okinawa to Guam between 2020 and 2025. Delays to the plan continue. Marine Corps Base Camp Blaz will be home to approximately 5,000 Marines from III Marine Expeditionary Force who will begin relocating from Okinawa, Japan, by FY 2025, according to the December 21, 2021, Guam Realignment Report. The plan is summarized in an article from the Pacific Daily News published on August 18, 2017. It includes "a Marine base on a military property at Naval Computer and Telecommunications Station; housing Marine families in homes to be built within the fence at Andersen; developing a live-fire training range complex on 338 acres of land at Andersen, adjacent to the wildlife refuge at *Ritidian*; and developing a hand-grenade training facility at Andersen South." It also includes many off-base infrastructure capital improvements. These include civilian water and wastewater projects, port projects, road improvements for routes 1, 3, and 11, and Agana bridge projects.

Public Law 111-84, “National Defense Authorization Act (NDAA) for Fiscal Year 2010,” section 2835, October 28, 2009, designates the DoD Inspector General as the chairperson of the Interagency Coordination Group of Inspectors General for Guam Realignment. It requires an annual report due February 1 of each year—Sec. 2851 of the Fiscal Year 2021 NDAA changed the reporting requirement from annual to biennial, with the following report for FY2023 due February 1, 2024, and every second February 1 after that.²⁵

The Interagency Coordination Group of Inspectors General’s Report for Guam Realignment Annual Report, published January 27, 2022, contains five sections identifying the programs and operations funded with appropriated amounts or funds otherwise made available for military construction on Guam in FY 2021. These sections reported that:

1. The DoD obligated \$1.4 billion and expended \$448.3 million. Other Federal agencies obligated \$8.8 million and expended \$1.9 million. (Section 1)
2. The DoD identified 270 military construction projects and programs totaling \$447 million, with estimated completion costs of \$1.9 billion. Other Federal agencies identified thirty-eight projects and programs directly associated with the realignment. Of the thirty-eight projects and programs, two projects and programs had incurred costs of \$335,249, and three projects and programs had estimated completion costs of \$9.4 million. (Section 2)
3. The Government of Japan provided revenues of \$401.9 million and earned \$26 million in interest associated with revenues. Also, the Government of Japan obligated \$918.9 million and expended \$268.6 million. (Section 3)
4. The DoD identified operating expenses of \$115.2 million. Other Federal agencies identified operating expenses of \$78,187. (Section 4)
5. The DoD identified 222 contracts, grants, agreements, or other funding mechanisms with obligations of \$1.2 billion. Other Federal agencies identified a total of thirty-five contracts, grants, agreements, or other funding mechanisms, with obligations of \$7.3 million. (Section 5)

In FY 2017, DoD obligated \$417.9 million and expended \$152.7 million. For FY 2017 and FY 2018 combined, obligations exceeded expenditures by \$452.1 million. That excess of new obligations increased in FY 2019 with \$309.4 million and expenditures of \$210.3 million. The excess of obligations over expenditures increased again in FY 2020 by \$164.2 million, with obligations of \$529.3 million and expenditures of \$365.1 million.

In FY 2021, DoD obligated \$1.4 billion and expended \$448.3 million, an excess of obligations over expenditures of \$951.7 million. The five-year accumulation of obligated

²⁵ National Defense Authorization Act for Fiscal Year 2010, Pub. L. No. 111-84 (2009), <https://www.govinfo.gov/app/details/PLAW-111publ84>.

funds available to disperse as work progresses is \$1.67 billion. The combined appropriations totaling over \$1.3 billion for FY 2022 and FY 2023 add to the available funding. This indicates that a substantial amount of work to be contracted and in-process has accumulated and will almost certainly substantially accelerate the pace of realignment-related construction activity. The expenditures have increased from \$152.7 million in FY2017 to \$448.3 billion in FY2021.

The report shows the total relocation project cost from inception to September 30, 2021, including costs incurred by DoD, other federal agencies, and the Government of Japan at \$2.6 billion, about thirty percent of the \$8.7 billion project cost. **Figure 2** demonstrates an increase in DoD construction over the next several years, peaking in FY25. FY25 includes an appropriation of \$238 million for military construction for the missile defense system and the Marine Corps base project shown in **Figure 3**.

Figure 2. DoD Construction in Guam

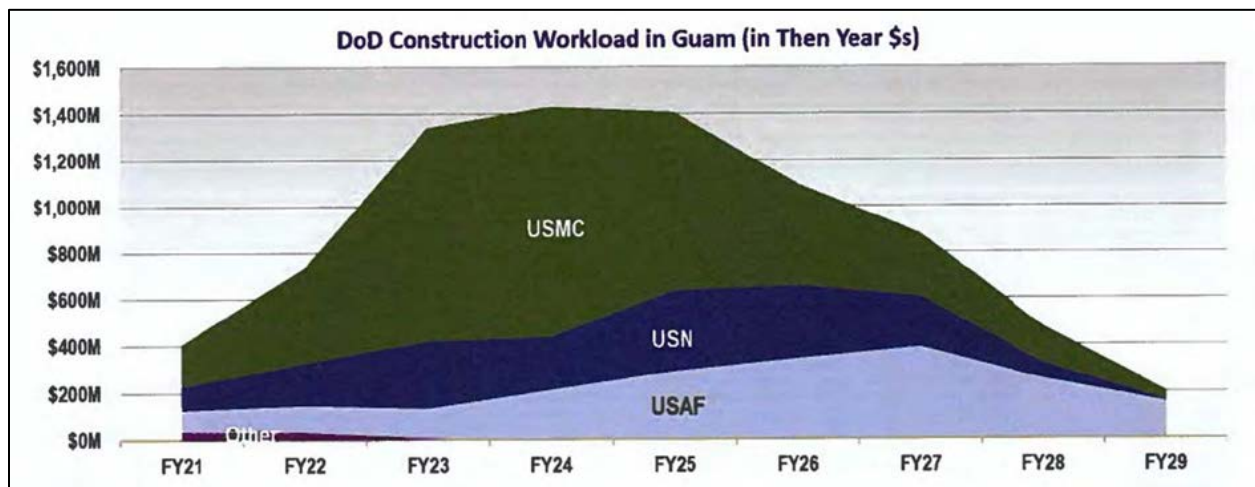


Figure 3. U.S. Missile Defense Agency Budget for Defense of Guam Program

(Dollars in millions)								
Fiscal Year	2022	2023	2024	2025	2026	2027	2028	Totals
RDT&E	110.6	393.2	397.6	291.3	272.2	238.8	232.1	1,935.8
Procurement	80	26.5	169.6	85.7	5.3	—	—	367.1
MILCON	—	—	—	438.0	—	—	—	438.0
Total	190.6	419.7	567.2	815.0	277.5	238.8	232.1	2,740.9
Source: Department of Defense Fiscal Year (FY) 2024 Budget Estimates, Missile Defense Agency Defense-Wide Justification Book Volume 2a of 5 Research, Development, Test & Evaluation, Defense-Wide, March 2023, see p. 2a 577. Also see Department of Defense Fiscal Year (FY) 2024 Budget Estimates, Missile Defense Agency Defense-Wide Justification Book Volume 2b of 2 Procurement, Defense-Wide, March 2023, see p. 2b 125. Military Construction (MILCON) data provided to CRS by the Under Secretary of Defense for Comptroller. Notes: RDT&E = Research, Development, Test and Evaluation accounts; MILCON = Military Construction accounts. Budget data for FY2024 reflects the 2024 President's Budget Request. Budget data for 2025 to 2028 reflect the Future Years Defense Program (FYDP). MDA budget documents indicated that costs for RDT&E related to the Guam Missile Defense system will continue beyond FY2028.								

SECTION 5 RISK ASSESSMENT AND HAZARD PROFILES

SECTION 5 – RISK ASSESSMENT AND HAZARD PROFILES

5.1 PURPOSE

The purpose of this section is to identify and screen the hazards that can affect Guam, profile the hazards selected by the GHS-OCD HM Section, inventory the EFMUTS, GBS, and population on Guam, and assess the vulnerability and potential losses to the assets from the qualifiable hazards addressed in the 2024 Guam HMP, and the impact on vulnerable populations. This effort builds on data acquired for the earlier versions of the Guam HMP and subsequent data and analyses provided for this 2024 Guam HMP. The information presented and analyzed was the best available data during the 2024 Guam HMP update process.

5.2 METHODOLOGY

Hazards United States – Multi-Hazard (HAZUS-MH) is FEMA's recommended risk assessment software program for earthquakes, flooding, and severe winds. However, due to the deadline of this planning update, Guam did not have enough time to update HAZUS-MH with its local geodatabases and administrative data for it to be used for risk assessment.

In the absence of HAZUS-MH, vulnerability analysis for all versions of the Guam HMP has been conducted using quantitative analysis in GIS. In the previous 2019 HMP Implementation Strategy the Bureau of Statistics and Plans was to complete a “Comprehensive inventory and update all EFMUTS at risk from hazards in order to provide emergency responders with accurate information about critical facilities. Inventory information should include exact location, facility type, owner/operator, replacement/insured value, year built, primary structural system, secondary building system/redundancy, building material, roof material/type, mitigation upgrades (e.g., shutters, seismic retrofit), potential secondary impacts due to failure, and prior disaster impacts.”

With the exception of capturing building material, this task was complete. As a result, the ability to perform quantitative vulnerability analysis and more accurate risk assessments were possible for this HMP update.

A quantitative vulnerability analysis uses detailed information on hazard location and probability/magnitude (where possible). A quantitative analysis was conducted for seismic hazards (faults, liquefaction), flooding, HAZMAT, sea level rise, severe wind, slope failure (landslide), tsunami inundation, and wildland fire. Tropical cyclone was analyzed through the analysis of the key sub hazards associated with tropical cyclones, including flooding and severe wind.

A quantitative analysis was not conducted on coastal erosion; disease; drought; stormwater flooding; high surf; lightning; non-seismic ground failure; salt spray; sea level rise, slope failure (mudslide and post-fire debris flow); terrorism; and transportation accident (aviation and port) due to lack of data to conduct such an analysis. GHS-OCD plans to conduct a vulnerability analysis for sea level rise when the data becomes

SECTION 5 RISK ASSESSMENT AND HAZARD PROFILES

available for download from the National Oceanic and Atmospheric Administration (NOAA). Likewise, a quantitative vulnerability analysis has not been prepared for HAZMAT sewage discharge because the sewage is discharged directly into the ocean and therefore does not affect the assets and population on land.

The quantitative analysis for the 7 hazards identified above was conducted in GIS by overlaying each identified hazard area on top of the assets identified in **Section 4.8 (Assets)**. The results of the exposure analyses were tabulated at the Territory-level in **Tables 22 and 23** and at the village level, as shown in **Appendix F (Vulnerability Analysis Results by Village)**.

5.3 DATA LIMITATIONS

The exposure analyses used in this plan are subject to the following limitations:

- In the case of population, no estimates of injuries or deaths are made, and no estimates of the value of lives/injuries are made
- In the case of EFMUTS and GBS, the entire structure value is assumed to be lost (i.e., no loss damage curves or worst-case scenario).
- No contents values are estimated for EFMUTS or GBS
- No loss of function costs are estimated for EFMUTS or GBS
- No displacement or temporary quarters costs are estimated for EFMUTS or GBS

5.4 IDENTIFY AND SCREEN HAZARDS

The first step in the risk assessment process is identifying and screening hazards affecting people and property in Guam. The hazards include a range of both natural and human-made hazards that may have occurred in the past and those likely to occur in the future (even if they have not occurred in the past).

A summary of the hazards that can affect Guam is shown in **Table 20**. This table was originally created for the 2005 Guam HMP, and the historical hazard information has been updated with each Guam HMP update. With subsequent plan versions, additional hazards have been included in **Table 20**. During the 2024 Guam HMP update, the HMWC made the decision to remove the following hazards.

- Lightning
- Salt Spray
- Transportation Accident
- Hazardous Materials

For the 2024 Guam HMP update, the SHMO and HMWG reviewed the hazards selected during the previous plan updates. These hazards were selected based on the following:

- Results of the historical hazard event database: The historical data revealed that these hazards have had a negligible impact on Guam compared to other more prevalent hazards, such as typhoons, high surf, and earthquakes. The frequency,

SECTION 5 RISK ASSESSMENT AND HAZARD PROFILES

intensity, and resulting damage from lightning, salt spray, transportation accidents, and hazardous materials incidents were significantly lower.

- Expert opinion of the risk presented by the hazards: Experts in hazard mitigation and emergency management provided insights that these hazards pose a minimal risk to the island. For instance, while lightning can be a concern, its occurrence is rare and typically results in minor damage. Similarly, salt spray, though a common environmental factor, does not significantly threaten critical infrastructure or public safety.
- The known or expected availability of information on the hazard: The lack of comprehensive and actionable data for these hazards is a pressing issue. Without sufficient information, it is challenging to develop effective mitigation plans. This further supports the rationale for focusing resources on hazards with a well-documented history and for which robust data is available.

As shown in **Table 20**, efforts were made to avoid the double-counting of events by aggregating them into a primary hazard event. For example, a tropical cyclone/typhoon accompanied by severe wind and flooding was entered only once under tropical cyclone/typhoon, though the multiple sub hazards were noted in the description of the event. Also, information regarding fatalities, injuries, and property damage was available for only a small proportion of the hazard events. In most cases, this information should not be considered an accurate representation of the potential damage experienced to date.

Table 20. Historical Disasters

Hazard	Historical Records						Further Evaluation/ Major Hazard Category
	Number of Records			Recorded Damages			
	Disaster/ Emergency Declarations	Other Significa nt Events	Total	Fatalitie s	Injuries	Losses (\$)	
Liquefaction	0	1	1	N/A	N/A	\$8,000,000	Earthquake
Post-fire Debris Flow	0	N/A	N/A	N/A	N/A	N/A	Slope Failure
Severe Wind	0	24	24	N/A	3	\$775,000	Severe Wind
Sinkholes	0	N/A	N/A	N/A	N/A	N/A	Non-Seismic
Terrorism	0	0	0	0	0	\$0	Terrorism
Tsunami	0	12	12	0	0	N/A	Tsunami
Tropical Cyclone/ Typhoon	16	199	222	86	461	\$2,047,408,640	Tropical Cyclone/Typhoon
Wildland Fire	1	5	6	0	1	\$250,000	Wildland Fire

Note: "Declarations" refers to Presidentially declared disasters or emergencies. The hazard event database covers the period 1971 to July 2019, though approximately 90 percent of the records are from 1970 to the present. Information on fatalities, injuries, and property damage is available for only a small proportion of the total number of records and should be considered incomplete.

N/A = not available

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Sources: FEMA 2019; Guam Power Authority 2019; NWS-WFO Guam 2019; NTSB 2004b; GHS-OCD 2019; National Response Center 2019; USGS 2019; NCDC 2014.

For the 2024 Guam HMP update, the GHMO and HMWG reviewed the hazards selected during the previous plan updates. These hazards were selected based on the following:

- Results of the historical hazard event database
- Expert opinion of the risk presented by the hazards
- The known or expected availability of information on the hazard

Table 21. Hazards Profiled in the 2024 Guam HMP

Hazard Categories	
Coastal Erosion	Sea Level Rise
Disease	Severe Wind
Earthquake: Surface Fault Rupture, Liquefaction, Lateral Spread	Slope Failure: Landslide, Mudslide, Post-Fire Debris Flow
Flooding: Coastal Flooding, Riverine Flooding, Stormwater Runoff	Terrorism
High Surf	Tropical Cyclone
Non-Seismic Ground Failure/Sinkholes	Tsunami
Wildfire	

5.5 PROFILES AND VULNERABILITY ANALYSIS

The hazards selected for profiling were analyzed in 2004–2005, updated in 2008, 2011, 2014, and 2019, and again updated in 2024; each hazard was analyzed methodically based on the following four categories: nature, location, previous occurrences, probability of future events, and climate change impact to hazard.

Vulnerable populations, GBS, and EFMUTS at risk of each identified hazard are listed in **Tables 22 and 23**, as well as **Appendix F** (Vulnerability Analysis Results by Village). A detailed summary of this analysis is provided under each hazard within this section.

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Table 22. Summary All-Hazard Vulnerability Analysis for Guam: Total

					Essential Facilities, Major Utilities, and Transportation Systems (EFMUTS)								
			Area Affected	Populati on	Essential Facilities		Major Utilities		Transportation Systems – Facilities		GBS		
Hazard*	Subhazard	Hazard Zone	% of Square Miles	% of No.	% of No.	% of Value (\$)	% of No.	% of Value (\$)	% of No.	% of Value (\$)	% of No.	% of Value (\$)	
Total Potential			210	154,805	362	1,421,358,974	359	2,412,249,591	836	2,195,788,078	38,420	8,546,686,338	
Coastline Erosion (Potentially Critical and Critical)			10	4,104	76	210,171,865	23	89,267,596	228	926,477,599	1,269	364,022,293	
Earthquake	Fault Proximity		46	29,169	74	384,751,886	83	424,196,465	298	793,066,346	4,780	1,239,737,588	
	Liquefaction	Very High	1	297	16	21,456,865	2	269,497,012	31	689,738,131	102	44,895,123	
		High	2	1,524	11	96,416,918	10	147,250,089	57	142,555,770	148	48,124,638	
Drought													
Flooding	100-year Floodplain		10	7,519	79	211,286,753	27	93,452,202	277	946,765,118	1,373	381,949,453	
High Surf													
Severe Wind		Extreme	116	79,405	135	818,089,067	215	1,655,423,589	376	1,135,330,237	19,812	1,882,150,128	
Sea Level Rise		5-10 ft	12	7,993	93	231,321,477	44	575,134,723	287	456,308,747	1,895	512,869,803	
Slope Failure		Land-slide	Very High	47	14,608	13	14,218,356	18	130,158,557	124	123,168,165	398	76,094,461
			High	9	2,924	18	12,948,308	35	139,887,120	82	27,251,860	826	102,463,810
Tsunami Inundation		Water Level at 16 feet above MSL	12	11,577	97	271,832,278	44	575,134,723	334	1,089,467,055	2,045	537,821,079	
Wildland Fire		Very High	83	56,998	38	161,582,931	90	439,485,671	264	76,614,111	8,702	1,637,215,355	
		High	82	51,190	111	404,301,537	148	931,183,183	292	130,828,092	13,094	2,764,788,193	

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Table 23. Summary All-Hazard Vulnerability Analysis for Guam: %

					Essential Facilities, Major Utilities, and Transportation Systems (EFMUTS)							
			Area Affected	Populati on	Essential Facilities		Major Utilities		Transportation Systems – Facilities		GBS	
Hazard*	Subhazard	Hazard Zone	% of Square Miles	% of No.	% of No.	% of Value (\$)	% of No.	% of Value (\$)	% of No.	% of Value (\$)	% of No.	% of Value (\$)
Total Potential			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Coastline Erosion (Potentially Critical and Critical)			5.0	4.7	21.4	14.9	7.5	5.2	30.1	68.2	5.5	6.5
Earthquake	Fault Proximity		21.9	18.6	20.0	18.6	22.9	20.0	32.3	11.6	15.9	18.1
	Liquefaction	Very High	0.2	0.2	4.2	1.5	0.6	15.0	4.5	49.7	0.5	0.8
		High	1.2	0.9	3.1	6.8	3.0	8.2	9.8	10.3	1.0	1.0
Drought												
Flooding	100-year Floodplain		5.0	4.7	21.4	14.9	7.5	5.2	30.1	68.2	5.5	6.5
High Surf												
Severe Wind		Extreme	55.2	52.8	36.9	57.6	59.9	59.6	39.1	77.0	46.6	23.5
Sea Level Rise		5-10 ft	5.6	5.1	26.2	19.1	12.7	31.9	39.1	78.5	8.2	9.1
Slope Failure		Land-slide	Very High	22.2	8.5	3.7	1.0	5.0	7.2	12.0	2.6	1.5
			High	4.3	1.6	5.1	0.9	9.7	7.8	5.3	2.0	2.8
Tsunami Inundation		Water Level at 16 feet above MSL	5.6	5.1	26.2	19.1	12.7	31.9	39.1	78.5	8.2	9.1
Wildland Fire		Very High	39.4	36.5	10.1	11.4	24.9	16.2	24.8	5.5	19.8	15.9
		High	39.2	32.6	30.7	28.4	41.2	35.9	30.1	5.2	34.1	30.9

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5.5.1 Coastal Erosion

Coastal erosion can be described as the horizontal retreat of the shoreline. It is a part of a larger process of shoreline change that includes erosion and accretion, except along coastal cliffs.

Coastal erosion is the movement of sediment from the shoreline into the ocean. Accretion is the movement of sediment onto a shoreline from the ocean. Many shorelines experience both erosion and accretion. If a balance of these two processes occurs, the shoreline is considered to be stable. Coastal cliffs generally erode in the form of a landslide into the ocean. Coastal cliffs cannot experience accretion. Many community reports raise the concern that the beach profile is not accreting and that there is a constant erosion rate along many of our coastline.

Due to the potential cycles of erosion and accretion, coastal erosion is generally quantified over several years. Coastal erosion is measured as a rate, expressed either as a linear length of retreat compared to time or as a volumetric loss compared to time. Coastal erosion on Guam can be caused by winds; ocean currents; storm surges; high surf; seismic activity; changes in the geometry of tidal inlets, river outlets, and bay entrances; human-made structures and human activities, such as shore protection structures and dredging; and/or local scour around structures. La Niña and El Niño events also contribute, with El Niño causing lower sea levels but increased tropical cyclone activity, while La Niña causes less tropical cyclone activity, but higher background sea levels. In addition, sea level rise affects coastal erosion. Sea levels appear to have risen about 8 inches over the last century, with greater rises over the last two decades.

Human-built structures, such as properly engineered shore protection structures, can greatly increase the rate of coastal erosion in adjacent properties that are not armored while preventing any beach profile from accreting parallel to the wall. Cleared areas that are exposed to prevalent winds and open ocean waves often have a higher potential to experience heavy coastal erosion than highly vegetated areas where structures are set back farther inland. The erosion of coastal cliffs can threaten the safety of land uses at the top of the cliffs. Coastal erosion can lead to sediment transport onto nearby reefs, which can lead to the decline of the health of these reefs.

Location

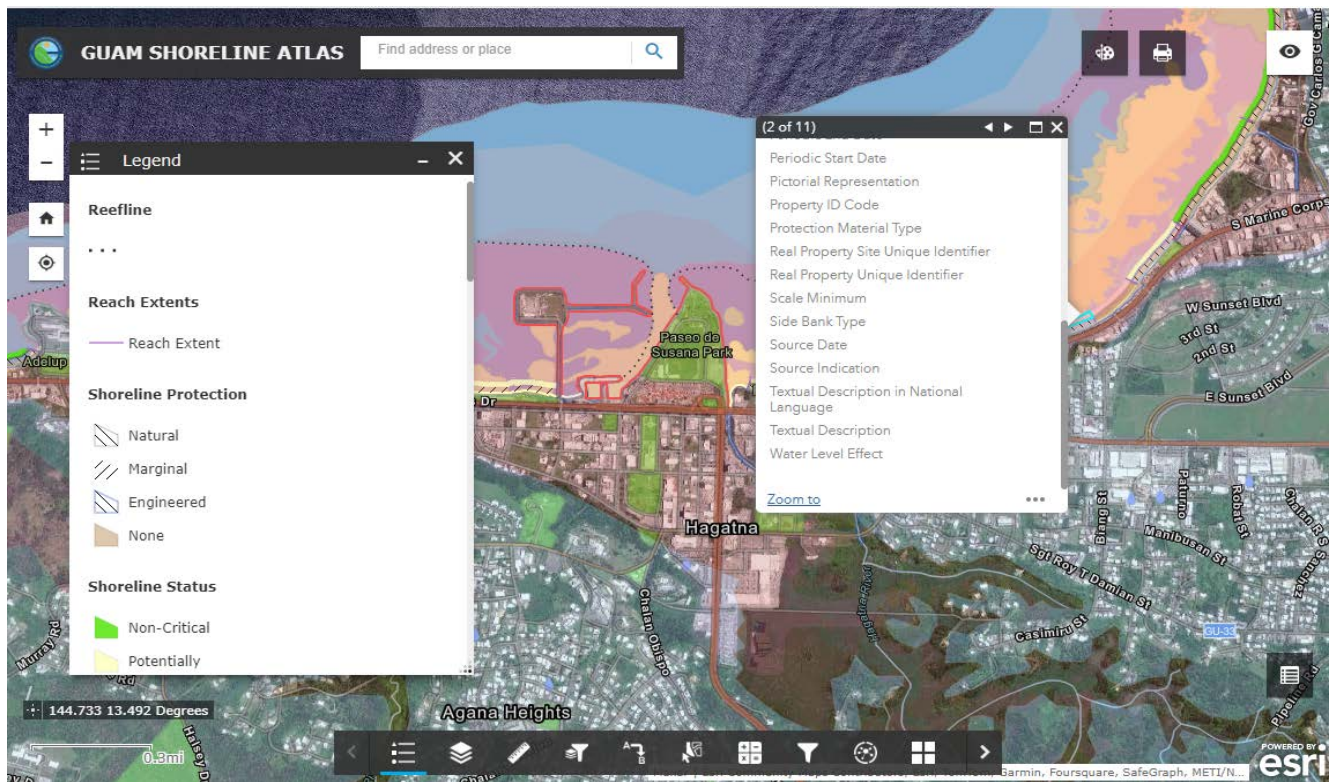
The entire coastline of Guam has the potential for coastal erosion hazards. The western coast of Guam has experienced the most coastal erosion to date due to tropical cyclones and monsoon surges that have produced high waves. Although there is a potential for coastal erosion island wide,

In October 2021 the Guam Shoreline Atlas was published. The objective of the Guam Shoreline Atlas is to describe the physical characteristics of the Guam shoreline, with emphasis on shorelines experiencing erosional problems, containing at-risk infrastructure, or needing shore protection. This Atlas comprehensively documents

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current shoreline conditions throughout Guam, providing shoreline managers with baseline information and a tool for future planning efforts.

This study was conducted by the U.S. Army Corps of Engineers, Honolulu District under the Planning Assistance to the States program for the non-Federal sponsor, the government of Guam (GovGuam) Bureau of Statistics and Plans, Guam Coastal Management Program (GCMP). The Guam Shoreline Atlas was completed in two phases. The first phase consisted of field investigations including ground photography and shoreline assessments, and the second phase consisted of the preparation of this Atlas. The field investigations were conducted to identify, photograph, document, and map existing shoreline features, conditions, and problem areas. Ground level digital photographs captured the site characteristics and documented the shoreline condition for inclusion in this Atlas. Global Positioning System (GPS) units were used to accurately map the shoreline features. The data collected from the field investigations were used to create this interactive Portable Document Format (PDF) for the user to easily view and access the data. Additionally, a Geographic Information System (GIS) geodatabase containing compatible spatial data from the study is also provided. A web map of the atlas can be found at <https://bsp.guam.gov/shorelineatlasmap/>



In the atlas, the shoreline status was classified into 3 types: Critical, Potentially Critical, and Non-Critical. These classifications are shown on the maps using the symbols indicated in the Map Legend.

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Critical is defined as existing and/or continuing shoreline erosion, protective structure failure, or storm damage vulnerability that is an immediate threat to existing structures or public facilities, and thereby justifies protective action.

Potentially Critical is defined as existing and/or continuing shoreline erosion, protective structure failure, or storm damage vulnerability that is a potential threat, and justifies protective action. However, protective action is not as urgent as for critical status.

Non-critical is defined as shoreline erosion, protective structure failure, or storm damage vulnerability that is either not currently a threat or does not exist, and does not justify protective action. These areas could become potentially critical or critical if erosion begins to threaten existing structures or public facilities.

The Atlas focused on 12 areas that where populations and development are impacted from coastal erosion. These include Tumon Bay, Hagatna Bay, Asan Bay, Piti Bay, Orote Peninsula, Hagat Bay, Nimitz Beach, Humatak Bay, Malesso, Manell & Inalahan, Talafofo Bay, and Anderson AAFB Ritidian point.

Previous Occurrences

No disaster has been declared on Guam due to coastal erosion. No comprehensive documentation is available regarding coastal erosion on Guam, and damage estimates due to coastal erosion have never been specifically reported. As illustrated by the above discussion of the causes of coastal erosion, coastal erosion is almost always associated with another hazard. Many large tropical cyclones have made landfall on Guam or have come close to making landfall. These storms all have resulted in storm surges, high surf, and high winds, all of which are key causes of coastal erosion. However, available historical records describe coastal erosion occurrences for only a few storms. Therefore, it is probable that incidences that have caused coastal erosion have been severely underreported.

Typhoon Andy in 1982, Typhoon Dale in 1996, Typhoon Halong in 2002, Super Typhoon Pongsona in 2002, and Super Typhoon Mawar in 2023 were all documented to have caused coastal erosion. No specific details are available about the locations of coastal erosion for Typhoon Andy. Typhoon Dale contributed to high surf for several days, resulting in large areas of coastal erosion along beaches on the western side of the island. The high surf and storm surge caused by Typhoon Halong led to erosion along the island's southeast shorelines. Super Typhoon Pongsona caused coastal erosion on the western side of the island, which washed out a few stretches of road and blocked several stretches of road with rubble and sand. Super Typhoon Mawar caused considerable damage to Guam's shorelines that were classified with a potentially critical in 2020. This was the especially case for the hardened shorelines near the High Water Mark in Tumon Bay, hardened shorelines in Hagatna Bay, the natural shoreline in Asan Bay, and Nimitz Beach in Agat. Areas in these locations that were classified as Potentially Critical in Guam's Coastal Atlas Web Map have been updated to Critical.

The west side of Guam is impacted is impacted from typhoons and monsoon activity often associated with El Nino events. East side erosion occurs from typhoons and from elevated sea levels due to La Nina events.

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Vulnerable assets include the coastal trees, beaches, coastal soil, and some near-shore infrastructure such as highways, buried cables, and sewer pump stations.

Vulnerable jurisdictions include all coastal areas that are non-cliff areas. This would be from Mangilao on the northeast, clockwise around the east, through the south, through the west to Agat. Then from Piti clockwise to Gun Beach and from Tanguisson clockwise through Arunao, to Ritidian Point through the northern beaches.

Climate change threatens coastal areas, which are already stressed by human activity, pollution, invasive species, and storms. Sea level rise could erode and inundate coastal ecosystems and eliminate wetlands. Warmer and more acidic oceans are likely to disrupt coastal and marine ecosystems on Guam.

Probability of Future Events

Because various factors contribute to coastal erosion events and given the general lack of data regarding erosion rates, the return rate for coastal erosion is unknown. However, high surf and storm surge caused by tropical storms and typhoons can result in coastal erosion. On average, three tropical storms and one typhoon pass within 180 nautical miles of Guam each year.

The Guam Coastal Management program conducted a study called An Aerial Analysis of Shoreline Variability along the Western Shore of Guam. Erosion rates varied in areas studied by However, most of the following areas studied experienced erosion. In some areas, residents claim the erosion rates are much higher.

- Anigua - erosion rate is erosion rate estimated at 6-inches a year.
- Adelup Point - erosion rate estimated at 1.5 inches a year.
- Fish Eye - negligible amount of erosion
- Apaca Point - erosion rate of 50 inches a year
- Gaan Point -erosion rate of 7 inches a year.
- Taelayag Beach - erosion in this area is negligible
- Sagua Beach - erosion rate estimated at 23-inches a year

Erosion remains highly probable in the future.

Climate Change Impacts²⁶

Many of Guam's shorelines are protected by wide fringing reefs, which results in a relatively mild wave climate along the shoreline, except during infrequent typhoon events. This results in narrow and mildly sloped beaches, often backed by vegetated beach berms. These areas are not as vulnerable to erosion, but will be affected by rising sea levels, and corral die resulting in larger waves that can reach the shoreline. The primary areas of concern are those in which buildings and roadways exist very close to the shoreline. In these areas, as sea levels rise, homeowners, businesses, and the Government of Guam will be required to adapt by using protective structures, elevating smaller infrastructure, or by retreat from the shoreline.

²⁶ Guam Shoreline Atlas 2.10 Sea Level Rise

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Summary of Impacts

As shown in **Tables 24 and 25**, in terms of the village-level population exposed to coastal erosion Tamuning/Tumon has 1,738 people (9.6 percent) followed by Hagatna with 703 (63.9 percent). Both of these communities had the greatest number of people in this hazard area in the 2024 Guam HMP. Both of these areas experienced a slight decrease between 2010 and 2020 according to the Guam Decennial Census.

Exposure of the Essential Facilities is spread throughout all affected villages. The village with the most exposure of Essential Facilities is Hagatna, with 11 facilities that are worth \$11.5 million. In addition, the most concentrated number of exposed Major Utilities are located in Piti (2 facilities valued at \$52 million), Hagatna (2 facilities valued at \$13.2 million), and Merizo (10 facilities worth \$12.6 million). The potential loss of transportation systems is also the highest in Piti, with 816 million, due to the port of Guam being located there.

In terms of village-level GBS exposure, Hagatna has the highest number of exposed GBS with 216 (64 percent of village structures) worth \$138 million.

Table 24.

Table F-11 Total Affected by Coastal Erosion			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	2.19	443	10	57,457,190	2	2,530,333	33	3,551,918	419	56,186,930
Asan/Maina	2.66	45	0	0	0	0	12	8,508,542	15	2,322,196
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	0	0	0	0	0	0	0	0	0
Dededo	2.56	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	703	28	26,304,004	2	13,204,685	46	33,864,514	216	138,189,037
Inarajan	6.11	180	7	2,409,492	3	2,916,318	31	34,493,846	98	11,296,098
Mangilao	0.81	194	0	0	0	0	0	0	3	697,245
Merizo	1.74	297	2	434,760	10	12,658,544	27	9,213,354	210	24,255,581
Mongmong- Toto-Maite	0.51	0	0	0	0	0	0	0	0	0
Piti	1.17	245	11	11,487,965	2	51,696,674	30	816,377,090	146	31,330,230
Santa Rita	4.19	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	215	1	371,960	0	0	17	65,213	21	3,223,681
Tamuning/Tumon	1.74	1,738	14	110,436,962	3	4,992,823	13	11,884,489	127	95,141,724
Umatac	2.28	43	3	1,269,532	1	1,268,219	20	8,518,633	13	1,379,572
Yigo	7.48	0	0	0	0	0	0	0	0	0
Yona	3.61	0	0	0	0	0	0	0	0	0
Total	45.86	4,104	76	210,171,865	23	89,267,596	228	926,477,599	1,269	364,022,293

Table F-12 Proportion Affected by Coastal Erosion			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)

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Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	7.82	7.83	45	84.01	22.22	5.17	100	86.98	26.53	26.53
Asan	2.12	2.15	0	0	0	0	66.67	67.83	3.06	3.06
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	0	0	0	0	0	0	0	0	0	0
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna	63.53	63.94	62.5	58.24	50	95.39	80	73.1	64.01	64.01
Inarajan	5.87	5.9	46.67	7.68	17.65	3.49	83.33	97.35	15.66	15.66
Mangilao	0	1.46	0	0	0	0	0	0	0.25	0.25
Merizo	13.73	13.73	20	6.68	62.5	46.6	100	96.48	55.19	55.19
Mongmong-	0	0	0	0	0	0	0	0	0	0
Piti	14.69	14.72	57.89	60.27	15.38	9.2	72.73	88.03	27.99	27.99
Santa Rita	0	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	6.69	6.69	12.5	8.61	0	0	100	7.12	2.16	2.16
Tamuning/	9.65	9.65	18.07	13.53	13.04	3.37	10	12.26	8.06	8.06
Umatac	4.76	4.86	33.33	25.97	5.26	1.35	66.67	47.69	9.47	9.47
Yigo	0	0	0	0	0	0	0	0	0	0
Yona	0	0	0	0	0	0	0	0	0	0

Impact to Vulnerable Communities

All Coastal Villages have major segments along their shorelines that are potentially critical or critical. For the southern villages, eroding shorelines impact the major segments along their primary road in and out of their village. Failure of their shorelines could result in members of these communities being unable to leave or return following catastrophic weather events that cause erosion.

Merizo, Hagatna, and Agat are in the top 4 most vulnerable according to Guam's Social Vulnerability Index. They are all coastal communities, one of the villages where the main roadway is along the shoreline.

Table 25.

Village	Venerable Exposed	Venerable Exposed as % of Total
Agana Heights	0	0%
Agat	443	8%
Asan/Maina	5	0%
Barrigada	0	0%
Chalan Pago-Ordot	0	0%
Dededo	0	0%
Hagatna (Agana)	626	57%
Inarajan	70	2%
Mangilao	140	1%
Merizo	279	13%
Mongmong- Toto-Maite	0	0%
Piti	0	0%

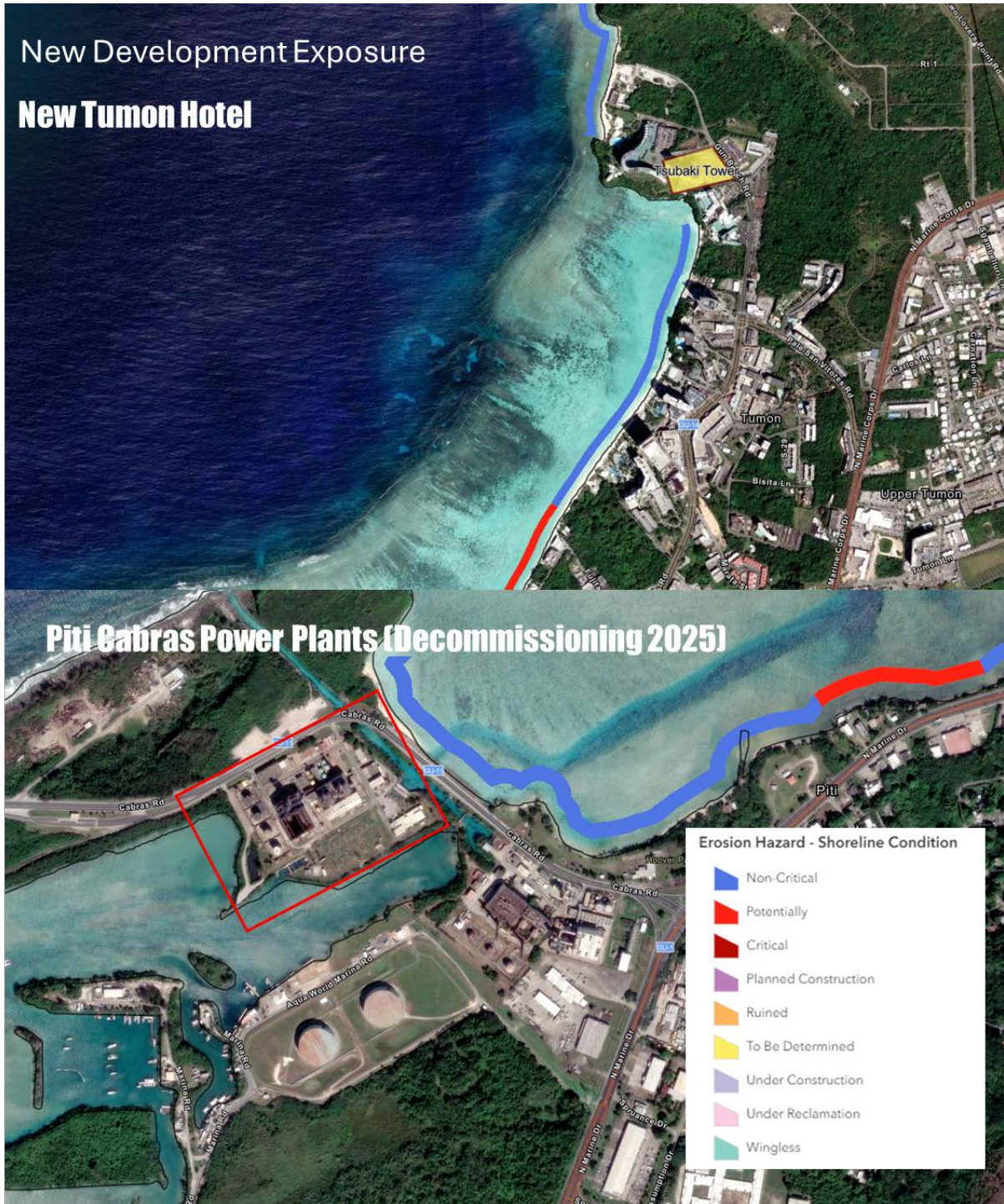
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Santa Rita	0	0%
Sinajana	0	0%
Talofofo	47	1%
Tamuning/Tumon	295	2%
Umatac	29	3%
Yigo	0	0%
Yona	0	0%
Total	1,935	

Future Developments

No future developments or land use changes are currently being planned or are public knowledge. Infrastructure projects to protect the shoreline where transportation and infrastructure are at the most risk are underway and listed in Section 6. Only 1 new development was done on the coastline since 2019, but it is on a cliff line, and the shorelines beside the property and classified as non-critical. In 2025 the Ukudu Power plant is expected to come on-line. This will result in the closure of the Cabras Power Plants in Piti being shut down, decreasing the vulnerability of utility systems on Guam to Coastal Erosion.

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5.5.2 Disease

Nature

A disease is a pathological (unhealthy or ill) condition of a living organism or part of the organism that is characterized by an identifiable group of symptoms or signs. Disease can affect any living organism, including people, animals, and plants. Disease affects people, animals, and plants both directly (through infection) and indirectly (through secondary effects). Some diseases can directly affect both people and animals. For this risk assessment, the major concern with respect to disease is an epidemic, a disease that affects numerous people, animals, or plants at one time.

Epidemics are generally identified by the infectious diseases involved. Infectious diseases are caused by the entry and growth of microorganisms within another living organism. Most, but not all, infectious diseases are contagious, that is, communicable to an organism through (1) direct or indirect contact with another organism infected with the disease, (2) something the organism has touched that contains the disease, or (3) another medium containing the disease (e.g., water or air).

Infectious diseases are the leading cause of death in humans worldwide and the third leading cause of death in humans in the U.S. A report from the Institute of Medicine titled *Microbial Threats to Health: Emergence, Detection, and Response* notes that the impact of infectious diseases on the U.S. has grown in the last 10 years and that the public health and medical communities remain inadequately prepared.

The Centers for Disease Control and Prevention (CDC) has established a list of over 50 nationally notifiable diseases. A notifiable disease is one that when diagnosed, health providers are required to report to state or local public health officials. Notifiable diseases are those of public interest because of their contagiousness, severity, or frequency. The long list includes such diseases as the following: AIDS; anthrax; botulism; cholera; diphtheria; encephalitis; gonorrhea; hantavirus pulmonary syndrome; hepatitis (A, B, C); HIV (pediatric); Legionellosis; Lyme disease; malaria; measles; mumps; plague; polio (paralytic); rabies (animal and human); Rocky Mountain spotted fever; rubella (also congenital); salmonellosis; SARS; streptococcal disease (Group A); streptococcal toxic-shock syndrome; *Streptococcus pneumoniae* (drug-resistant); syphilis (also congenital); tetanus; toxic-shock syndrome; trichinosis, tuberculosis, typhoid fever; and yellow fever.

In addition to diseases that occur only in humans, there also is significant concern about diseases that affect both humans and animals, known as zoonotic diseases.

Approximately 40 zoonotic diseases are known to exist, including rabies, tuberculosis and brucellosis, trichinosis, ringworm, giardiasis, and Lyme disease.

In Guam, the Department of Public Health and Social Services (DPHSS) seeks to prevent infectious diseases from entering the island and to control those that are endemic or have already entered. Of particular concern to DPHSS are new pandemic diseases, such as SARS, new strains of HIV, new influenza strains, botulism, and bioterrorism incidents such as anthrax, smallpox, or chemical attacks of sarin or VX gas.

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DPHSS monitors and controls more than 70 infectious diseases of public health concern such as measles, rubella, pertussis, hepatitis B, and various gastrointestinal diseases.

Diseases affecting animals and plants, particularly livestock and agricultural products, are also of major concern. According to the National Animal Health Emergency Management System, an animal health emergency is defined as the appearance of disease with the potential for a sudden negative impact through direct impact on productivity, real or perceived risk to public health, or real or perceived risk to a foreign country that imports livestock and agricultural products from the United States.

A division of the USDA, the Animal and Plant Health Inspection Service (APHIS), is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. Major programs within APHIS relating to disease are Veterinary Services (VS) and Plant Protection and Quarantine. Both types of programs are discussed below.

VS protects and improves the health, quality, and marketability of animals, animal products, and veterinary biologics by (1) preventing, controlling, and/or eliminating animal diseases and (2) monitoring and promoting animal health and productivity. Among other activities, VS conducts surveillance on national animal diseases, foreign animal diseases, emerging animal diseases, and invasive plant species. Most VS efforts are targeted at diseases on the Organization Internationale des Epizooties (OIE) disease list.

The Plant Protection and Quarantine program, also located within USDA's APHIS, safeguards agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds. Several thousand foreign plants and animal species have become established in the U.S. over the past 200 years, with approximately one in seven becoming invasive. An invasive species is an alien (i.e., nonnative) species whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health. Invasive plants, animals, and pathogens have often reduced the economic productivity and ecological integrity of agriculture, forestry, and other natural resources of the United States. Invasive species on Guam have severely impacted natural and environmental resources. Common vertebrate invasive species in Guam include the brown tree snake and the musk shrew. Numerous invertebrate invasive species, such as the giant African land snail, predatory flatworm *Platydemus Manokwari*, cycad *Aulocapsis* scale, and coconut rhinoceros beetle (CRB), have recently become established in Guam.

The Guam Department of Agriculture is primarily concerned with the plant, livestock, and wild animal diseases and infections. The OIE develops standards and guidelines for use in protecting against incursions of diseases or pathogens during trade in animals and animal products. The concern is with both animal-to-animal diseases as well as diseases transmitted from animals or arthropod vectors to humans.

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Many other hazards, such as floods, earthquakes, or droughts, can create conditions that significantly increase the frequency and severity of diseases. These other hazards can affect basic services (e.g., water supply and water quality, wastewater disposal, and electricity), the supply and quality of food, and the capacity of both the public health and the agricultural health system, which can lead to concentrations of diseases and, potentially, large losses of life and economic value.

Since the anthrax attacks that occurred after the attacks of September 11, 2001, the possibility that diseases might be used against humans, animals, or plants has become a growing concern, especially for diseases capable of disrupting the human or animal food chain.

Location

All of Guam and the people residing in Guam are susceptible to diseases. **Table 26** is the Annual Summary of Notifiable Diseases and Conditions for Guam from 2019 to 2023 provides a detailed account of the prevalence of various diseases and conditions over these five years. The data highlights fluctuations in disease occurrences, notable trends, and the impact of specific health threats on the population.

Table 26. Guam 2019 – 2023 Annual Summary of Notifiable Disease and Conditions

Disease or Condition	2019	2020	2021	2022	2023
Achromobacter Xylosoxidans	7	10	0	0	0
Acinetobacter baumannii, MDR**	60	29	18	2	5
Brucellosis	0	0	3	1	1
Campylobacteriosis	13	6	10	4	14
Candida auris	3	0	0	0	0
Chancroid	0	0	0	0	0
Chickenpox	18	4	1	12	4
Chlamydia	1,230	775	716	741	746
Cholera O1 El Tor or Ogawa	0	0	0	0	0
Chryseobacterium	2	0	0	0	0
Citrobacter freundii	0	0	1	1	5
Clostridium difficile	9	9	10	12	31
Coccidioidomycosis	1	1	0	0	1
Conjunctivitis	199	144	35	48	53
COVID-19	0	7,333	12,335	40,504	3,116
Dengue	21	2	1	2	2
Diphtheria	0	0	0	0	0
Escherichia coli, other	195	93	146	210	271

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Elizabethkingia	0	1	0	0	0
Enterobacter cloacae	3	2	0	0	0
Enterococcus	16	25	0	0	0
Fish poisoning (Ciguatera)	0	0	0	0	0
Fish poisoning (Scombroid)	0	0	0	0	0
Foodborne illness	1	0	0	0	0
Giardiasis	1	0	0	0	0
Gonorrhoea	314	202	199	277	181
Hand, foot, and mouth disease	2	0	0	9	29
Haemophilus influenza, invasive	7	0	0	0	0
Hansen's disease	15	6	12	0	4
Hepatitis A	226	126	4	241	1
Hepatitis B*	22	102	94	33	99
Hepatitis C*	103	124	84	1	37
Herpes simplex Type 1	2	10	0	0	0
Herpes simplex Type 2	17	0	1	0	2
Herpes zoster	0	0	0	0	0
HIV/AIDS	13	8	3	3	7
Human papillomavirus	6	34	0	6	2
Influenza	1,268	148	41	425	1,665
Kawasaki syndrome	0	0	0	0	0
Klebsiella pneumonia, MDR**	41	32	32	40	52
Legionellosis	1	0	2	0	0
Leptospirosis	2	7	4	2	10
Lyme disease	0	0	0	1	0
Malaria	0	0	1	0	0
Measles	0	0	0	0	0
Meningitis, aseptic	0	0	0	0	0
Meningitis, other or unspecified	0	9	0	0	0
Meningitis, meningococcal	9	0	0	0	0
Methicillin-resistant Staphylococcus aureus	681	259	451	435	522
Mumps	1	9	0	1	1
Pertussis	12	0	0	0	0
Proteus mirabilis	7	3	1	8	15

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Pseudomonas aeruginosa	35	11	28	25	22
Respiratory syncytial virus	89	0	56	140	140
Rheumatic fever	0	0	0	0	0
Salmonellosis	15	15	19	22	23
Scabies	122	14	33	14	16
Scarlet fever	0	0	0	0	0
Shigellosis	50	7	8	11	12
Streptococcus agalctiae (Strep Group B)	0	15	0	0	9
Streptococcal sore throat	299	47	70	195	943
Streptococcal disease, other	425	113	332	248	0
Syphilis, all stages	4	12	11	4	3
Syphilis, unspecified stage	21	10	10	15	3
Trichomonas	1	2	3	2	6
Tuberculosis	79	57	3	0	45
Vancomycin-resistant Enterococcus	23	25	75	76	73
Vibrio cholerae non-O1	1	0	0	0	1
*Chronic cases					
**Multi-drug resistant					

Source: DPHSS 2024.

In 2019, *Achromobacter xylosoxidans* had seven reported cases, which increased to 10 in 2020 but dropped to zero in subsequent years. Multi-drug-resistant *Acinetobacter baumannii* significantly decreased from 60 cases in 2019 to five in 2023. Brucellosis had no cases in 2019 and 2020 but appeared with three cases in 2021, followed by 1 case each in 2022 and 2023.

Campylobacteriosis saw varying numbers, starting with 13 cases in 2019, dipping to 4 in 2022, and rising again to 14 in 2023. *Candida auris*, which had 3 cases in 2019, did not reappear in the following years. Chancroid and Cholera O1 El Tor or Ogawa had no reported cases throughout the five years.

Chlamydia remained consistently high but showed a decreasing trend from 1,230 cases in 2019 to 746 in 2023. COVID-19 emerged in 2020 with 7,333 cases and peaked in 2022 with 40,504 cases before dropping to 3,116 in 2023. Dengue had its highest occurrence in 2019, with 21 cases, and maintained a low incidence in the subsequent years.

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Diseases like Coccidioidomycosis and Legionellosis showed minimal occurrences. Conjunctivitis notably decreased during the pandemic, starting at 199 cases in 2019 and dropping to 35 in 2021 but rising to 53 in 2023.

Foodborne illnesses and certain types of poisoning, such as Ciguatera and Scombroid, remained extremely rare or absent. Notable spikes were seen in Hepatitis A in 2022, with 241 cases, and in Hepatitis B in 2020, with 102 cases. Hepatitis C significantly dropped from 124 cases in 2020 to just 1 in 2022 before slightly increasing to 37 in 2023.

Infections like Gonorrhea saw fluctuations, with the highest number of cases being 314 in 2019 and dropping to 181 in 2023. Hand, foot, and mouth disease had a surge in 2023, with 29 cases after a period of low incidence. Influenza cases showed dramatic variations, peaking in 2023 at 1,665.

Multi-drug resistant *Klebsiella pneumonia* remained relatively stable but increased to 52 cases in 2023. Methicillin-resistant *Staphylococcus aureus* fluctuated, reaching 681 cases in 2019 and 522 in 2023. Salmonellosis cases gradually increased from 15 in 2019 to 23 in 2023.

Respiratory syncytial virus cases increased between 2022 and 2023, maintaining a high of 140 cases each year. Streptococcal infections varied, with a significant rise in streptococcal sore throat cases to 943 in 2023. Tuberculosis cases dropped significantly during the pandemic years but saw a resurgence to 45 cases in 2023.

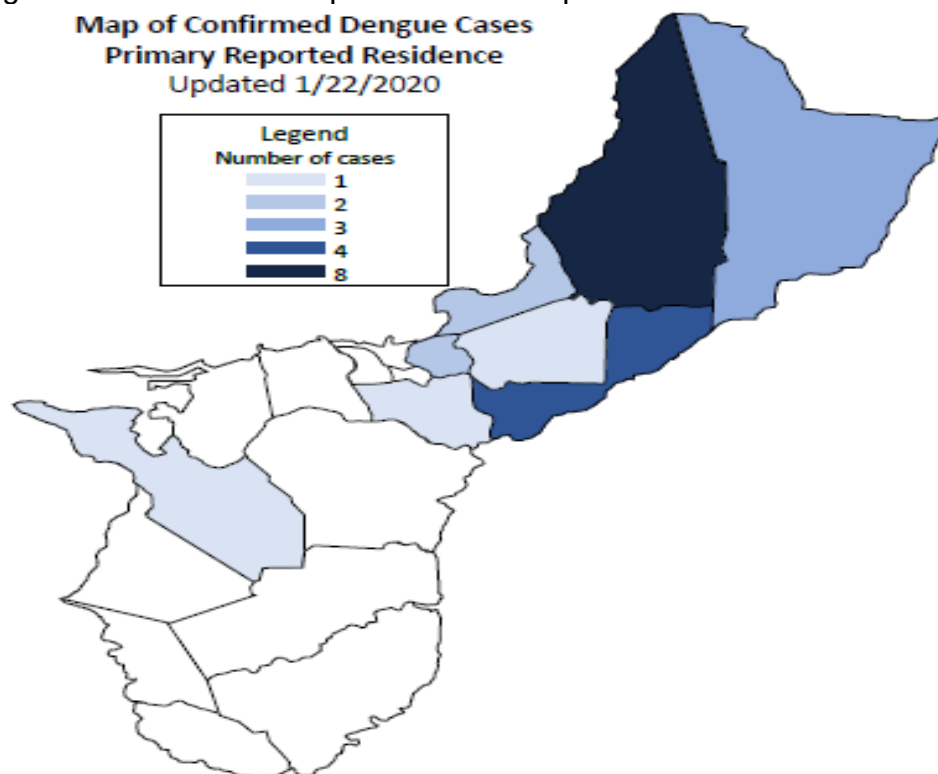
Overall, the data from Guam between 2019 and 2023 reflects the dynamic nature of infectious diseases, with certain conditions showing significant spikes while others remained stable or decreased over time. This summary underscores the importance of continuous monitoring and public health interventions to manage and control the spread of these diseases.

Previous Occurrences

Title 10 of the Guam Code Annotated, Chapter 3, mandates the reporting of any communicable disease or any other disease dangerous to the public health to the Department of Public Health and Social Services. **Table 26** represents the communicable diseases and diseases of potential concern reported by the local healthcare facilities and laboratories from 2019 to 2023. Guam maintains active surveillance on major communicable diseases, however, since 2019 the island has experienced numerous emerging threats, the most notable being the SARS-CoV-2 (COVID-19) pandemic beginning in 2020, which resulted in the downward trend in disease reporting. Regardless, Guam continues to surveil for sexually transmitted diseases (e.g., Chlamydia, Neisseria gonorrhea, HIV/AIDS), vaccine preventable diseases (e.g., Influenza, Measles, Pertussis), other respiratory infections such as Tuberculosis and Respiratory Syncytial Virus, and antimicrobial resistance (e.g., methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, *Escherichia coli*).

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Figure 1 displays the number of cases with a laboratory confirmed dengue virus result by village of residence. The village with the most reported cases was Dededo, where a total of 8 residents reported a dengue infection. Mangilao followed with a total count of 4 cases. This map was reported for situational awareness, while other maps were generated to focus the public health response effort.



Source: DPHSS 2024

Similarly with Figure 2, this map represents the number of cases by village of primary residence. The villages with the highest density of reported cases were the northern villages, including Dededo, Yigo, Mangilao, Tamuning/Tumon, and Barrigada. This map was published daily, while other maps were generated to focus public health interventions including testing and vaccination outreach.

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Guam COVID-19 Situation Report - 315 March 12, 2020 – June 2, 2023

COVID-19 Case Count*	Total	Past 14 days
COVID-19 Cases	61,877	85
Confirmed cases	51,479	36
Probable cases	10,398	49

*<https://www.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/> - CSTE/CDC COVID-19 case definition (August 5, 2020)

Summary

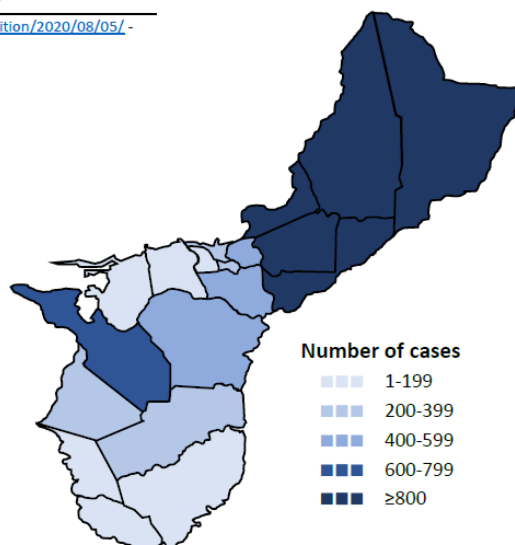
As of June 2, 2023, there have been 61,877 cases of COVID-19 reported on Guam. Eighty-five (85) new cases of COVID-19 were reported to DPHSS from May 19 - June 1, 2023: 36 confirmed cases and 49 probable cases. No new COVID-19 cases were reported deceased since the last situation report; totaling 413.

Confirmed cases - past 14 days: 36 cases tested positive by molecular testing - 16 at GPHL, 12 at DLS, and 8 at DoD.

Probable cases - past 14 days: 49 cases tested positive by antigen testing - 26 at GRMC, 15 at GMHA, 4 at GFD, 2 at GPHL, and 2 at FHP.

Eight (8) new cases were identified through contact tracing. One (1) new case reported recent travel to the US. One-hundred four (104) cases were reported released from isolation.

COVID-19 Cases
Primary Reported Residence



Source: DPHSS

Probability of Future Events

Emerging infectious diseases (EIDs) are communicable diseases that are new or have previously existed in populations, and are rapidly growing. These diseases are caused by pathogens that can be readily transmitted, pose a risk to morbidity and mortality, and require public health action. Their emergence may also result in public concern and social disruption and have the potential to burden the local, national, or global economy. Major drivers of EIDs are pathogen spillover events, or the transmission of disease from animals to humans, caused by conversion of intact ecosystems and interactions between humans and animals, and increased globalization, or trade-motivated travel leading to increased interjurisdictional human interactions. The health impacts vary depending on the specific emerging pathogen. EID's include, but are not limited to, influenza viruses, Ebola, human immunodeficiency virus (HIV), or resistance-developing bacteria. The major health concern for all EID's is its pathogenicity in populations where there is no previously existing immune response. Due to this occurrence, human populations are at greater risk for developing severe disease. Influenza A, for example, is a concern because of its ability to infect multiple species including swine populations, avian populations, and human populations. Guam's current surveillance systems are equipped to monitor such EIDs, and is continually improving. Future strategies include building a collaborative, multidisciplinary approach to optimize the health of human, animal, and environmental ecosystems given their integrated influence on EIDs.

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5.5.3 Drought

Nature

Drought is a normal part of virtually every climate on the planet, including areas of both high and low rainfall. Drought is different from normal aridity, which is a permanent characteristic of the climate in areas of low rainfall. Drought is the result of a natural decline in the expected precipitation over an extended period-of-time, typically one or more seasons. The severity of a drought can be aggravated by other climatic factors, such as prolonged breezy conditions and low relative humidity.

Drought is a complex natural hazard. This complexity is reflected in the following four definitions commonly used to describe it:

- Meteorological drought is defined solely on the degree of dryness, expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
- Hydrological drought is related to the effects of precipitation shortfalls on stream flows and reservoir, lake, and groundwater levels.
- Agricultural drought is defined principally in terms of soil moisture deficiencies relative to water demands of plant life, usually crops.
- Socioeconomic drought associates the supply and demand for economic goods or services with elements of meteorological, hydrologic, and agricultural drought. Socioeconomic drought occurs when the demand for water exceeds the supply as a result of a weather-related supply shortfall. This type of drought is also called a water management drought.

A drought's severity depends on numerous factors, including duration, intensity, geographic extent, the regional water supply capacity/resources, and the demands of humans and vegetation. Due to its multidimensional nature, drought is difficult to define and poses difficulties in terms of comprehensive risk assessments. Drought differs from other natural hazards in three ways. First, the onset and end of a drought are difficult to determine due to the slow accumulation and lingering effects of an event after its apparent end. Second, the lack of an exact and universally accepted definition of drought adds to the confusion about its existence and severity. Third, in contrast to other natural hazards, the impact of the drought is not always obvious and may be spread over a large geographic area. These characteristics hinder the preparation of drought contingency or mitigation plans by many governments.

Drought can cause a shortage of water for human and industrial consumption, hydroelectric power, recreation, and navigation. Water quality can also decline, and the number and severity of wildland fires can increase. A severe drought can result in the loss of agricultural crops and forest products, undernourished wildlife and livestock, lower land values, and higher unemployment.

The US Drought Monitor (USDM) also provides classifications for the western North Pacific Micronesian islands. These are D0-abnormally dry, D1-moderate drought, D2-Severe Drought, D3-Extreme Drought, and D4-Exceptional Drought. These can be further be classified as Short term, less than 6 months, or Long-term, more than 6

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months. Further information on the US Drought Monitor can be found at <https://droughtmonitor.unl.edu/>. The USDM evaluates drought based on rainfall criteria derived from meteorological drought, agricultural drought, and sociological drought for the Pacific Islands. These criteria were determined through meetings among a Weather Forecast Office (WFO) Guam scientist, a Water and Environmental Research Institute of the Western Pacific at the University of Guam scientist, and the USDM.

Location

The entire island of Guam is susceptible to drought.

Previous Occurrences

A review of the monthly rainfall data from the Western Regional Climate Center for the weather station at Tiyan indicated that meteorological droughts might also have occurred in 1950/1951/1952/1953, 1959, 1965/1966, 1973, and 1975. In more recent years, the Government of Guam has recognized droughts immediately following an El Niño cycle in 1973, 1977, 1983, 1987, 1993, 1998, 2016, and 2019. The Weather Forecast Office in Guam characterizes the following years as drought years for Guam, based on four consecutive or more months of less than 4 inches of rain: 1950, 1952, 1953, 1959, 1960, 1966, 1969, 1973, 1977, 1978, 1983, 1987, 1993, 1998, 2001, 2009, 2010, 2016 and 2019. Drought extends over the entire island of Guam.

Updated occurrences since the 2019 HMP are:

- April 16, 2020: Guam/Rota D2-S, Tinian/Saipan/Northern CNMI D3-S
- April 30, 2020: Guam D2-S, Rota D3-S, Tinian/Saipan/Northern CNMI D3-SL
- March 15, 2024: Guam/Tinian/Saipan D2
- March 29, 2024: Guam/Tinian/Saipan D2
- April 12, 2024: Guam/Tinian/Saipan D2
- April 26, 2024: Guam*/Tinian/Saipan D3
- May 10, 2024: Guam/Rota D2, Tinian/Saipan D3
- May 24, 2024: Guam D2, Rota/Tinian/Saipan D3

Vulnerable assets are surface water sources that include the Fena Reservoir, rivers, and springs. Agriculture that cannot be irrigated and trees depending on the severity of the drought. Grassfire risk is greatly increased.

Vulnerable jurisdictions include the southern half of Guam and areas around Mount Santa Rosa. Global climate change affects a variety of factors associated with drought on Guam. There is high confidence that increased temperatures will lead to more precipitation falling as rain and increased evaporation and transpiration.

Probability of Future Events

Scientific studies of Guam's climate have shown that droughts in Guam typically follow a moderate or strong El Niño event. Generally, the intensity of a drought that occurs in the year after an El Niño event in the western North Pacific Ocean is proportional to the

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strength of the El Niño event. Weak El Niño events tend to occur every 3-5 years; moderate events every 7-10 years; and strong events every 20-30 years.

Summary of Potential Impacts

Drought on Guam poses multifaceted challenges due to its complex nature, impacting various sectors including water supply, agriculture, wildlife, and employment. It can lead to shortages in water for consumption and industry, compromised water quality, increased wildfire occurrences, crop failures, malnourishment in wildlife and livestock, decreased land values, and heightened unemployment rates.

Drought on Guam presents significant challenges to the island's agriculture sector, albeit relatively small in scale. Reduced soil moisture levels due to drought conditions can hinder crop growth and productivity, affecting local farmers and food production. Without adequate irrigation systems, crops become more susceptible to withering and yield losses, leading to potential economic setbacks for agricultural businesses and limited food supply for the local population.

Compromised water quality is another consequence of drought, posing risks to both human health and ecosystems. As water sources diminish during prolonged dry spells, concentrations of pollutants and contaminants in remaining water bodies can increase, affecting drinking water supplies and aquatic habitats. Elevated levels of pollutants such as sediment, nutrients, and chemicals can degrade water quality, impacting marine life and ecosystems dependent on freshwater inflows. Consequently, compromised water quality exacerbates environmental stresses and threatens the overall health of Guam's ecosystems, highlighting the interconnectedness of drought impacts on various sectors.

Other impacts of drought include increased wildfire risk, negative public health and tourism impacts, loss of cultural practices, and reduced crop yields.

Jurisdictions' Vulnerability

The entire island of Guam is vulnerable to drought, with the southern half and areas surrounding Mount Santa Rosa particularly susceptible. Vulnerable assets include surface water sources like the Fena Reservoir, rivers, and springs, along with agriculture reliant on irrigation and trees. Additionally, there's a heightened risk of grassfires. Climate change exacerbates these vulnerabilities, with increased temperatures likely leading to more precipitation as rain and higher evaporation and transpiration rates.

The jurisdiction is vulnerable to the compound effects of climate change, including warming, changing drought conditions, and sea level rise, which contributes to saline contamination of freshwater supplies. Water supplies limited to rainwater catchments, are particularly vulnerable to drought periods since water storage is often insufficient to sustain the local population.

Summary of Recent and Project Developments in the Hazard Prone Area

No developments since the 2019 HMP.

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5.5.4 Earthquake

Nature

An earthquake is a sudden motion or trembling caused by a release of strain accumulated within or along the edge of the earth's tectonic plates. The effects of an earthquake can be felt far beyond the site of its occurrence. Earthquakes usually occur without warning and, after just a few seconds, can cause massive damage and extensive casualties. The most common effect of earthquakes is ground motion or the vibration or shaking of the ground during an earthquake.

Ground motion generally increases with the amount of energy released and decreases with distance from the fault or epicenter of the earthquake. It causes waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves. Two kinds of seismic waves occur: P (primary) waves are longitudinal or compressional waves similar in character to sound waves that cause back-and-forth oscillation along the direction of travel (vertical motion), and S (secondary) waves, also known as shear waves, are slower than P waves and cause structures to vibrate from side to side (horizontal motion). Also, two kinds of surface waves occur: Raleigh waves and Love waves. These waves travel more slowly and typically are significantly less damaging than seismic waves.

In addition to ground motion, several secondary natural hazards can occur from earthquakes. Surface fault rupture, liquefaction, and lateral spread are addressed within this section. Landslide is addressed in **Section 5.3.12** (Slope Failure), and tsunamis are addressed in **Section 5.3.16** (Tsunami Inundation).

- Surface Fault Rupture is the differential movement of two sides of a fault at the earth's surface. Displacement along faults, both in terms of length and width, varies but can be significant (e.g., up to 20 feet in width and 200 miles in length). Surface faulting can cause severe damage to linear structures, including railways, highways, pipelines, and tunnels.
- Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Poor water pressure may also increase sufficiently to cause the soil to behave like a fluid for a brief period and cause deformations. Liquefaction causes lateral spreads (horizontal movements of commonly 10 to 15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to 12 miles), and loss of bearing strength (soil deformations causing structures to settle or tip). Liquefaction can cause severe damage to property.
- Lateral Spreads are a type of landslide but are distinctive because they usually occur on very gentle slopes or flat terrain and occur in a rapid fluid-like flow movement, caused by liquefaction. Ground failure is usually triggered by rapid ground motion, such as that experienced during an earthquake, but can also be artificially induced. When coherent material, either bedrock or soil, rests on materials that liquefy, the upper units may undergo fracturing and extension and may then subside, translate, rotate, disintegrate, or liquefy and flow. Lateral spreads are almost always discussed in conjunction with liquefaction.

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- Landslides occur as a result of horizontal seismic inertia forces induced in the slopes by the ground shaking. The most common earthquake-induced landslides include shallow, disrupted landslides such as rockfalls, rockslides, and soil slides. Debris flows are created when surface soil on steep slopes becomes totally saturated with water. Once the soil liquefies, it loses the ability to hold together and can flow downhill at very high speeds, taking vegetation and/or structures with it. Slide risks increase after an earthquake during the wet season. Landslides are further addressed in **Section 5.3.12** (Slope Failure).
- Tsunamis: As an Oceanic Plate subducts beneath a Continental Plate, it sometimes brings down the lip of the Continental Plate with it. Eventually, too much stress is put on the lip, and it snaps back, sending shockwaves through the earth's crust, causing a tremor under the sea, known as an undersea earthquake. Factors that affect tsunami generation from an earthquake event include magnitude (generally, a 7.5 magnitude [M] and above), depth of event (a shallow marine event that displaces the seafloor), and type of earthquake (thrust as opposed to strike-slip). Tsunamis are further addressed in **Section 5.3.16** (Tsunami Inundation).

The severity of an earthquake can be expressed in terms of intensity and magnitude. Intensity is based on the damage and observed effects on people and the natural and built environment. It varies from place to place depending on the location with respect to the earthquake epicenter, which is the point on the Earth's surface that is directly above where the earthquake occurred. The severity of intensity generally increases with the amount of energy released and decreases with distance from the fault or epicenter of the earthquake. The scale most often used in the U.S. to measure intensity is the Modified Mercalli (MM) Intensity Scale. As shown in **Table 27**, the MM Intensity Scale consists of 12 increasing levels of intensity that range from imperceptible to catastrophic destruction. Peak ground acceleration (PGA) is also used to measure earthquake intensity by quantifying how hard the earth shakes in a given location. PGA can be measured in g, which is vertical acceleration due to gravity.

Magnitude is the measure of the earthquake strength. It is related to the amount of seismic energy released at the earthquake's hypocenter, the actual location of the energy released inside the earth. It is based on the amplitude of the earthquake waves recorded on instruments, known as the Richter magnitude test scales, which have a common calibration.

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Table 27. Magnitude/Intensity/Ground-Shaking Comparisons

Magnitude	Intensity	PGA (% g)	Perceived Shaking
0 – 4.3	I	<0.17	Not Felt
	II-III	0.17 – 1.4	Weak
4.3 – 4.8	IV	1.4 – 3.9	Light
	V	3.9 – 9.2	Moderate
4.8 – 6.2	VI	9.2 – 18	Strong
	VII	18 – 34	Very Strong
6.2 – 7.3	VIII	34 – 65	Severe
	IX	65 – 124	Violent
	X	124 +	Extreme
7.3 – 8.9	XI		
	XII		

Source: USGS 2011.

Location

The entire island of Guam is susceptible to the impact of an earthquake. This susceptibility reflects the presence of various known surface faults (**Figure D-13**), and past seismic activity felt on Guam (**Figures D-15 and D-16**).

Surface Fault Rupture: The general locations of known surface faults on Guam are shown in **Figure D-13**. **Figures D-15 and D-16** incorporate the reconnaissance mapping that included a preliminary assessment of potential seismic activity, but was not field-checked. Both sets of fault traces are shown in **Figure D-13**. To account for the uncertainty in the location of surface fault traces and the width of the deformation zone, the zones that are considered to have a potentially high surface faulting hazard encompass a 0.18-mile radial buffer (984.25 feet.) surrounding the faults. As shown in **Figure D-13**, many locations throughout Guam have surface fault traces. Approximately, 45.78 square miles of land area, or 21.8 percent of the island, is within the surface fault hazard zones, meaning that they have a higher threat of surface faulting from a known surface fault than areas farther away from the faults. The known surface faults are organized into concentrated areas on Guam. A large concentration of faults exists in the southwestern portion of the island, east of Apra Harbor, and in the northeast part of the island.

Liquefaction and Lateral Spreads: Previous studies have recommended rankings of high, moderate, and low, for the various areas of Guam that are potentially susceptible to liquefaction. This ranking is based on geological units and historical observations of each area. High potential areas contain beach sands, eolian sand, marine deposits, sands, and artificial fill. Areas with a moderate potential for liquefaction contain alluvial deposits in valleys. Low potential areas contain lagoon and estuarine deposits. **Figure D-14** shows the areas on Guam with high, moderate, and low potential for liquefaction

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to occur and the areas where liquefaction has occurred historically. Since lateral spreads are a result of liquefaction, it is assumed that areas susceptible to lateral spreading correlate with the areas of liquefaction susceptibility.

Based on an analysis of the available geologic data, 2.98 square miles of Guam have potential risk for liquefaction or lateral spreading to occur. Areas with a high risk for liquefaction or lateral spreading are mainly surrounding Tumon Bay and Apra Harbor, as much of the area surrounding Apra Harbor contains extensive areas of fill. This area has exhibited liquefaction and lateral spreading in historical earthquakes. In addition, the larger river valleys and along the coastlines of Merizo, Inarajan, and Agat are also susceptible to liquefaction and lateral spread.

The rest of Guam generally has a very low potential for liquefaction or lateral spreading to occur because the types of shallow material mapped at the surface are not conducive to liquefying. However, this assessment is limited by the scale and resolution of the previous mapping on Guam; small areas of sediments more susceptible to liquefaction may exist in these very low potential areas.

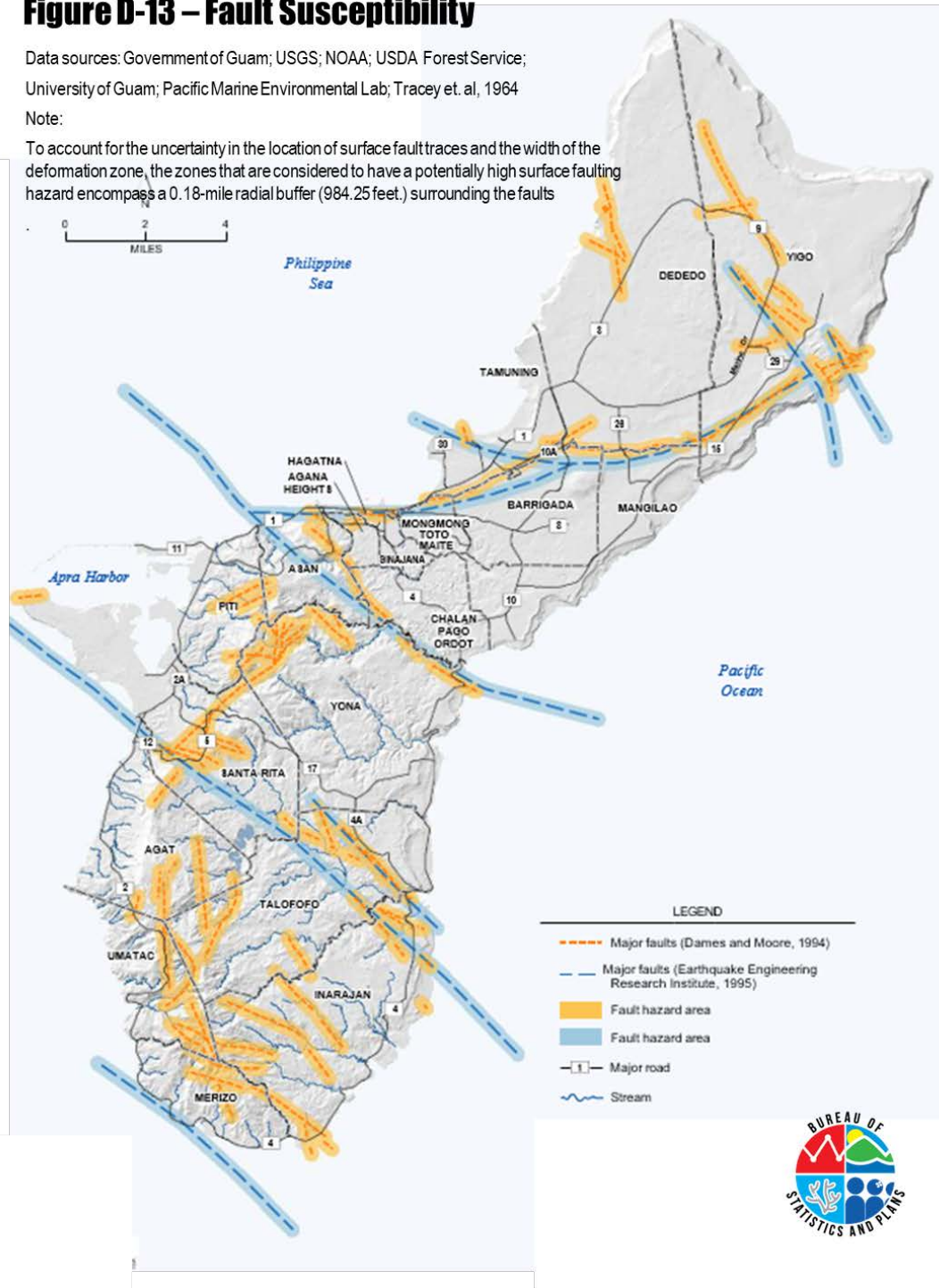
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Figure D-13 – Fault Susceptibility

Data sources: Government of Guam; USGS; NOAA; USDA Forest Service;
University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

Note:

To account for the uncertainty in the location of surface fault traces and the width of the deformation zone, the zones that are considered to have a potentially high surface faulting hazard encompass a 0.18-mile radial buffer (984.25 feet.) surrounding the faults



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Previous Occurrences

The most significant recent earthquake on Guam occurred on August 8, 1993. This M 7.8 event occurred 31 miles south of Guam at a depth of 37 miles along the Mariana Trench. No consensus exists as to the source of this earthquake, but evidence from a recent study of aftershocks suggests that this earthquake was an interplate event (i.e., it occurred between the Pacific Plate and the Philippine Sea Plate). Liquefaction and lateral spreading caused major damage to commercial and naval port facilities. Landslides were predominantly small local slumps and rockfalls along limestone bluffs. Buildings were damaged or destroyed throughout the island.

The preliminary estimate of damage to commercial buildings was \$112 million. No compiled damage cost is available for this earthquake.

One Presidentially declared earthquake disaster has occurred on Guam. On October 12, 2001, a M 7.3, maximum MM Intensity VII earthquake struck Guam. This seismic event was believed to have caused one injury, but no published estimates of total damage are available. According to the information available, the center of the earthquake was southeast of the initial center point of the August 1993 series, and the earthquake had the following effects: the power was lost, a new school in Piti was affected, several schools in the Santa Rita area were affected, many buildings were damaged, and utilities were disrupted. No other earthquakes associated with damage have been reported. Information on other significant earthquakes since 1975 is provided in **Table 28**.

Table 28. Recent M 5.7 or Greater Earthquakes Felt on Guam, 1975–2019

Event Date	Description	Magnitude	MM Intensity
1 Nov 1975	From the same area as the 1936 event. Damage in excess of \$1,000,000. No landslides were noted. This quake was 70 miles deep and was preceded by loud subterranean noises. Many businesses lost stock from shelves, and a number of structures were damaged; only one injury was reported. The earthquake was felt strongly in many parts of the island. Epicenter 12.5 miles north of the island	7.1	VIII
13 Feb 1983	One person slightly injured at Tamuning/Tumon/Tumon. Felt throughout Guam. Epicenter about 25 miles north of the island. Minor damage reported in northern Guam.	6.3	V
5 Apr 1990	Felt on Guam. Also felt on Saipan.	7.3	IV

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8 Aug 1993	The most severe examples of ground failure were at the filled area of Cabras (Piti power plant and commercial port) and at the Navy wharves across the harbor. Two cases of building failure in the Tumon area were noted. Old residential units in the Apra Heights housing area suffered notable damage and were also razed. No bridge failures occurred, but the Talofofo, Ylig, and Pago bridges required repairs as well as the utilities along the bridges. Forty-eight people injured on Guam. Extensive damage (IX) to hotels in the Tumon Bay area. Damage (VII) occurred at several locations in the northern half of the island. One end of the approach to a bridge at Pago Bay fell more than 18 inches. Many landslides and rockslides were reported, mainly in the southern half of the island. The preliminary estimate of loss from damage to commercial buildings is placed at \$112 million, and loss from damage to private residences is estimated at several million dollars.	7.8	IX
23 Apr 1997	Two separate earthquakes occurred from the fault plane of the August 1993 series. Four people injured and some damage to buildings on Guam. Felt (VII) at Inarajan, Merizo, and Yona; (VI) in central Guam; (IV) at Dededo and Yigo. A M 5.7 earthquake was followed 5 seconds later by a M 6.3 earthquake (not an aftershock). Centered about 27 miles west of Rota. Originated at a depth of 65 miles.	5.7; 6.3	VII
12 Oct 2001	Southeast of the initial shock of the August 1993 series. Power was lost. The new school in Piti (on alluvial clay) was most conspicuously affected as well as schools in the Santa Rita area. One person injured, many buildings damaged (VII) and utilities disrupted on Guam.	7.3	VII
26 Apr 2002	Northwest of the August 1993 initial shock. Power was lost through most of Guam. At least 5 people slightly injured and some minor damage (VII) to buildings on Guam. Water and sewer lines broke, and power outages occurred throughout the island.	7.1	VII
9 May 2008	Felt on Guam, also felt on Saipan. No reports of damage or injury.	6.7	IV
11 Sept 2012	155 miles southwest of Hagatna with an epicenter depth of more than 6 miles. Felt on Guam. No reports of damage or injury.	5.8	V
17 Sep 2014	26.7 miles northwest of Piti Village, Guam. No reports of damage or injury.	6.7	V
29 Aug 2022	14.3 miles NE of Yigo. No reports of damage or injury	5.7	V

Sources: GHS-OCD 2019; USGS NEIC 2019; EERI 1995; WERI 1998; Repetti 1948.

Surface Fault Rupture: Although surface fault ruptures have not been observed historically along any of the known faults on Guam (**Figure D-13**), abundant geologic evidence shows that many faults ruptured prehistorically in the late Quaternary (past 130,000 years) and, thus, have the potential for surface rupture. This geologic evidence

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of prehistoric ruptures includes fault scarps offsetting limestones that are likely Quaternary or even late Quaternary in age, offsets of late Quaternary marine terraces, and even offsets of young algal pools.

Liquefaction and Lateral Spread: The only readily available information on historical liquefaction and lateral spread events concerns the earthquake that occurred on August 8, 1993. The areas of historic liquefaction and lateral spread are shown in **Figure D-14**. The occurrences were originally documented in the 1995 EERI report on this event. As shown in **Figure D-14**, liquefaction and lateral spreading were observed at the following locations:

In the areas surrounding Apra Harbor and Piti Power Plant, liquefaction occurred where coral fill material overlies fine-grained lagoonal and estuarine deposits. The groundwater in these areas was approximately 7 to 8 feet below the ground surface. At the commercial port facility, liquefaction and lateral spreading caused horizontal displacement of up to 24 inches and crane tracks and bulkheads were warped. Cracks were observed that extended for 200 to 300 feet and were up to 8 feet deep. According to information on the website of the Guam Power Authority, damage of \$8-\$10 million occurred at the port

At the Naval Station port facilities, most of the wharves sustained structural damage from liquefaction and lateral spreading. The Navy allocated \$2.8 million toward initial wharf repairs, but the estimate for the total cost of the damage was \$25.15 million. Extensive evidence of liquefaction was observed at the Piti Power Plant. Ground fissures and sand boils ejected coral sands. Liquefaction caused up to 4 feet of settlement. Although liquefaction and lateral spreading caused nonstructural damage, no structural damage occurred to the plant due to liquefaction or lateral spreading.

Liquefaction was evident near the new courthouse in downtown Hagatna. This area was developed with fill material on top of fine-grained Hagatna marsh sediments. No cost estimate of the damage to this area is available.

Probability of Future Events

Fault and seismic data for the region in which Guam is located are generally scarce. Guam is in a remote region of the Pacific Ocean, and the historical seismic catalog for moderate-sized events is most likely incomplete and the historical record for large events is likely inadequate because the recurrence intervals for subduction zone earthquakes may belong. However, based on recorded occurrences from 1975-2013, an earthquake of significant size ($>M 5.7$) is likely to be felt on Guam every 4-5 years.

The 1999 Global Seismic Hazard Assessment Program (GSHAP) conducted a generalized global probabilistic seismic hazard analysis that included Guam. GSHAP calculated PGAs with a 10 percent chance of being exceeded in 50 years. Guam lies in the PGA contour range of 0.16g to 0.24g. The GSHAP analysis only considered regional source zones; the potential hazard from the subduction zone or crustal faults was not included in the analysis.

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Surface Fault Rupture: Beyond identifying the general locations of the potentially active fault traces on Guam, the data available on these faults are not adequate to characterize the faults and analyze the probability for surface faulting to occur. To fully characterize the hazards from surface faulting, the exact locations, ages, sense of motion, and dips associated with the faults need to be researched and identified. However, the approximate locations of many potentially active faults have been identified, and these faults do show evidence of movement that is likely Quaternary or even late Quaternary.

Liquefaction and Lateral Spreads: Specific data, including depth to the water table, boring logs, blow count information, and detailed age data for the geological units, none of which are available for Guam, are generally used to determine the probability for liquefaction and lateral spreading to occur. However, as described above, based on recorded occurrences from 1975- 2022, an earthquake is likely to be felt on Guam every 4-5 years. Liquefaction and lateral spreading on Guam may occur as a result of these earthquake events.

Climate Change Impacts

Since Earthquakes are not a climate related hazard, climate change has no impact on future events.

Summary of Potential Impacts

Earthquake: Fault Proximity (Surface Fault Rupture)

Similar to results from earlier versions of the Guam HMP, a moderate percentage of Guam's population (18.6 percent) was found to be directly exposed to surface faulting while a similar proportion of the GBS was exposed at about 16 percent or 4,780 buildings. In addition, 74 Essential Facilities (worth \$264.9 million), 83 Major Utilities (worth \$424 million), and 298 Transportation Systems (worth \$13.0 million) are located in this hazard area.

The assessment of the vulnerability to surface faulting represents an overemphasis of the hazard because a larger area has been determined to be exposed than actually will be exposed and because the analysis assumes all characterized faults to rupture across the island at the same time. Two different data sources of surface fault locations often characterize different faults and different fault locations. Research has not been conducted to verify which dataset of faults is correct. In addition, the location of these surface faults has not been specifically characterized.

Therefore, to remain conservative in assessing Guam's vulnerability, both datasets are used, and a 984-foot buffer around each fault is used to describe the exposed area. As shown in **Tables F-3 and F-4**, in terms of the village-level population exposed to surface faulting, Tamuning/Tumon has 5,497 people (31 percent) followed by Dededo with 3,640 (8.5 percent). Both of these communities had the greatest number of people in this hazard area in the 2024 Guam HMP. Both of these areas experienced a slight decrease between 2010 and 2020 according to the Guam Decennial Census.

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Exposure of the Essential Facilities is spread throughout all affected villages. The village with the most exposure of Essential Facilities is Hagatna, with 28 facilities that are worth \$28 million. In addition, the most concentrated number of exposed Major Utilities are located in Yigo (16 facilities valued at \$58 million), Tamuning/Tumon (10 facilities valued at \$70.3 million), and Dededo (10 facilities worth \$89 million). Hagatna and Tamuning/Tumon also have the most concentrated number of Transportation Systems, with 31 facilities valued at \$24.5 million and 40 facilities valued at \$30 million, respectively.

In terms of village-level GBS exposure, Yigo has the highest number of exposed GBS with 1,065 (21.7 percent of village structures) worth \$150 million. In this hazard area, Tamuning/Tumon has 419 GBS (26.5 percent) worth \$313.7 million, and Santa Rita has 130 GBS (29.5 percent) worth \$18.9 million. In 2023, the greatest number of building permits (93 permits or 29 percent of the total permits issued) were issued in Dededo.

Earthquake: Liquefaction

Similar to the earlier versions of the Guam HMP, a relatively small population of 1,728 people (approximately 1.0 percent) on Guam currently resides in areas with very high or high levels of exposure to liquefaction, as shown in **Tables 5-17 and 5-18**. The percentage of EFMUTS located in areas with very high or high levels of exposure is also relatively low with 16 Essential Facilities (worth \$21.4 million), 2 Major Utilities (worth \$269 million), and 31 Transportation Systems (worth \$689,738 million). The exposed GBS is also relatively low with 102 structures (0.51 percent), valued at \$44 million.

The high value of the Transportation Systems located in the hazard area is due to the location of port facilities in Apra Harbor. In addition to the potential costs of replacement of the facilities at the port, irreparable damage to these facilities could severely affect all movement of goods on and off Guam. A value for the normal and daily functions of these facilities has not been assessed for this analysis but would be a potential secondary effect of this hazard event.

Similar to earlier versions of the Guam HMP, and shown in **Tables F-5 to F-7**, in terms of village-level population exposed to very high and high liquefaction hazard, Santa Rita leads with 512 people (approximately 14.2 percent of the village population), followed by Tamuning/Tumon (506 people, 2.81 percent of the village population) and Piti and Hagatna (155 and 168, respectively).

Table F-3 Total Affected by Fault Proximity			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	1,421	1	1,851,449	1	387,935	11	154,239	28	3,988,753
Agat	2.19	1,166	1	52,314,016	0	0	33	3,274,641	161	21,602,212
Asan/Maina	2.66	981	1	12,958,533	4	13,728,555	12	3,630,211	226	34,043,695
Barrigada	2.12	2,158	4	16,975,021	5	2,817,191	25	705,941,200	1,022	214,957,424

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Chalan Pago-Ordot	0.74	776	1	1,851,313	0	0	0	0	18	3,009,072
Dededo	2.56	3,640	1	1,178,833	10	89,868,234	25	7,145,106	849	201,806,788
Hagatna (Agana)	0.43	560	28	27,997,685	2	1,515,791	40	30,246,431	247	158,482,381
Inarajan	6.11	996	3	1,116,900	4	23,522,733	12	8,932,613	62	7,155,638
Mangilao	0.81	1,050	0	0	3	12,461,659	12	89,534	185	38,906,283
Merizo	1.74	615	2	1,080,391	8	9,249,430	14	307,494	123	14,151,652
Mongmong-Toto-Maite	0.51	1,637	3	4,439,744	2	1,653,489	15	3,316,669	77	22,872,311
Piti	1.17	266	0	0	0	0	4	0	21	4,421,379
Santa Rita	4.19	1,915	2	2,189,455	6	34,626,260	4	623,866	130	18,465,769
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	931	2	432,009	4	24,475,223	17	165,690	52	8,148,748
Tamuning/Tumon	1.74	5,497	21	248,952,502	10	70,314,352	31	24,505,700	419	313,519,130
Umatac	2.28	332	0	0	4	32,813,986	10	353,678	13	1,379,572
Yigo	7.48	4,072	4	11,414,035	16	58,316,123	25	4,197,748	1,033	150,026,365
Yona	3.61	1,155	0	0	4	48,445,504	8	181,528	114	22,800,416
Total	45.86	29,169	74	384,751,886	83	424,196,465	298	793,066,346	4,780	1,239,737,588

Table F-4 Proportion Affected by Fault Proximity			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	35.92	36.06	16.67	21.85	25	3.24	100	72.73	16.45	16.45
Agat	20.62	20.62	5	76.49	0	0	100	80.19	10.2	10.2
Asan	46.91	46.93	20	85.85	40	29.01	66.67	28.94	44.86	44.86
Barrigada	24.94	24.94	16.67	37.97	29.41	11.8	46.67	78.26	21.88	21.88
Chalan Pago-	13.1	13.1	12.5	18.11	0	0	0	0	2.64	2.64
Dededo	8.46	8.47	2.86	1.85	10.42	10.39	16.67	14.03	5.98	5.98
Hagatna	50.59	50.9	62.5	61.99	50	10.95	70	65.29	73.41	73.41
Inarajan	32.6	32.64	20	3.56	23.53	28.15	33.33	25.21	9.92	9.92
Mangilao	7.88	7.89	0	0	10.71	16.4	20	0.61	13.95	13.95
Merizo	28.43	28.43	20	16.6	50	34.05	50	3.22	32.2	32.2
Mongmong-	28.02	28.01	37.5	34.46	28.57	18.07	100	89.77	19.79	19.79
Piti	15.92	15.96	0	0	0	0	9.09	0	3.95	3.95
Santa Rita	25.52	25.53	28.57	5.3	50	59.69	20	5.21	29.53	29.53
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	28.93	28.95	28.75	10	44.44	60.66	100	18.09	5.46	5.46
Tamuning/	30.53	30.52	26.2	30.5	43.48	47.46	23.33	25.28	26.56	26.56
Umatac	37.44	37.47	0	0	21.05	34.93	33.33	1.98	9.47	9.47

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Yigo	20.91	20.91	36.3 6	56.79	48.4 8	51.43	50	28.67	21.7 1	21.71
Yona	17.83	17.82	0	0	23.5 3	30.73	25	0.83	6.83	6.83

Table F-5 Total Affected by Very High Liquefaction			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	0	0	0	0	0	0	0	0	0
Agat	2.19	0	0	0	0	0	0	0	0	0
Asan/Maina	2.66	0	0	0	0	0	0	0	0	0
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	0	0	0	0	0	0	0	0	0
Dededo	2.56	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	157	15	19,606,058	0	0	23	11,169,267	55	35,405,409
Inarajan	6.11	0	0	0	0	0	0	0	0	0
Mangilao	0.81	0	0	0	0	0	0	0	0	0
Merizo	1.74	0	0	0	0	0	0	0	0	0
Mongmong-Toto-Maite	0.51	0	0	0	0	0	0	0	0	0
Piti	1.17	39	1	1,850,807	2	269,497,012	4	678,567,666	40	8,551,731
Santa Rita	4.19	101	0	0	0	0	4	1,197	7	937,984
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	1.74	0	0	0	0	0	0	0	0	0
Umatac	2.28	0	0	0	0	0	0	0	0	0
Yigo	7.48	0	0	0	0	0	0	0	0	0
Yona	3.61	0	0	0	0	0	0	0	0	0
Total	45.86	297	16	21,456,865	2	269,497,012	31	689,738,131	102	44,895,123

Table F-6 Proportion Affected by Very High Liquefaction			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	0	0	0	0	0	0	0	0	0	0
Asan	0	0	0	0	0	0	0	0	0	0
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	0	0	0	0	0	0	0	0	0	0
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna	14.12	14.27	35	43.41	0	0	40	24.11	16.4	16.4
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	0	0	0	0	0	0	0	0	0	0
Merizo	0	0	0	0	0	0	0	0	0	0
Mongmong-	0	0	0	0	0	0	0	0	0	0
Piti	2.31	2.34	5.2 6	9.71	15.3 8	47.96	9.0 9	73.17	7.6 4	7.64

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Santa Rita	1.34	1.35	0	0	0	0	20	0.01	1.5	1.5
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	0	0	0	0	0	0	0	0	0	0
Tamuning/	0	0	0	0	0	0	0	0	0	0
Umatac	0	0	0	0	0	0	0	0	0	0
Yigo	0	0	0	0	0	0	0	0	0	0
Yona	0	0	0	0	0	0	0	0	0	0

Table F-7 Total Affected by High Liquefaction			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	0	0	0	0	0	0	0	0	0
Agat	2.19	0	0	0	0	0	0	0	0	0
Asan/Maina	2.66	0	0	0	0	0	0	0	0	0
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	0	0	0	0	0	0	0	0	0
Dededo	2.56	155	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	14	0	0	1	1,265,236	11	3,108,494	13	8,592,288
Inarajan	6.11	0	0	0	0	0	0	0	0	0
Mangilao	0.81	0	0	0	0	0	0	0	0	0
Merizo	1.74	43	1	372,279	0	0	0	0	0	0
Mongmong-Toto-Maite	0.51	0	0	0	0	0	0	0	0	0
Piti	1.17	168	1	1,850,807	4	140,817,246	15	123,805,909	81	17,248,976
Santa Rita	4.19	512	0	0	2	1,374,841	9	257,449	29	4,064,595
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	1.74	506	9	94,193,832	3	3,792,767	22	15,383,918	24	17,942,360
Umatac	2.28	0	0	0	0	0	0	0	0	0
Yigo	7.48	127	0	0	0	0	0	0	2	276,419
Yona	3.61	0	0	0	0	0	0	0	0	0
Total	45.86	1,524	11	96,416,918	10	147,250,089	57	142,555,770	148	48,124,638

Table F-8 Proportion Affected by High Liquefaction			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	0	0	0	0	0	0	0	0	0	0
Asan	0	0	0	0	0	0	0	0	0	0
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	0	0	0	0	0	0	0	0	0	0
Dededo	0.36	0.36	0	0	0	0	0	0	0	0
Hagatna	1.18	1.24	0	0	25	9.14	20	6.71	3.98	3.98
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	0	0	0	0	0	0	0	0	0	0

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Merizo	1.96	2	10	5.72	0	0	0	0	0	0
Mongmong-	0	0	0	0	0	0	0	0	0	0
Piti	10.07	10.11	5.26	9.71	38.4 6	25.06	36.3 6	13.35	15.4 1	15.41
Santa Rita	6.82	6.82	0	0	16.6 7	2.37	40	2.15	6.5	6.5
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	0	0	0	0	0	0	0	0	0	0
Tamuning/ Umatac	2.81	2.81	10.8 4	11.54	13.0 4	2.56	16.6 7	15.87	1.52	1.52
Yigo	0.64	0.65	0	0	0	0	0	0	0.04	0.04
Yona	0	0	0	0	0	0	0	0	0	0

Jurisdictions' Vulnerability

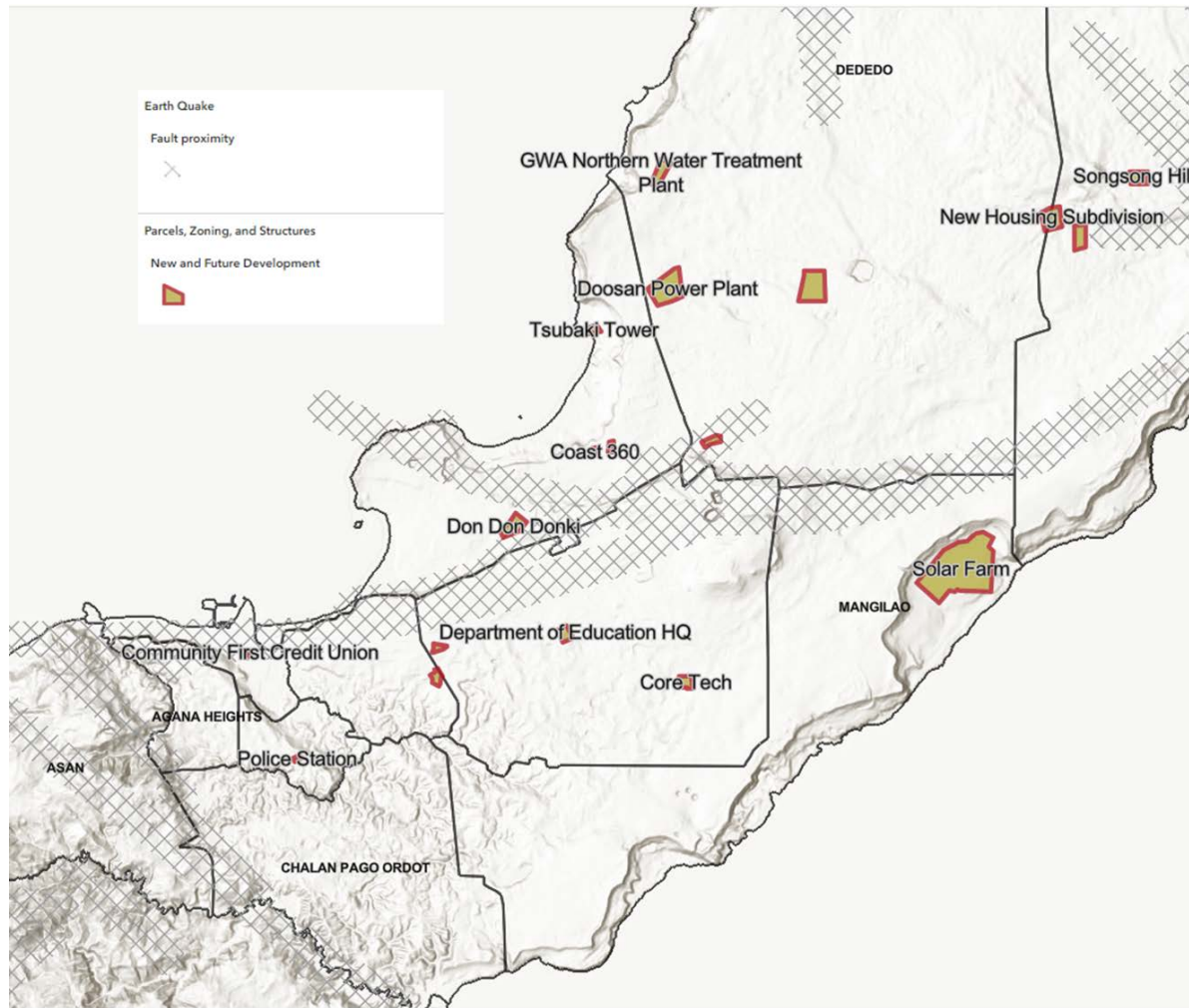
The estimated impact to Guam's vulnerable population is 13,836,

Village	Village SVI	Venerable Exposed	Venerable Exposed
Agana Heights	0.28	398	10%
Agat	1	1,166	21%
Asan/Maina	0.11	108	5%
Barrigada	0.44	949	11%
Chalan Pago-Ordot	0.33	256	4%
Dededo	0.78	2,840	7%
Hagatna (Agana)	0.89	498	45%
Inarajan	0.39	389	13%
Mangilao	0.72	756	6%
Merizo	0.94	578	27%
Mongmong- Toto-Maite	0.83	1,359	23%
Piti	0	0	0%
Santa Rita	0.06	115	2%
Sinajana	0.56	0	0%
Talofofo	0.22	205	6%
Tamuning/Tumon	0.17	935	5%
Umatac	0.67	223	25%
Yigo	0.61	2,484	13%
Yona	0.5	578	9%
Total		13,836	

Summary of Recent and Project Developments in the Hazard Prone Area

As depicted in the figure below, there are 2 new developments that are located within the fault buffer. They include Community First Credit Union in Hagatna, and iLearn Charter School in Dededo.

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5.5.5 Flooding

Nature

Flooding is one of the most common natural hazards; it occurs whenever rainfall accumulates in an area faster than it can drain off or can be absorbed by the soil. This accumulation causes an overflow from a water body onto an adjacent floodplain. However, all floods are not alike, and different areas are susceptible to different types of flooding. Guam is vulnerable to coastal flooding, riverine flooding and stormwater runoff, and flash flooding. Flooding on Guam is often associated with tropical cyclones; this connection is described below, but for further information specific to tropical cyclones, see Section 5.3.15 (Tropical Cyclone). Severe flooding can also occur without a tropical cyclone.

Flooding is a major concern for the Government of Guam. Several initiatives starting as far back as 1975 were done to study the flooding problems on Guam. Various agencies such as the Bureau of Statistics and Plans, Guam Coastal Management Program, US Army Corps of Engineers, Federal Highways Administration, Department of Public Works, Office of Civil Defense and the University of Guam contribute to work over the past 40 years. The Guam Coastal Management Program and the US Army Corps of Engineers are currently updating the 1980 Guam Comprehensive Flood Study.

Coastal Flooding: Coastal flooding in the western North Pacific Ocean is primarily due to inundation from ocean water that is associated with storm surges and wind-driven waves. A storm surge occurs in the right-front quadrant of the storm with respect to its direction of motion where the seawater surface of an approaching tropical cyclone is elevated in the shape of a mound. This occurs because of the extremely low pressure that exists within and near to the eye of a tropical cyclone and the piling up of water in the right-front quadrant of the storm with respect to its direction of motion. The sea level can be as much as 5 feet higher than normal during a storm surge in a strong typhoon due to the low pressure and much higher due to the piled-up water. The strong winds associated with a tropical cyclone also produce wind-driven waves that ride on top of the storm surge mound. With the addition of astronomical high tide, the incursion of seawater onto a normally dry land area (i.e., coastal flooding and inundation) can occur.

When a tropical cyclone passes directly over a small island, all shorelines of the island can be exposed to coastal flooding. Bays, river outlets, and reefs that occur on or close to a coast can exacerbate coastal flooding. The small size and restricted entrances of some bays can act to focus and contain the high water associated with storm surges and wind-driven waves. Strong winds often drive this high water toward the shore; the result can be a coastal flooding event. Raised sea levels can prevent rivers and streams from draining into the ocean and can cause the water in the rivers and streams to back up. This backup of water can result in flooding near the outlet of these waterways.

Generally, healthy reefs have a damping effect on storm surges and wind-driven waves. The shallower the water over a reef and the wider the reef, the more damping the effects of the reef on a storm surge and wind-driven waves. Conversely, the deeper the water over the reef and the narrower the reef, the more coastal inundation and coastal

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flooding that can occur. Coastal flooding and inundation are greatest when wind-driven waves riding on top of a storm surge approach a reef in a perpendicular direction. The force of the incoming storm surge can reduce the normal drainage of water across a reef and cause water to build up on the inside of a reef.

This water buildup can lead to increased coastal flooding. A channel in a reef or a location where a reef folds into a coastline can serve as a funnel for large amounts of water to come onto the shore in the form of large waves. This phenomenon can also result in increased levels of coastal flooding.

Storm surges can also result in coastal flooding in urban areas by causing storm drains to back up in low-lying areas. When a storm surge elevates the seawater to the same elevation as or above the elevation of storm drain outlets that drain into the ocean, the storm drains are not able to drain, and the storm runoff backs up into the storm drains and onto the nearby streets.

Riverine Flooding and Stormwater Runoff: The most common type of flooding is riverine flooding, also known as overbank flooding. Riverine floodplains range from narrow, confined channels in the steep valleys of mountainous and hilly regions to wide, flat areas in plains and coastal regions. The amount of water in the floodplain is a function of the size, land cover, and topography of the contributing watershed, the regional and local climate, and the land use characteristics of the floodplain. In steep valleys, flooding is usually rapid and deep, but of short duration. In flat areas, flooding is typically slow, relatively shallow, but can last for longer periods of time.

On Guam, flooding in rivers and streams is typically caused by prolonged periods of rainfall from tropical cyclones, monsoon surges, or slow-moving thunderstorms. These systems can saturate the ground and overload the rivers in numerous smaller basins that drain into larger rivers. Intense rates of rainfall (greater than 1 inch per hour) can lead to flash flooding. Flash flooding is most likely to occur in valleys in mountainous areas. The northern ecoregion of Guam has essentially no stream drainages because the area consists primarily of permeable limestone, which results in rapid infiltration of water even during heavy rainfall. Little or no surface water runoff occurs in this area, except where there are impermeable surfaces such as streets and parking lots. However, the southern ecoregion of Guam has a dense network of rivers and streams. This area consists primarily of basaltic volcanic rocks, which have limited infiltration capacities.

Heavy rainfall and the associated flooding can cause large amounts of soil and debris to enter into rivers. Debris can also enter rivers if it has been blown there by severe winds (see **Section 5.3.11** [Severe Wind]). Debris that becomes a part of floodwaters can cause damage to the culverts and bridges that floodwaters are either flooding through or around. This type of debris can completely dam bridges, culverts, and other drainages and cause floodwaters to bypass these structures and enter into areas that typically do not receive floodwaters. The dammed drainages can suddenly give way and cause flash-flood conditions farther downstream. In addition, large amounts of soil and

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debris can become deposited on the reefs surrounding tropical islands. This deposition of silt and debris is highly detrimental to the health of the coral polyps that create and maintain the reefs.

Although heavy rainfall events associated with tropical cyclones, particularly typhoons, and monsoon surges are well documented and acknowledged as a major hazard, Guam also experiences heavy rainfall events that are not associated with tropical cyclones or monsoons. These events result in significant stormwater runoff that may overwhelm local stormwater systems and local river and stream systems, if any, and cause localized flooding. Although this type of flooding is recognized as a hazard, the areas subject to this type of sub hazards have not been well documented to date and are not identified on FIRMs because these events are typically relatively small in size and extent.

Flooding due to stormwater runoff or street flooding often occurs when storm drains cannot convey the amount of water that could flow through them. This hazard can be due to high rates of rainfall, inadequate drainage design, storm surges, and/or debris blocking the storm drain conveyances. As the number of paved surface increases in Guam due to the growth of urban areas, the amount of stormwater runoff will increase. This increase, when combined with inadequate stormwater runoff conveyances, can lead to increased flooding.

Seismic forces, lack of vegetation, and heavy rainfall generally propagate slope failure on Guam. Seismic forces tend to destabilize slopes, and heavy rainfall can saturate the destabilized slopes and dislodge loose rocks. (A detailed discussion of slope failure is provided in **Section 5.3.12** [Slope Failure].) These events can result in rockslides, mudflows, and debris flows. These hazards can further exacerbate floods or result in the changing of floodplains.

Flash Flooding: A flash flood, also a freshwater source, is the fastest-moving type of flood; this hazard can fill a normally calm area with a rushing current in a relatively small amount of time. Flash floods in Guam are caused by heavy rain that is often, but not always, associated with a tropical cyclone. Flash floods occur when waterfalls too quickly on saturated soil or dry soil that has poor absorption ability. This water cannot be absorbed into the soil and therefore flows elsewhere.

The main defining characteristic of a flash flood is the timescale in which it develops; a flash flood generally develops in less than 6 hours. Flash flood waters also move at very fast speeds and have the power to move boulders, tear out trees, and destroy both buildings and transportation infrastructure. During a flash flood, walls of water can reach heights of 10 to 20 feet, scouring the walls of mountain streams. This combination of power and suddenness makes flash floods particularly dangerous.

Heavy, persistent rainfall on Guam is more often associated with slow-moving tropical cyclones than with fast-moving storms of comparable intensity. Many of the rain events on Guam occur from storms that are of less-than-typhoon intensity. The heaviest rains in typhoons occur in a concentrated area near the eye. Therefore, a typhoon needs to

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pass relatively close to an area for the area to receive the heaviest rains of the typhoon. Weaker storms are less organized than a typhoon, but heavy rains can extend farther from the center and can, therefore, have a broader sweep of heavy squalls than a typhoon. Monsoon surges can continually feed moisture into a tropical cyclone, or they can independently produce copious rains and flash floods on the island.

Rainfall is generally higher in mountainous areas than over flat terrain. For this reason, flash floods are generally constrained to the southern half of the island of Guam. Flash floods can occur when heavy rain (e.g., 2 inches per hour) falls for 1 hour or less or when heavy rain (e.g., 1 inch per hour) falls for more than 2 or more hours in mountainous areas. Even rainfall of 1 inch per hour for 1 hour or heavier rates of rainfall for shorter periods can cause drainage systems to overflow and force manhole covers to pop up, a hazard to both vehicles and pedestrians.

Location

Coastal Flooding: As shown in **Figure D-17**, the entire coast of Guam is susceptible to coastal flooding. Apra Harbor is particularly susceptible.

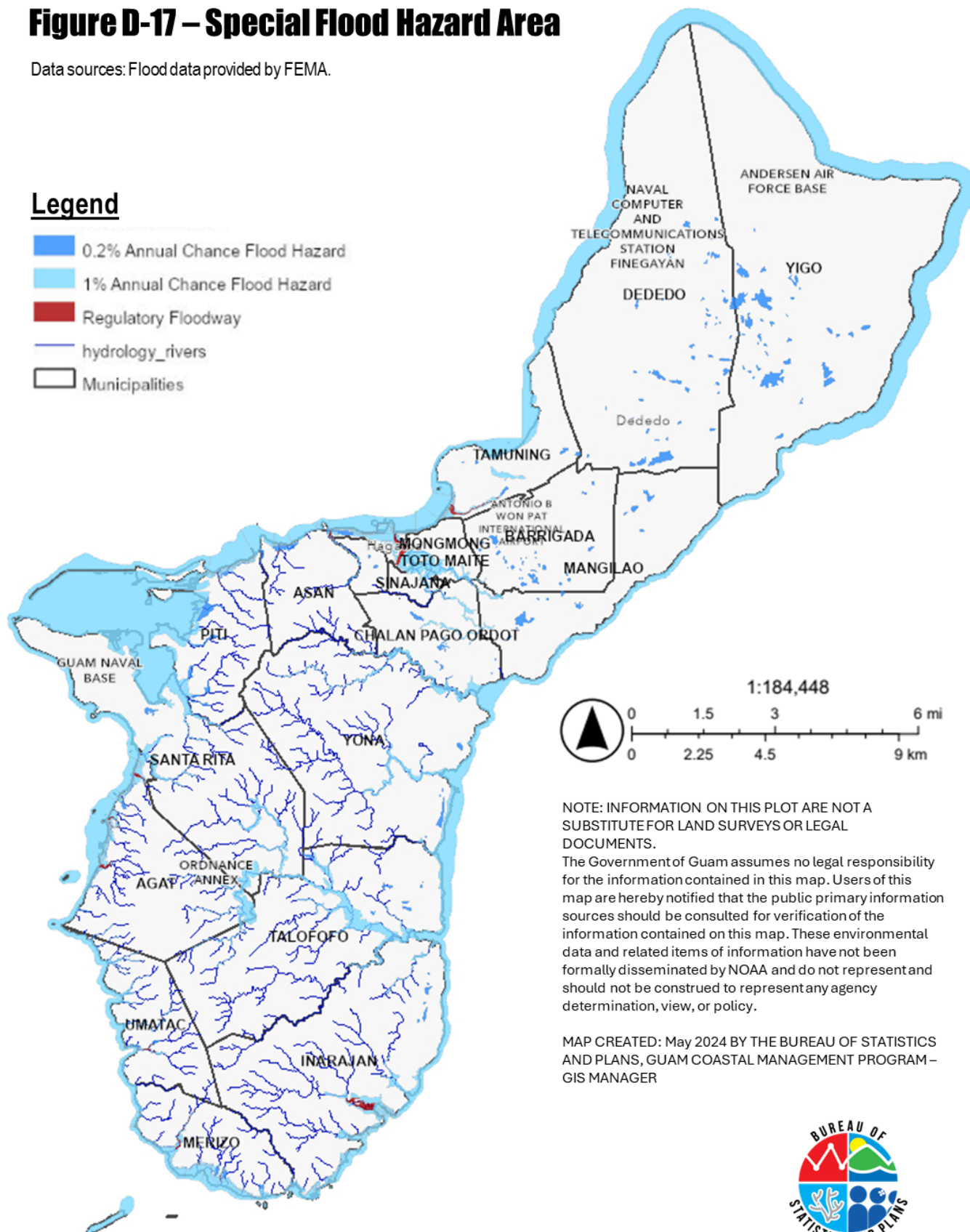
Riverine Flooding and Stormwater Runoff: As shown in **Figure D-17**, riverine flooding generally occurs in the southern portion of Guam, near the villages of Agat, Santa Rita, Talofofo, Inarajan, Merizo, Umatac. Some central locations, such as Maina and Chalan Pago are also susceptible to riverine flooding. Although stormwater runoff is recognized as a hazard, the areas subject to this type of sub hazards have not been well documented to date and are not identified on FIRMs because these events are typically relatively small in size and extent.

Flash Flooding: WERI has reported that flash floods occur in the mountainous areas of Guam, but no comprehensive data are available on the locations of past occurrences of flash flooding on Guam. However, return frequencies of various rainfall rates have been determined.

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Figure D-17 – Special Flood Hazard Area

Data sources: Flood data provided by FEMA.



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Previous Occurrences

Flooding on Guam occurs in a number of ways, and each may be affected by climate change. Surface water flooding occurs where heavy rainfall cannot absorb into the ground or drain away. River flooding, closely linked to surface flooding, occurs when streams burst their banks.

Coastal Flooding: Although previous occurrences of this hazard are not well documented, coastal flooding has been a significant and recurring hazard on Guam. The combination of heavy rains, storm surges, the presence of developed urban areas at low elevations along the coast, reef structure, and small bay entrances has produced frequent coastal flooding during tropical cyclones.

Table 29 shows the major typhoons passing near or over Guam from 1950 to 2013, with their modeled wave heights. The coastal inundation from Super Typhoon Yuri in November 1991, Typhoon Omar in August 1992, Typhoon Gay in November 1992, and Super Typhoon Pongsona in December 2002 has been well documented. Typhoon Omar and Typhoon Gay caused coastal inundation of 9 and 11 feet, respectively, above mean high tide in areas that were (and still are) developed at low elevations along the western coast. Super Typhoon Yuri caused near-historic inundation on Guam's eastern coast from Pago Bay at the northern end to the Saluglula Pools and the Tipoco Cemetery in Inarajan at the southern end. Super Typhoon Pongsona produced maximum coastal inundation of approximately 18 feet on coastal areas of eastern Guam. The coastal inundation associated with Typhoons Tingting and Chaba was estimated at 6 feet.

Coastal flooding has generally occurred in southern and eastern Guam along bays that have small restricted entrances that focus and contain the high water generated by the storm surge, wind-generated waves, and large upland discharges of heavy rains that result during tropical cyclones. Inarajan Bay, Talofofo Bay, Ylig Bay, and Pago Bay experience frequent coastal flooding along their adjacent uplands when tropical cyclones pass to the south of Guam. Seawater in Pago Bay is sometime driven over an elevated ridge of land to form an inland lake. During Super Typhoon Yuri, several houses floated off their foundations in this temporary coastal flood lake.

Table 29. Estimated Wave Heights of Tropical Storms and Typhoons at the Date of Maximum Impact on Guam, 1950–2019

Date	Name	Modeled Significant Wave Height (feet)
08/11/1951	Tropical Cyclone Marge	14
11/11/1962	Super Typhoon Karen	20
09/05/1964	Typhoon Sally	8
11/23/1968	Tropical Storm Ora	6
05/21/1976	Typhoon Pamela	23

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11/08/1977	Typhoon Kim	13
08/17/1979	Tropical Depression Judy	3
10/03/1983	Tropical Storm Mac	13
11/12/1984	Typhoon Bill	17
11/27/1991	Super Typhoon Yuri	30
08/28/1992	Typhoon Omar	18
10/21/1992	Typhoon Brian	11
11/23/1992	Typhoon Gay	15
12/16/1997	Super Typhoon Paka	22
12/08/2002	Super Typhoon Pongsona	25
01/18/2003	Tropical Storm Yanyan	9
04/14/2003	Super Typhoon Kujira	12
09/05/2003	Super Typhoon Maemi	8
06/27/2004	Typhoon Tingting	15
08/22/2004	Typhoon Chaba	15
09/20//2004	Typhoon Meari	6
10/12/2004	Typhoon Tokage	8
10/20/2004	Typhoon Nock-Ten	10
12/19/2004	Tropical Storm Noru	7
01/16/2005	Tropical Storm Kulap	6
05/31/2005	Tropical Storm Nesat	8
08/25/2005	Tropical Storm Talim	6

Table 30. Estimated Wave Heights of Tropical Storms and Typhoons at the Date of Maximum Impact on Guam, 1950–2019

Date	Name	Modeled Significant Wave Height (feet)
08/31/2005	Super Typhoon Nabi	9
08/05/2006	Super Typhoon Saomi	9
04/02/2007	Typhoon Kong-Rey	9
12/11/2008	Typhoon Dolphin	6

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10/15/2009	Super Typhoon Lupit	8
10/27/2009	Typhoon Mirinae	8
11/25/2009	Super Typhoon Nida	13
05/22/2012	Typhoon Sanvu	10
10/10/2013	Typhoon Wipha	8
10/16/2013	Super Typhoon Francisco	12
04/27/2014	Typhoon Tapah	7
07/03/2014	Super Typhoon Neoguri	7
07/12/2014	Super Typhoon Rammasun	8
07/30/2014	Super Typhoon Halong	8
10/05/2014	Super Typhoon Vongfong	15
03/15/2015	Tropical Storm Bavi	11
05/15/2015	Super Typhoon Dolphin	24
07/05/2015	Typhoon Chan-hom	12
08/02/2015	Super Typhoon Soudelor	6
08/15/2015	Typhoon Goni	13
10/16/2015	Typhoon Champi	12
11/20/2015	Typhoon In-Fa	20
08/23/2016	Tropical Storm Fourteen	4
09/09/2017	Typhoon Talim	3
10/24/2017	Typhoon Saola	6
07/04/2018	Super Typhoon Maria	13
08/15/2018	Typhoon Soulik	6

Table 31. Estimated Wave Heights of Tropical Storms and Typhoons at the Date of Maximum Impact on Guam, 1950–2019

Date	Name	Modeled Significant Wave Height (feet)
09/10/2018	Super Typhoon Mangkhut	18
09/20/2018	Super Typhoon Trami	6
09/29/2018	Super Typhoon Kong-Rey	8

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10/25/2018	Super Typhoon Yutu	27
02/23/2019	Super Typhoon Wutip	25

Sources: WERI 2019, NCDC 2019, NWS-WFO Guam 2019.

Riverine Flooding and Stormwater Runoff: The flood events on Guam reported in the National Climatic Data Center's (NCDC's) Storm Event Database are attributed to localized heavy rainfall events from monsoon surges, tropical cyclones, or a combination of the two. In addition to coastal flooding (addressed in the preceding section), flooding on the island also occurs in riverine areas and urban areas. In 1975 and 1976, several flood hazard studies were completed to provide site-specific flood information at the following locations:

- Agana River
- Agat Area
- Asan Area
- Geus River
- Inarajan River
- Asso River
- Pago River
- Salinas River
- Tamuning Area
- Umatac River
- Ylig River

Individual flood hazard studies were prepared to provide information on flood potential and flood hazards at various locations. Each report includes a history of past floods in the area and identifies areas that are subject to flooding in the future. It does not include solutions to address flood problems, however.

The 1980 Guam Comprehensive Study resulted in two documents: 1) Flooding and Drainage on Guam, a reference handbook of basic information regarding Guam's precipitation, streamflow and related hydrologic data, and 2) the Guam Storm Drainage Manual, a design manual of policies, standards, and design criteria for storm drainage facilities.

In 1982, USACE completed the report Alternative Solutions for Flood Prone Areas in Guam to provide the Government of Guam with comprehensive alternative plans for those areas planned for development. This study establishes design criteria for drainage areas, specifies capacity, types, and locations for drainage facilities includes preliminary cost estimates, and suggests legislation for floodplain regulation. Individual areas studied include Agat, Umatac, Merizo, Inarajan, and Agana.

In 1983, USACE completed another report with the same title, Alternative Solutions for Flood Prone Areas in Guam, to aid the Government of Guam in resolving the flood and drainage problems in Santa Rita, Yigo, and Dededo.

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In June 2003, the Water and Environmental Research Institute of the Western Pacific (WERI) at the University of Guam published Technical Report No. 102, Creation of a 50-Year Rainfall Database, Annual Rainfall Climatology, and Annual Rainfall Distribution Map for Guam. The report includes an annual rainfall distribution map for Guam (see Figure 1-1) that visually identifies the rainfall maxima and minima on the island. It also concludes that, unlike the Hawaiian Islands, the topography of Guam has little effect on rainfall during major precipitation events (such as during a typhoon).

Preliminary regional flood frequency regression equations were developed in 2010 by USACE to estimate peak flow for a particular frequency event at ungaged sites in southern Guam. These equations were derived from 14 USGS stream gages with 10 or more years of record and are applicable for southern Guam watersheds with drainage areas between 0.28 square miles (mi²) and 7.13 mi². Flood frequency analysis of data at each stream gage was run using Bulletin 17B procedures with a generalized skew of 0.50 having a mean square error of 0.174. The equations developed are below:

$Q_2 = 729 (DA^{0.843})$ $Q_5 = 1,160 (DA^{0.846})$ $Q_{10} = 1,360 (DA^{0.849})$ $Q_{20} = 1,700 (DA^{0.854})$ $Q_{50} = 2,210 (DA^{0.860})$

$Q_{100} = 2,640 (DA^{0.864})$ $Q_{200} = 3,770 (DA^{0.870})$ $Q_{500} = 3,860 (DA^{0.877})$

Where Q_x = recurrence interval in years and DA = drainage area in square miles

A GIS-Based Watershed Management Plan for the Piti-Asan Watersheds, published in October 2012 through WERI as Technical Report No. 139, evaluates existing and future conditions of the Piti and Asan watersheds and recommends various management strategies to address soil erosion issues. These challenges and recommendations were important to keep in mind during the development of our recommendations to address the issue of riverine flooding.

Predictions of Flow Duration Curves at Ungauged Sites in Guam, published in January 2015 through WERI as Technical Report No. 154, estimates the average flow for gauged and ungauged sites in Guam. This data can be used to represent the baseflow in the hydraulic model.

Typhoon Chata'an was recorded to have delivered rainfall totals that exceeded 21 inches over the mountainous areas of southern and central Guam. Flooding and siltation occurred in Fena Reservoir during this event; as a result, there was a lack of potable water for several days. This storm also caused flooding in southern Guam that resulted in numerous landslides and severe erosion along watercourses. All the stream-gauging stations operated by the U.S. Geological Survey (USGS) were damaged or destroyed during these floods. Peak flows in many rivers in southern Guam reached record levels during this storm. Four of the nine gauging sites had water elevation recurrence intervals that were determined to be greater than the 100-year flood level. A river gauge on the Ylig River recorded a peak height of 23.45 feet, which was 4.82 feet higher than the previous maximum level recorded in 1953. The Fena Reservoir level was 5.36 feet above the spillway crest and 0.86 feet higher than the previous maximum recorded level in 1953. The northern part of Guam received less than 10 inches of rain, and the central part of the island received 10 to 13 inches. Recorded rainfall totals were

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determined to be less than what was actually received because severe winds caused water to be sucked out of gauges or the gauges did not catch the rain well when the rainfall was occurring along a horizontal plane due to severe winds.

Few direct historical accounts of flooding on Guam exist for events before 2002, so the most useful historical information about floods on Guam can be obtained by examining historical rainfall events. Large rainfall events on Guam are generally attributed to tropical cyclones that move slowly across the island. In 1976, Typhoon Pamela dropped over 27 inches of rain in 24 hours as it moved across the island at 7 mph. Over half of the heaviest rain events on Guam occur from weak tropical cyclones or monsoon surges. The highest recorded hourly rain rate was from Super Typhoon Pongsona, which delivered 7.22 inches per hour in the eyewall cloud. It is believed that many of the intense typhoons and super typhoons that have crossed Guam, such as Typhoon Pamela and Super Typhoon Karen, have delivered large quantities of rain that were under-recorded due to rain gauge destruction, malfunction, or power outage. Most recently, Typhoon Tinting delivered a recorded 16 inches in a 24-hour period on June 27, 2004. Typhoon Chaba produced heavy rains with a peak 24-hour total of 9.05 inches.

The one recorded event of flooding from stormwater runoff on Guam occurred in August 1984; the flooding occurred after a rainfall of 15.18 inches was recorded. The Governor of Guam issued an emergency declaration that noted that flooding in the Fineli Beach Area of Agat occurred as a result of stormwater runoff from higher areas. This is a common occurrence when the coastal waters are elevated, and rainfall cannot run back into the open ocean.

Many urban storm drains are overwhelmed if rainfall exceeds a rate of 1 inch per hour. Such rainfall rates can occur on Guam during strong monsoon surges and tropical cyclones. Rainfall rates during typhoons and super typhoons often exceed 4 to 5 inches of rainfall per hour at their peak of rainfall intensity. Poor storm drain conveyance in conjunction with storm surges can exacerbate coastal flooding. No street flooding data are readily available for Guam. In built-up areas generally subjected to coastal flooding, street flooding, and coastal flooding are generally inseparable events.

Flash Flooding: Flash floods in Guam are poorly documented; no comprehensive record of these events in Guam is available. However, a few occurrences of flash flooding have been noted. In 1999, the Red Cross responded to a flash flood, providing assistance to 14 families. The most significant flash flooding event occurred in June 2004, during Typhoon Tinting. Typhoon Tinting was still a tropical storm when it passed over Guam, but it brought record-breaking rainfall to Guam. In 24 hours, 21.85 inches of rain fell on Guam; this rainfall shattered both the record for highest single-day rainfall on Guam and the record for the highest monthly rainfall for June. Although over 20 inches of rain fell in 24 hours over much of Guam during this event, rainfall was somewhat less over the northeastern portion of Guam where 11.33 inches fell at Andersen Air Force Base in 30 hours. These extreme levels of rainfall caused island-wide flash floods and mudslides, road closures, and inundations.

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Although the flash flooding event in 2004 caused much damage for Guam, this type of event is not common. WERI has reported that flash floods generally occur in the mountainous areas of Guam and do not result in significant damage.

The distribution of rainfall on Guam is mixed; the events that produce more than 10 inches of rain per day come from near-direct or direct passages of tropical cyclones. According to a 2004 WERI report, the maximum rainfall rate observed in the eye-wall cloud of typhoons affecting Guam was measured in Typhoon Pongsona (2002) at about 0.12 inches/minute over 60 minutes or about 7.22 inches per hour. However, rainfall rates could be somewhat higher during stronger typhoons or during comparable typhoons passing over the more mountainous terrain of central Guam. This likelihood is reflected in the increasing rates with respect to return periods (**Tables 32 and 33**). For events producing less than 10 inches per day, the source may be peripheral thunderstorms of more distant tropical cyclones, island-induced thunderstorms, or thunderstorms advected into Guam. These events are most commonly associated with upper cold low-pressure systems embedded in the Tropical Upper Tropospheric Trough (a common feature of the summer troposphere in the western North Pacific Ocean). These events are more short-lived than typhoon events, but can have higher, short-term intensities.

Table 32. Rainfall for Typhoon Eye-Wall (inches)

Return Period	1-minute	5-minute	10-minute	15-minute
2-year	0.09	0.45	0.90	1.35
5-year	0.10	0.50	1.50	1.50
10-year	0.11	0.55	1.10	1.65
15-year	0.12	0.60	1.20	1.80
25-year	0.13	0.65	1.30	1.95
50-year	0.14	0.70	1.40	2.10
100-year	0.16	0.80	1.60	2.40

Rainfall amounts in inches for Typhoon Eye-Wall occurrences for the designated time periods and the designated return periods.

Table 33. Rainfall for Non-Tropical Cyclone Thunderstorms (inches)*

Return Period	1-minute	5-minute	10-minute	15-minute
2-year	0.10	0.50	0.89	1.25
5-year	0.12	0.60	1.07	1.50
10-year	0.14	0.70	1.24	1.74
15-year	0.15	0.75	1.33	1.86
25-year	0.16	0.80	1.42	1.99
50-year	0.18	0.90	1.60	2.24
100-year	0.20	1.00	1.78	2.49

Rainfall amounts in inches for Non-Tropical Cyclone Thunderstorms for the designated time periods and the designated return periods.

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*Table slightly modified based on personal communication with Dr. Bill Merkel and Dr. Merkel's draft Rainfall- Frequency tables for Guam and the CNMI.

Probability of Future Events

Coastal Flooding: Coastal flooding on Guam is mainly caused by storm surges associated with tropical storms. On average, three tropical storms and one typhoon pass within 180 nautical miles of Guam each year.

Riverine Flooding and Stormwater Runoff: On Guam, riverine flooding is typically caused by prolonged periods of rainfall from slow-moving tropical cyclones or monsoon surges during the wet season (June – December). As noted above, on average, three tropical storms and one typhoon pass within 180 nautical miles of Guam each year.

No methodology has been employed to quantitatively determine the frequency of flooding on Guam due to stormwater runoff. To a certain extent, the probability of flooding due to stormwater runoff can be based on the designed conveyance capacity of a stormwater facility and the system's ability to prevent sediments from settling at drains.

Guam is updating its Comprehensive Flood Mitigation study and anticipates a high probability of flooding impacts in the future. Hagatna River, Manell watershed, upper Namo River (Santa Rita), and Umatac River remain a high priority flood mitigation area of Guam.

Flash Flooding: High levels of rainfall are common on Guam, but flash floods require high levels of rainfall in very short periods. Flash flooding is most likely to occur during the wet season (June – December) when westerly moving storm systems bring heavy showers or steady and sometimes torrential rain.

Summary of Potential Impacts

The 2007 Guam FIRM was used to determine the Special Flood Hazard Area (SFHA). As such, the population on Guam that is located in the 100-year floodplain consists of 7,519 people (4.74 percent), as shown in Table F-9 (Appendix F [Vulnerability Analysis Results by Village]). The percentage of people in this hazard area is nearly the same as in previous versions of the HMP. A similarly small proportion of Guam's GBS is exposed to the floodplain with 1,373 buildings (5.5 percent), worth \$381.9 million. A larger portion of EFMUTS is exposed with 79 facilities (16.8 percent), worth \$211.5 million.

A large portion of the exposed EFMUTS facilities are located adjacent to Apra Harbor and are a part of the port facilities. As such, a total of 277 facilities (30.8 percent) in Transportation Systems, worth \$946.8 million, are exposed to a flood. Though it is unlikely that a flood would completely destroy some of the large facilities at the port, such as the cranes used to load and unload cargo, the potential exposure of these facilities to flood shows that a flood could affect the regular functions of these facilities. If a flood affects the functions at the port in Apra Harbor, the movement of goods on and off the island would be affected. A value for the normal and daily functions of these

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facilities has not been assessed for this analysis, but disruption of these functions would be a potential secondary effect of this hazard event.

In terms of village-level population exposure, as shown in Tables F-9 and F-10, Tamuning/Tumon has 1,738 people (9.65 percent of the village population) residing in the SFHA while Mongmong-Toto-Maite has 1,092 people (18.68 percent of the village population).

Exposure of the EFMUTS is concentrated in Hagatna with 28 facilities (mostly Essential Facilities) worth \$26.0 million. Tamuning/Tumon follow with 14 exposed facilities each, worth \$110.5 million.

Hagatna has 216 GBS structures (64.0 percent of the village GBS), worth \$138 million, that are exposed to a flood hazard. Agat has 364 exposed structures (26.7 percent of the village GBS) with a value of \$31.0 million. Merizo has 372 exposed structures (55.2 percent of the village GBS), and their value is \$30.6 million. Only 6 building permits were issued for Hagatna, 7 building permits in Agat in 2018, and no building permit was issued in Merizo during this time period.

Table F-9 Total Affected by Flooding			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	78	0	0	0	0	11	16,796	0	0
Agat	2.19	443	10	57,457,190	2	2,530,333	33	3,551,918	419	56,186,930
Asan/Maina	2.66	45	0	0	0	0	12	8,508,542	15	2,322,196
Barrigada	2.12	10	0	0	0	0	0	0	3	687,707
Chalan Pago-Ordot	0.74	420	1	372,103	4	4,184,606	9	3,128,809	14	2,302,396
Dededo	2.56	99	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	703	28	26,304,004	2	13,204,685	46	33,864,514	216	138,189,037
Inarajan	6.11	180	7	2,409,492	3	2,916,318	31	34,493,846	98	11,296,098
Mangilao	0.81	194	0	0	0	0	0	0	3	697,245
Merizo	1.74	297	2	434,760	10	12,658,544	27	9,213,354	210	24,255,581
Mongmong- Toto-Maite	0.51	1,092	0	0	0	0	0	0	14	4,206,933
Piti	1.17	245	11	11,487,965	2	51,696,674	30	816,377,090	146	31,330,230
Santa Rita	4.19	722	0	0	0	0	4	82,623	32	4,558,600
Sinajana	0	576	0	0	0	0	0	0	35	4,936,362
Talofofo	5.15	215	1	371,960	0	0	17	65,213	21	3,223,681
Tamuning/Tumon	1.74	1,738	14	110,436,962	3	4,992,823	13	11,884,489	127	95,141,724
Umatac	2.28	43	3	1,269,532	1	1,268,219	20	8,518,633	13	1,379,572
Yigo	7.48	152	0	0	0	0	0	0	0	0
Yona	3.61	266	2	742,786	0	0	23	17,059,291	6	1,235,162
Total	45.86	7,519	79	211,286,753	27	93,452,202	277	946,765,118	1,373	381,949,453

Table F-10 Proportion Affected by Flooding	Essential Facilities	Major Utilities	Transportation Systems	GBS

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Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	1.94	1.97	0	0	0	0	100	7.92	0	0
Agat	7.82	7.83	45	84.01	22.2 2	5.17	100	86.98	26.5 3	26.53
Asan	2.12	2.15	0	0	0	0	66.6 7	67.83	3.06	3.06
Barrigada	0.12	0.12	0	0	0	0	0	0	0.07	0.07
Chalan Pago-Dededo	7.08	7.09	12.5	3.64	21.0 5	16.13	28.5 7	14.56	2.02	2.02
Hagatna	0.23	0.23	0	0	0	0	0	0	0	0
Inarajan	63.53	63.94	62.5	58.24	50	95.39	80	73.1	64.0 1	64.01
Mangilao	5.87	5.9	46.6 7	7.68	17.6 5	3.49	83.3 3	97.35	15.6 6	15.66
Merizo	1.46	1.46	0	0	0	0	0	0	0.25	0.25
Mongmong-Piti	13.73	13.73	20	6.68	62.5	46.6	100	96.48	55.1 9	55.19
Santa Rita	18.68	18.68	0	0	0	0	0	0	3.64	3.64
Sinajana	14.69	14.72	57.8 9	60.27	15.3 8	9.2	72.7 3	88.03	27.9 9	27.99
Talofofo	9.62	9.63	0	0	0	0	20	0.69	7.29	7.29
Tamuning/Umatac	20.22	20.18	0	0	0	0	0	0	1	1
Yigo	6.69	6.69	12.5	8.61	0	0	100	7.12	2.16	2.16
Yona	9.65	9.65	18.0 7	13.53	13.0 4	3.37	10	12.26	8.06	8.06
	4.76	4.86	33.3 3	25.97	5.26	1.35	66.6 7	47.69	9.47	9.47
	0.78	0.78	0	0	0	0	0	0	0	0
	4.1	4.1	16.6 7	0.69	0	0	75	78	0.37	0.37

RL properties are properties that suffer from repeated flooding. FEMA defines an RL property as a property with at least two \$1,000 claims within any 10-year period since 1978. Table 5-19c and Figure D-30 show that as of June 30, 2012, there are 15 RL properties in Guam. As of April 30, 2019, and for the 2014 Guam HMP, there were 16 RL properties on Guam. No actions have been taken to mitigate these properties to date. There were attempts to elevate certain RL properties. However, due to the type of building construction on Guam, they were not cost efficient. However, a mitigation action has been included for this Guam HMP to address RL properties (see Section 6.5 [Mitigation Actions] for additional information).

Table 34 demonstrates repetitive loss properties that reflect the extent of flooding vulnerabilities in Guam. As of June 30, 2024, Guam has 17 repetitive loss buildings, with only two insured. These RL buildings have suffered a total of 35 losses, with 1 of these losses being insured. The total loss from these buildings is approximately \$606,040, with \$43,845 of this amount being insured. Notably, there are no properties with four or more losses, but there is one with 2 to 3 losses exceeding its total value, which is not insured. The data underscores the importance of addressing flood mitigation measures to reduce these properties' financial and structural impacts. Some notable properties with repetitive losses are located in Agat, Merizo, Piti, and Tumon,

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highlighting specific areas within Guam that are more prone to repetitive flooding incidents.

Guam Repetitive Loss Community Summary, as of May 7, 2024

The data on this report contains repetitive loss properties only. Mitigated properties (properties that are no longer repetitive) are not included in the counts.

Table 34. Repetitive Loss Properties

	AE, A1-30, AO, AH, A	VE, V1-30, V	B, C, X	TOTAL
RL Buildings (Total)	12	0	5	17
RL Buildings (Insured)	0	0	1	1
RL Losses (Total)	27	0	8	35
RL Losses (Insured)	0	0	2	2
RL Payments (Total)	\$462,665.57	\$0.00	\$251,151.66	\$713,817.23
Building	\$396,353.24	\$0.00	\$209,686.96	\$606,040.20
Contents	\$66,312.33	\$0.00	\$41,464.70	\$107,777.03
RL Payments (Insured)	\$0.00	\$0.00	\$85,310.18	\$85,310.18
Building	\$0.00	\$0.00	\$43,845.48	\$43,845.48
Contents	\$0.00	\$0.00	\$41,464.70	\$41,464.70

Post - FIRM SFHA RL Buildings: 0

Insured Buildings with 4 or More Losses: 0

Insured Buildings with 2-3 Losses > Building Value: 1

Total Target RL Buildings: 1

Table 35 provides a detailed account of the repetitive loss properties in Guam, showing the property locations, types, flood insurance status, and the number of losses. Most of these properties are single-family homes, with several located in Agat, Piti, and Tamuning/Tumon. Some properties, such as those in Agana and Merizo, have suffered multiple losses and are situated in the Special Flood Hazard Area (SFHA). The detailed breakdown highlights the critical need for targeted flood insurance and mitigation efforts in these vulnerable locations to safeguard residential properties from future flood damage.

Table 35. Repetitive Loss Properties Guam Repetitive Loss Properties, as of April 30, 2019

Property Locator	Property Location	Most Recent Date of Loss
33033	Homigneros Maya	10/7/1985
95517	Old Agat	12/15/1997

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105261	Merizo	7/30/1999
119361	Piti	12/8/2002
119363	Agat	7/5/2002
122527	Tumon	12/8/2002
	Tumon	12/8/2002
	Tumon	12/8/2002
122528	Sinajana	12/8/2002
	Chalan Pago	12/8/2002
	Sinajana	11/27/1991
	Sinajana	11/27/1991
122529	Dededo	12/16/1997
	Tamuning	12/7/2002
	Tamuning	12/16/1997
122532	Inarajan	12/8/2002
122728	Tumon	12/8/2002
122731	Agat	8/15/2011
122733	Agat	12/8/2002
122734	Piti	12/8/2002
122738	Apurguan	12/8/2002
128732	Umatac	6/18/2004
136741	Agat	10/12/2004
212572	Agana	9/10/2018
	Agana	8/28/2011
237864	Agat	9/19/2013

Source: FEMA NFIP 2024.

Table 36 shows that from 1995-2024, Guam had 17 repetitive loss properties. These properties had not undergone significant mitigation to prevent further losses. The data indicates that, despite the recognition of repetitive loss properties over the years, comprehensive and cost-effective mitigation strategies were not fully implemented due to the unique building constructions in Guam. This underscores the ongoing challenge of effectively addressing repetitive flood loss properties and improving flood management practices to protect these vulnerable assets from repeated flood damage.

Table 36. Repetitive Loss Properties Guam Repetitive Loss Properties, as of 2012

Village	Occupancy 1	Flood Insurance	Number of Losses	SFHA
OLD AGAT	2-4 FAMILY (OLD METHODOLOGY)	NO	2	A01
MERIZO	SINGLE FMLY (OLD METHODOLOGY)	NO	2	AE
PITI	SINGLE FMLY (OLD METHODOLOGY)	NO	3	A04

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AGAT	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A
TAMUNING	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A
CHALAN PAGO	SINGLE FMLY (OLD METHODOLOGY)	YES	2	X
TAMUNING	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A
INARAJAN	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A06
TUMON	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A
AGAT	SINGLE FMLY (OLD METHODOLOGY)	NO	3	A02
AGAT	SINGLE FMLY (OLD METHODOLOGY)	NO	2	A04
PITI	OTHR-NONRES (OLD METHODOLOGY)	NO	2	A
APURGUAN	SINGLE FMLY (OLD METHODOLOGY)	NO	2	B
UMATAC	SINGLE FMLY (OLD METHODOLOGY)	NO	2	B
AGAT	SINGLE FMLY (OLD METHODOLOGY)	NO	2	
AGANA	SINGLE FMLY (OLD METHODOLOGY)	NO	3	A
AGAT	SINGLE FMLY (OLD METHODOLOGY)	NO	2	X

Source: FEMA SQANet 2024.

Jurisdictions' Vulnerability

Table 37 Some villages in Guam are particularly vulnerable to flooding based on their SVI, which measures community resilience to disasters. Villages such as Agat (SVI: 1.00), Merizo (SVI: 0.94), and Hagatna (SVI: 0.89) have high SVI scores, indicating higher vulnerability to flooding events. These villages have significant portions of their populations exposed to flooding risks. For example, Hagatna has 57% of its population classified as vulnerable, making it extremely susceptible to flooding. Other highly vulnerable villages include Mongmong-Toto-Maite, with an SVI of 0.83 and 16% of its population exposed, and Dededo, with an SVI of 0.78, substantial population and critical facilities at risk.

Flooding poses significant threats to both populations and structures in these vulnerable jurisdictions. Socially vulnerable and underserved communities, such as the elderly, young children, and those living in poverty, are at higher risk during flooding events due to mobility issues, health vulnerabilities, and limited resources for evacuation and recovery. For instance, Agat and Merizo have substantial vulnerable populations at increased risk during flood events.

Protecting critical infrastructure is not just a matter of convenience but a necessity to ensure the safety and well-being of our communities. Villages such as Dededo and Mangilao host significant critical facilities, are at high risk, and require robust infrastructure improvements to mitigate flooding risks. Enhancing communication and disaster preparedness in high SVI areas, such as Agat and Merizo, is crucial for improving community resilience to flooding. Investing in resilient infrastructure in these vulnerable villages will help mitigate the flooding risks and protect the population and vital structures.

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Table 37

Village	Village SVI	Vulnerable Exposed	Vulnerable Exposed
Agana Heights	0.28	22	1%
Agat	1	443	8%
Asan/Maina	0.11	5	0%
Barrigada	0.44	5	0%
Chalan Pago-Ordot	0.33	139	2%
Dededo	0.78	77	0%
Hagatna (Agana)	0.89	626	57%
Inarajan	0.39	70	2%
Mangilao	0.72	140	1%
Merizo	0.94	279	13%
Mongmong- Toto-Maite	0.83	906	16%
Piti	0	0	0%
Santa Rita	0.06	43	1%
Sinajana	0.56	322	11%
Talofofo	0.22	47	1%
Tamuning/Tumon	0.17	295	2%
Umatac	0.67	29	3%
Yigo	0.61	93	0%
Yona	0.5	133	2%
Total		3,674	

Summary of Recent and Project Developments in the Hazard Prone Area

Guam is experiencing ongoing and projected developments that could significantly affect flood hazards. The island's flood hazard profile highlights several areas of concern based on territorial and local government risk assessments. Recent developments in Guam have led to changes in land use and the built environment, particularly in flood-prone areas. Villages such as Hagatna, Agat, and Merizo have substantial portions of their built environment within the SFHA. For instance, Hagatna has 402 structures (64% of the village's general building stock) exposed to flood hazards, worth approximately \$139.8 million. Similarly, Agat and Merizo have 364 and 372 structures exposed, respectively. This structure increase within flood-prone areas necessitates enhanced flood mitigation strategies to reduce potential damage and loss.

Also, changes in population demographics in Guam impact vulnerability to flood events. Villages like Mongmong-Toto-Maite and Tamuning/Tumon have increased significantly, well above the island average from 2000 to 2010. Mongmong-Toto-Maite's population increased by 16.8%, and Tamuning/Tumon's by 9.3%. Additionally, villages with high SVI scores, such as Agat (SVI: 1.00) and Merizo (SVI: 0.94), have substantial vulnerable populations exposed to flood hazards. For instance, 21% of Agat's and 27% of Merizo's populations are classified as vulnerable. These demographic changes emphasize the need for targeted interventions to protect socially vulnerable and underserved communities from flooding.

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Territorial assets, including essential facilities and infrastructure, are increasingly vulnerable to flood hazards. Hagatna has 35 essential facilities worth \$26.0 million exposed to flood hazards, while Piti and Tamuning/Tumon each have 21 exposed facilities, with Piti's valued at \$99.0 million and Tamuning/Tumon's at \$73.8 million. The concentration of essential facilities in flood-prone areas stresses the critical need for resilient infrastructure to ensure the continuity of essential services during flood events.

New developments in Guam have increased the risk of flooding in existing high-risk jurisdictions. For instance, constructing new residential and commercial buildings in villages such as Dededo and Tamuning/Tumon, among the highest in building stock and value, adds to the flood risk. The average value of a building in Guam has significantly increased, highlighting the economic impact of potential flood damage. Additionally, infrastructure projects, such as relocating the Ukudu Power Plant from a coastal flood zone to a less vulnerable area, demonstrate efforts to mitigate flood risks. However, the continued development in flood-prone regions necessitates comprehensive flood management and mitigation strategies to protect these investments.

Guam's flood hazard profile and recent development trends indicate a growing need for enhanced flood mitigation and management strategies. The increasing population and infrastructure exposure to flood hazards and projected climate change impacts highlight the urgency of implementing resilient and adaptive measures to safeguard vulnerable communities and critical territorial assets. By addressing these vulnerabilities through informed planning and investment in flood defenses, Guam can better prepare for and mitigate the impacts of future flood events.

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5.5.6 High Surf

Nature

Ocean swells, rough seas, and surf are caused by the fetch of the wind, that is, the area over which a strong wind blows. Swells become fully developed after the wind blows over sufficient fetch length (roughly greater than 500 miles) for about 24 to 36 hours. Generally, islands in the western Pacific Ocean receive large ocean swells and high surf from the fetch of the wind of nearby tropical cyclones, monsoon surges, and/or distant tropical and extratropical cyclones. These waves can be over 30 feet in height. On islands surrounded by reefs, high surf hazards are often coupled with extremely strong rip current hazards such as seawater and breaks on the reefs, interacts with the coast and rapidly flows through the channels back into the open ocean. Tropical cyclones create swells that emanate from the region just outside the cyclone's center or eye. The swells associated with a cyclone generally arrive at a location up to a couple of days ahead of the actual storm. The ocean swell and the high waves at a location increase in size as the storm gets closer. Larger tropical cyclones produce larger swells due to the larger fetch length and width. For storms that pass over or near to an island, the specific locations where devastating waves occur depend on the direction the tropical cyclone is traveling and the track that the storm takes.

Although the hazard of high surf is often associated with tropical cyclones, high surf is not only associated with tropical cyclones. Generally, four sources other than nearby tropical cyclones can lead to high surf:

- Swells or a combination of swells and wind waves from easterly trade winds. These generally occur in winter and spring.
- Swells or a combination of swells and wind waves from westerly monsoon winds. These generally occur in summer and fall.
- Swells from distant winter storms near Japan, which occur primarily in winter and spring.
- Swells from slow-moving typhoons that are less than 300 nautical miles away.
- Strong monsoon surges can last from a few days to more than 2 weeks. The persistent southwestern winds of a monsoon surge can produce a long fetch, generating large ocean swells and high surf when they reach land.
- Swells caused by monsoon surges can combine with swells generated by tropical cyclones; the result can be amplified swell sizes and even higher surf. Generally, this event occurs when a large swell from a monsoon surge travels through the periphery of a tropical cyclone.

The western North Pacific Ocean is susceptible to large ocean swells that have been generated from distant tropical cyclones that will not come near the area. Most commonly these swells occur with large, intense, slow-moving tropical cyclones that take a track west of Guam and south of Japan. These storms generate large swells that can come as a surprise because no nearby storm is associated with the high surf.

Location

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Tropical cyclones that pass north of Guam generally produce high waves on the northwest coastlines. Tropical cyclones that pass to the southwest or the west of the island can produce high surf and rough seas on the southern and western coasts. A tropical cyclone approaching from the southeast produces hazardous waves on the east and southeast sides of Guam. Westward-moving storms produce the highest surf on the northeast side of the island if they pass over or to the south of the island. Rapidly moving tropical cyclones that pass north of Guam generally, do not produce damaging swells on the western side of Guam.

Previous Occurrences

Large ocean swells from passing and distant cyclones, monsoon surges, and trade winds have resulted in hazardous high surf on all coasts of the island. According to the NCDC's Storm Event Database, between 2003 and 2013 high surf, rip currents, and rough seas resulted in 35 deaths and 41 injuries in Guam. Five of these fatalities occurred on June 29, 2004, when three kayaks were overturned by high surf related to Typhoon Tingting, which had passed the Mariana Islands the day before (440 miles north-northwest of Guam).

High surf events can lead to strong rip currents and drownings and to coastal run-up, inundation, coastal erosion, and property damage. Run-up refers to the vertical height of the saltwater on what is normally dry land and inundation referring to the inland distance of the saltwater. High surf (that triggers advisories) in Guam is defined as 9 feet or greater on north, west, and south exposures and 12 feet or greater on eastern exposures. Fifteen (15) feet on any exposure triggers a high-surf warning. Advisory events can last from 2 to 10 days (average duration is 4 days), and warning events can last from 1 to 3 days. Worst conditions usually occur during a new or full moon. The number of days of high surf is not as critical as the number of high-surf events for property damage because it only takes one short period of flooding to cause property damage.

Duration is important for impacts on coastal erosion. **Table 38** shows the estimated monthly frequency of high-surf events requiring advisories or warnings.

Table 38. Estimated Monthly Frequency of High Surf Event Advisories/Warnings

Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
3/1	3/1	3/1	1/0	0/0	0/0	1/0	2/0	3/1	3/1	2/1	3/1	24/7

Source: NCDC 2000.

Super Typhoon Paka, which passed directly over Guam, produced waves ranging from 6 to 30 feet along the northern coast, the entire western coast, and the entire southern coast of Guam. Super Typhoon Pongsona produced waves that were estimated to have been 25 to 30 feet on the high sea cliffs of northeast Guam. Several occurrences are documented in which the rough seas associated with typhoons that have affected the island have damaged sewage outfall structures, which channel sewer water (with solids removed) to the open ocean. These events have caused treated sewage to drain into the sea at locations much closer to the coastline than the locations of the outfall structures. Damage to outfall pipes occurred during Typhoon Pamela in 1976, Typhoon

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Dale in 1996, and Super Typhoon Paka in 1997. Ocean swells caused by monsoon surges can generate high seas and surf as high as 18 to 30 feet. These waves affect the western coast of Guam and have been known to cause coastal erosion and prevent ships from entering or leaving Apra Harbor for long periods. A large wave event between August 11 and 13, 1974, caused by a strong monsoon surge resulted in the sinking of a 700-foot, 40,000-ton passenger liner at the mouth of Apra Harbor. The ocean liner was being towed by an ocean tug to Taiwan for scrap metal when it sunk near the mouth of the harbor. This multi-day high-surf hazard resulted in more than \$4 million in damage. The high surf events that struck Guam during Typhoon Andy in 1982 and Typhoon Dale in 1996 were believed to have been produced by a combination of monsoon-surge-generated ocean swells and swells generated by the typhoons after they had passed to the west of Guam. The high surf from both of these storms caused large amounts of coastal erosion. The waves from Dale threw large boulders up on the Navy housing area at the Orote Point (80-90 ft. high).

Probability of Future Events

As discussed above, high waves in Guam are produced by multiple climatic events. High-wave events with a recurrence interval of less than 20 to 25 years that affect the reefs and open bays on the western side of the island are generally produced by monsoon surges. High waves in this same area with a return period that is greater than 25 years are generally generated by typhoons with a wind intensity of 125 mph or greater. **Table 39** illustrates the probability, as calculated by WERI (1999), for waves to affect Guam.

High-wave events along the west-side cliffs are generally produced by monsoon surges up to the point of the 50-year recurrence event, where typhoons again become the dominant high-wave generators for larger-magnitude events.

Table 39. Average Recurrence Interval for High Surf on Guam

Average Return Period (Years)	Wave Heights (feet) On East-Side Cliffs	Wave Heights (feet) on East-Side Bays/Reefs	Wave Heights (feet) On West-Side Cliffs	Wave Heights (feet) on West-Side Bays/Reefs
1.0	10	1/<1	-	-
2.0	12	3/1	15	3/1
4/0	15	4/2	20	4/2
10	20	7/4	30	7/4
20	25	10/6	33	10/6
25	27	11/7	35	10/6
50	37	15/9	40	13/8
60	38	17/11	42	14/9
80	40	19/13	44	17/11
100	42	21/14	45	18/12
150	45	22/15	46	19/13
200	47	23/16	47	21/14
300	50	25/16	50	22/15
400	52	28/17	50	24/16
500	54	30/18	50	25/16

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600	55	>30/>18	50	27/17

Note: Calculated recurrence intervals included high surf produced by trade winds (waves affecting east-side cliffs) and monsoon induced waves (waves affecting the western side of the island).

Source: WERI 1999.

Summary of Potential Impacts

Amount			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	2.19	443	10	57,457,190	2	2,530,333	33	3,551,918	419	56,186,930
Asan/Maina	2.66	45	0	0	0	0	12	8,508,542	15	2,322,196
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	0	0	0	0	0	0	0	0	0
Dededo	2.56	99	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	703	28	26,304,004	2	13,204,685	46	33,864,514	216	138,189,037
Inarajan	6.11	180	7	2,409,492	3	2,916,318	31	34,493,846	98	11,296,098
Mangilao	0.81	194	0	0	0	0	0	0	3	697,245
Merizo	1.74	297	2	434,760	10	12,658,544	27	9,213,354	210	24,255,581
Mongmong- Toto-Maite	0.51	0	0	0	0	0	0	0	0	0
Piti	1.17	245	11	11,487,965	2	51,696,674	30	816,377,090	146	31,330,230
Santa Rita	4.19	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	215	1	371,960	0	0	17	65,213	21	3,223,681
Tamuning/Tumon	1.74	1,738	14	110,436,962	3	4,992,823	13	11,884,489	127	95,141,724
Umatac	2.28	43	3	1,269,532	1	1,268,219	20	8,518,633	13	1,379,572
Yigo	7.48	0	0	0	0	0	0	0	0	0
Yona	3.61	0	0	0	0	0	0	0	0	0
Total	45.86	4,203	76	210,171,865	23	89,267,596	228	926,477,599	1,269	364,022,293

%			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	7.82	7.83	45	84.01	22.22	5.17	100	86.98	26.53	26.53
Asan	2.12	2.15	0	0	0	0	66.67	67.83	3.06	3.06
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	0	0	0	0	0	0	0	0	0	0
Dededo	0	0.23	0	0	0	0	0	0	0	0
Hagatna	63.53	63.94	62.5	58.24	50	95.39	80	73.1	64.01	64.01

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Inarajan	5.87	5.9	46.6 7	7.68	17.6 5	3.49	83.3 3	97.35	15.6 6	15.66
Mangilao	0	1.46	0	0	0	0	0	0	0.25	0.25
Merizo	13.73	13.73	20	6.68	62.5	46.6	100	96.48	55.1 9	55.19
Mongmong-	0	0	0	0	0	0	0	0	0	0
Piti	14.69	14.72	57.8 9	60.27	15.3 8	9.2	72.7 3	88.03	27.9 9	27.99
Santa Rita	0	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	6.69	6.69	12.5	8.61	0	0	100	7.12	2.16	2.16
Tamuning/	9.65	9.65	18.0 7	13.53	13.0 4	3.37	10	12.26	8.06	8.06
Umatac	4.76	4.86	33.3 3	25.97	5.26	1.35	66.6 7	47.69	9.47	9.47
Yigo	0	0	0	0	0	0	0	0	0	0
Yona	0	0	0	0	0	0	0	0	0	0
Total	4.96	4.74	21.4 1	14.86	7.46	5.19	30.0 8	68.24	5.45	6.5

Jurisdictions' Vulnerability

Vulnerable assets include coastal roads, near-shore buried cables, sewer lines, and pump stations, and near-coastal buildings. Also see coastal erosion. Vulnerable jurisdictions include all non-cliff coastal areas. Populated areas are of the greatest risk to the high costs of high surf. High surf associated with typhoons is the most destructive. Typhoons passing south of the island cause most destruction on the east and south coasts. Typhoons passing north of the island cause most destruction on the west and north coasts. Typhoons passing over the island cause most destruction on all coasts.

Village	Venerable Exposed	Venerable Exposed as % of Total
Agana Heights	0	0%
Agat	443	8%
Asan/Maina	5	0%
Barrigada	0	0%
Chalan Pago-Ordot	0	0%
Dededo	0	0%
Hagatna (Agana)	626	57%
Inarajan	70	2%
Mangilao	140	1%
Merizo	279	13%
Mongmong- Toto-Maite	0	0%
Piti	0	0%
Santa Rita	0	0%
Sinajana	0	0%
Talofofo	47	1%
Tamuning/Tumon	295	2%
Umatac	29	3%
Yigo	0	0%

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Yona	0	0%
Total	1,935	

Summary of Recent and Project Developments in the Hazard Prone Area

No developments since the 2019 HMP.

5.5.7 Slope Failure

Slope failure can lead to a variety of sub hazards. For the island of Guam the concerns are with landslides, mudslides, and post-fire debris flows.

Nature

Landslide: Landslides are the dislodging and falling of a mass of soil or rocks along a sloped surface; the dislodged mass itself is also referred to as a landslide. Landslides can be earthquake- induced or non-earthquake-induced. Earthquake-induced landslides occur as a result of ground shaking. The most common earthquake-induced landslides include shallow rock falls, disrupted rock slides, and disrupted slides of earth and debris. Non-earthquake-induced landslides may involve a wide range of combinations of natural rock, soil, or artificial fill. The susceptibility of hillside and mountainous areas to non-earthquake-induced landslides depends on variations in geology, topography, vegetation, and weather. These landslides may also occur due to indiscriminate development on sloping ground or the creation of cut-and-fill slopes in areas of unstable or inadequately stable geologic conditions. Non-earthquake-induced landslides often occur as a result of intense or prolonged precipitation that can saturate slopes and cause failures.

Mudslide: Mudslides are another type of soil failure; mudslides are defined as flows of rivers of liquid mud down a hillside. They occur in relatively steep areas of clay when soils become saturated and moderate to heavy rain is occurring. If no brush, tree, or ground cover is present to hold the soil, mud will form and flow down the slope.

Post-Fire Debris Flow: Post-fire debris flows are defined as fast-moving, highly destructive flows of rain, water, rock, and soil within a burned area and downstream of that area. They are most common in the 2 years after a fire and are usually triggered by heavy rainfall.

The threats of erosion, flooding, and debris flows are significantly increased by the following processes:

- Reduced infiltration and increased runoff: A fire's consumption of vegetative cover increases the exposure of the soil surface to raindrop impact. Soil-heating destroys the organic matter that binds the soil together. Extreme heating may also cause the development of water- repellant, or "hydrophobic," soil conditions, which further reduce infiltration.
- Changes in hill slope conditions: Fires remove obstructions to overland flow, such as trees, downed timber, and plants. The removal of these obstructions can increase flow velocity and therefore, erosive power. Increased sediment movement also fills depressions, reducing storage capacity and further

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contributing to increased velocity and volume of flow. These factors combine to allow more of the watershed to contribute flow to the flood at the same time, and this combination of factors increases the volume of the flood.

- Changes in channel conditions: Increased overland flow and sediment transport result in increased velocity and volume of flow in defined channels. These conditions increase channel erosion and peak discharges.

The occurrence of erosion, floods, and debris flows in burned areas also depends on precipitation intensity—storms with high intensity are more likely to initiate the processes described above and result in flood events. Also, easily eroded types of soils facilitate changes in hillslope conditions and increase the volume of runoff.

In extreme situations, the conditions described above combine to form a post-fire debris flow. These flows are often the most destructive events resulting from heavy rainfall in fire-affected areas. They occur with little warning, carry vast quantities of rock and other material, and strike objects with extreme force. Because of their viscosity and density, debris flows can move or carry away objects as large as vehicles and bridges, and they can travel great distances down canyons and stream valleys. Debris flow fronts can travel at high speeds, exceeding 50 miles per hour. In most cases, only large basins designed specifically to trap these flows are capable of resisting the forces that accompany them.

Location

Landslide: An adequate landslide inventory map is not available for Guam. Therefore, the most appropriate way to identify where landslide hazards occur on Guam is to determine the susceptibility of an area based on the geologic units mapped at the surface.

Susceptibility to landslide hazards on Guam has been determined by the geology and the slope angle of the various specific areas on the island. Using these two factors, a quantitative rating of the potential of an area for a landslide to occur was defined. As shown in **Figure D-23**, all slopes with an angle of 30 percent or more are considered to have a moderate to high potential for a landslide to occur. All slopes that have a slope of less than 5 percent are considered to have low potential, regardless of the geologic deposits present. As such, Yona, Santa Rita, Piti, Asan/Maina, Talofoto, Inarajan, Merizo, Umatac, and Agat all have proportionally large areas with a moderate, a moderate to high, or a high potential for landslides to occur. Only the relatively flat areas along the eastern coast of this half of the island and the flat areas around Apra Harbor have a low potential for landslides.

It is important to note that this simplified assessment does not include some potentially important factors, such as local geologic structures. Many of the landslides triggered during August 3, 1993, earthquake were associated with faults. When the orientation of potential landslide failure planes (such as bedding or fault planes) is favorable for failure with respect to the slope, landslides can occur in geologic units not generally prone to fail, particularly during earthquakes or when the ground is saturated.

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Mudslide: The areas most susceptible to mudslides are steep areas made of clay, areas where mudslides occurred before, but bedrock is not yet exposed and sloped clay areas where vegetation has been removed. Steep refers to angles that range from 10 degrees from the vertical to about 40 degrees from the vertical. For angles of less than 10 degrees from the vertical, water flows over the clay and forms waterfalls. For angles greater than 40 degrees from the vertical, gravity does not normally cause the mud to give way. As such, Nimitz Hill, Santa Rita, the Cross Island Road, and the southern mountain areas are the most susceptible mudslide locations on Guam.

Post-Fire Debris Flow: Land that is adjacent to or downslope of recently burned areas is susceptible to potentially hazardous debris flows. Areas susceptible to recent burn and potential debris flow include localities on the west coast, such as Agat and Umatac, and the areas near Talofoto, Inarajan, and Merizo.

Figure D-23 – Landslide / Slope Failure

Government of Guam; USGS; NOAA; USDA Forest Service;
University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

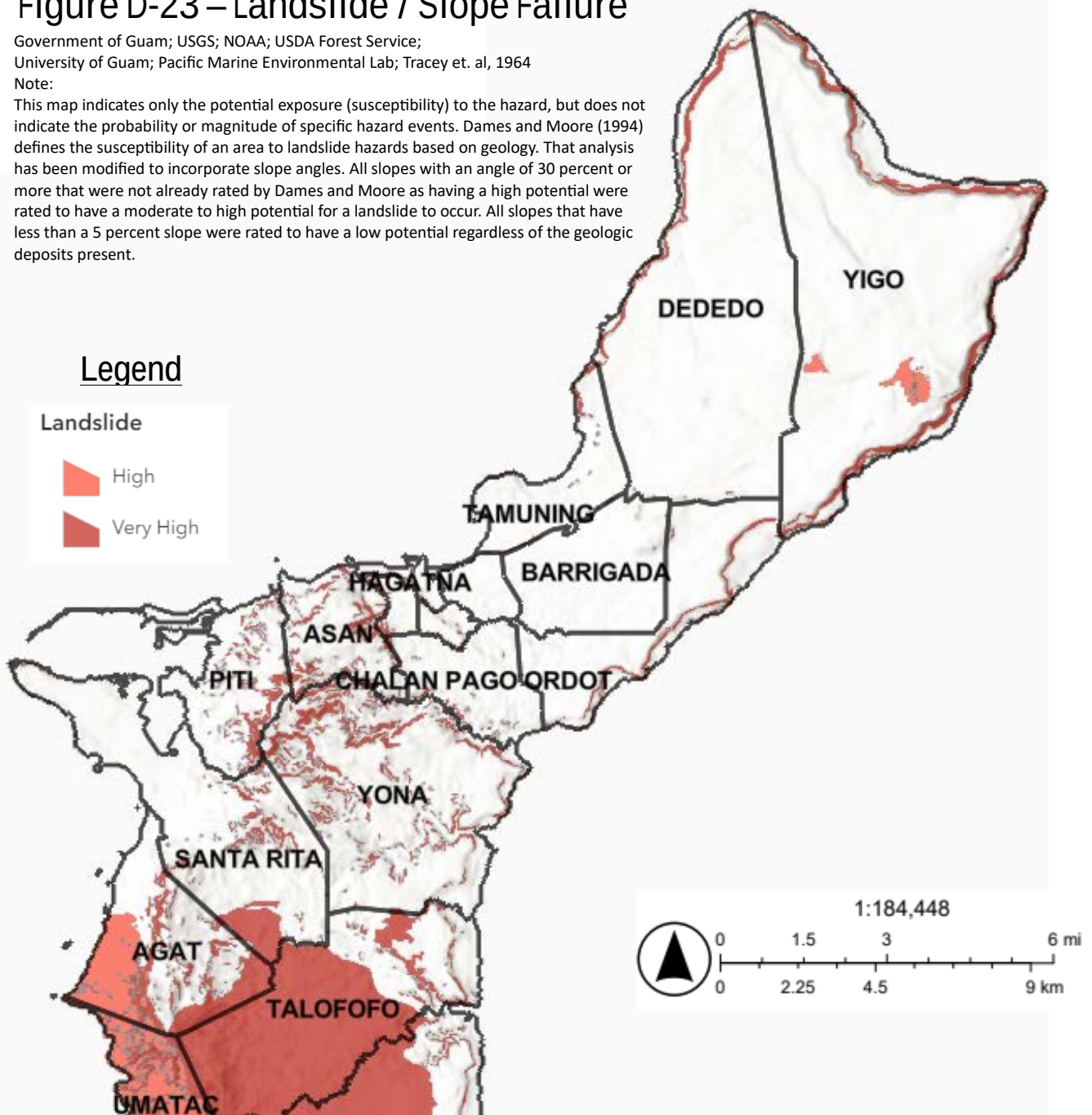
Note:

This map indicates only the potential exposure (susceptibility) to the hazard, but does not indicate the probability or magnitude of specific hazard events. Dames and Moore (1994) defines the susceptibility of an area to landslide hazards based on geology. That analysis has been modified to incorporate slope angles. All slopes with an angle of 30 percent or more that were not already rated by Dames and Moore as having a high potential were rated to have a moderate to high potential for a landslide to occur. All slopes that have less than a 5 percent slope were rated to have a low potential regardless of the geologic deposits present.

Legend

Landslide

-  High
-  Very High



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Post-Fire Debris Flow: Previous occurrences of post-fire debris flows have not been documented on Guam to date.

Extent and Vulnerable Jurisdictions: Slope failure here is generally addressed as mudslides. These occur in steep areas (within a 40-degree angle from the vertical) made of clay soil. Once the soil is saturated, continued heavy rain can cause slope failure.

Vulnerable jurisdictions include steep areas along the Cross Island Road, Santa Rita, Nimitz Hill Estates, and southern mountains. This becomes more threatening as people dig into clay hillsides to build houses.

Probability of Future Events

Landslide: The probability of future landslides is unknown. However, landslides are likely to result from large earthquakes felt on Guam (3-5 years) and tropical cyclones and typhoons (on average, three tropical cyclones and one typhoon pass within 180 nautical miles of Guam each year).

Mudslide: The probability of future mudslides is unknown. However, mudslides are likely to occur after tropical cyclones and typhoons (on average, three tropical cyclones and one typhoon pass within 180 nautical miles of Guam each year), and other prolonged or intense rainstorm events which generally occur during the wet season from June – December.

Post-Fire Debris Flow: Post-fire debris flows are most common in the 2 years after a fire; they are usually triggered by heavy rainfall. Flooding and increased runoff may continue for several years after a fire, but it is unusual for post-fire debris flows to be produced beyond the second rainy season after a wildfire. Some of the largest debris-flow events have been triggered by the first intense rainstorm of the storm season. However, because a number of complex factors lead to debris flow (rainfall, wildfire, and slope and soil conditions), the probability of future post-fire debris flows on Guam is unknown.

Summary of Potential Impacts

As shown in **Table F-21**, 46 percent of the landmass on Guam has a very high or high susceptibility to landslides. Similar to previous versions of the plan, approximately 10 percent of the population (17,608) is exposed to this hazard. The number of exposed EFMUTS includes 31 Essential Facilities worth \$27.2 million, 53 Major Utilities (worth \$270 million), and 206 Transportation Systems (worth \$150.4 million). Of the GBS, 1,224 structures (worth \$178.6 million) are exposed. A detailed account of the total affected and the proportion affected by village for both High Chance or Landslide and Very High Chance of Landslide can be found in **Tables F-21 to F-24**.

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Table F-21 Total Affected by Very High Landslide			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	346	0	0	0	0	0	0	1	186,708
Agat	2.19	1,460	0	0	1	10,811,423	17	94,331	1	148,250
Asan/Maina	2.66	362	0	0	2	11,196,746	6	121,676	29	4,318,070
Barrigada	2.12	21	0	0	0	0	4	90,205	0	0
Chalan Pago-Ordot	0.74	200	0	0	0	0	5	3,070,789	2	319,144
Dededo	2.56	1,251	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	66	0	0	1	250,555	6	13,898	24	15,479,072
Inarajan	6.11	2,340	4	9,603,457	5	22,787,387	31	34,582,428	155	17,896,309
Mangilao	0.81	700	1	374,850	0	0	0	0	3	529,906
Merizo	1.74	1,195	1	62,480	2	2,531,709	14	356,196	43	4,957,473
Mongmong- Toto-Maite	0.51	33	0	0	0	0	0	0	0	92,460
Piti	1.17	209	0	0	0	0	4	84,299,304	10	2,205,093
Santa Rita	4.19	846	0	0	0	0	0	0	1	187,597
Sinajana	0	161	0	0	1	387,642	0	0	35	4,936,362
Talofofo	5.15	2,333	3	1,058,854	3	22,009,947	17	184,741	37	5,835,459
Tamuning/Tumon	1.74	632	2	734,614	1	50,431,954	4	67,856	18	13,338,728
Umatac	2.28	362	2	2,384,101	2	9,751,193	10	203,633	19	1,987,049
Yigo	7.48	1,203	0	0	0	0	0	0	1	138,209
Yona	3.61	890	0	0	0	0	8	83,109	18	3,538,571
Total	45.86	14,608	13	14,218,356	18	130,158,557	124	123,168,165	398	76,094,461

Table F-22 Proportion Affected by Very High Landslide			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	8.74	8.77	0	0	0	0	0	0	0.77	0.77
Agat	25.8	25.81	0	0	11.11	22.09	50	2.31	0.07	0.07
Asan	17.28	17.31	0	0	20	23.66	33.33	0.97	5.69	5.69
Barrigada	0.24	0.24	0	0	0	0	6.67	0.01	0	0
Chalan Pago-	3.36	3.37	0	0	0	0	14.29	14.29	0.28	0.28
Dededo	2.91	2.91	0	0	0	0	0	0	0	0
Hagatna	5.88	5.99	0	0	25	1.81	10	0.03	7.17	7.17
Inarajan	76.68	76.68	26.67	30.61	29.41	27.27	83.33	97.6	24.81	24.81
Mangilao	5.25	5.26	3.57	0.39	0	0	0	0	0.19	0.19
Merizo	55.23	55.24	10	0.96	12.5	9.32	50	3.73	11.28	11.28
Mongmong-	0.55	0.56	0	0	0	0	0	0	0.08	0.08
Piti	12.52	12.52	0	0	0	0	9.09	9.09	1.97	1.97
Santa Rita	11.27	11.28	0	0	0	0	0	0	0.3	0.3
Sinajana	5.62	5.63	0	0	11.11	6.33	0	0	1	1
Talofofo	72.53	72.56	37.5	24.51	33.33	54.55	100	20.17	3.91	3.91

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Tamuning/	3.51	3.51	2.41	0.09	4.35	34.04	3.33	0.07	1.13	1.13
Umatac	40.72	40.79	22.2 2	48.77	10.5 3	10.38	33.3 3	1.14	13.6 4	13.64
Yigo	6.18	6.18	0	0	0	0	0	0	0.02	0.02
Yona	13.73	13.73	0	0	0	0	25	0.38	1.06	1.06

Table F-23 Total Affected by High Landslide			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	0	0	0	0	0	0	0	0	0
Agat	2.19	1,199	3	4,370,330	4	12,852,330	17	390,392	329	44,157,463
Asan/Maina	2.66	0	0	0	0	0	0	0	0	0
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	0	0	0	0	0	0	0	0	0
Dededo	2.56	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	0	0	0	0	0	0	0	0	0
Inarajan	6.11	0	0	0	0	0	0	0	0	0
Mangilao	0.81	0	0	0	0	0	0	0	0	0
Merizo	1.74	866	8	6,073,621	11	20,834,986	27	9,060,562	304	35,014,352
Mongmong- Toto-Maite	0.51	0	0	0	0	0	0	0	0	0
Piti	1.17	0	0	0	0	0	0	0	0	0
Santa Rita	4.19	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	1.74	0	0	0	0	0	0	0	0	0
Umatac	2.28	526	7	2,504,357	17	84,190,938	30	17,658,882	120	12,580,762
Yigo	7.48	333	0	0	3	22,008,866	8	142,024	74	10,711,233
Yona	3.61	0	0	0	0	0	0	0	0	0
Total	45.86	2,924	18	12,948,308	35	139,887,120	82	27,251,860	826	102,463,810

Table F-24 Proportion Affected by High Landslide			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	0	0	0	0
Agat	21.19	21.19	15	6.39	44.4 4	26.26	50	9.56	20.8 5	20.85
Asan	0	0	0	0	0	0	0	0	0	0
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	0	0	0	0	0	0	0	0	0	0
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna	0	0	0	0	0	0	0	0	0	0
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	0	0	0	0	0	0	0	0	0	0
Merizo	40.03	40.05	80	93.32	68.7 5	76.7	100	94.88	79.6 7	79.67
Mongmong-	0	0	0	0	0	0	0	0	0	0
Piti	0	0	0	0	0	0	0	0	0	0

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Santa Rita	0	0	0	0	0	0	0	0	0	0
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	0	0	0	0	0	0	0	0	0	0
Tamuning/	0.18	0	0	0	0	0	0	0	0	0
Umatac	59.28	59.34	77.78	51.23	89.47	89.62	100	98.86	86.36	86.36
Yigo	1.7	1.71	0	0	9.09	19.41	16.67	0.97	1.55	1.55
Yona	0	0	0	0	0	0	0	0	0	0
Total	4.26	1.63	5.07	0.91	9.67	7.76	5.26	1.96	2.81	1.48

Jurisdictions' Vulnerability

Village	Very High	High
Agana Heights	97	0
Agat	1,460	1,199
Asan/Maina	40	0
Barrigada	9	0
Chalan Pago-Ordot	66	0
Dededo	976	0
Hagatna (Agana)	59	0
Inarajan	913	0
Mangilao	504	0
Merizo	1,123	814
Mongmong- Toto-Maite	27	0
Piti	0	0
Santa Rita	51	0
Sinajana	90	0
Talofofo	513	0
Tamuning/Tumon	107	0
Umatac	242	353
Yigo	734	203
Yona	445	0
Total	7,456	2,569

Summary of Recent and Project Developments in the Hazard Prone Area

No developments since the 2019 HMP.

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5.5.8 Sea Level Rise

Nature

With respect to climate change, scientists attribute sea level rise to two different mechanisms: thermal expansion and the loss of land-based ice. Thermal expansion occurs when ocean water is heated. Warmer seawater takes up more space in the ocean, thereby causing a rise in water level. The melting of land-based ice, such as glaciers and polar ice caps, releases water into the ocean.

Climate change can be described as a change in global or regional climate patterns, attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels. The natural systems consist of warming sea surface temperatures and ocean acidification.

Location

The NOAA Sea Level Rise and Coastal Flooding Impacts Viewer shows that the southern part of Merizo, parts of Inarajan and Hagatna, and a portion of Piti between Naval Base Guam and Cabras Power Plant are most impacted by sea level rise for sea level rise scenarios of 1-6 feet above mean higher high water levels.

The shallow nearshore waters surrounding Guam host approximately 108 km² of coral reef habitat, with an additional 110 km² of reef area located greater than 3 nautical miles offshore. This natural structure reduces the effects of storm surge and coastal erosion by absorbing wave energy during storm events. As waves break on the structure, their energy is reduced, calming waters on the shoreward side of the breakwater and reducing the direct impacts to the shoreline.

Breakwaters are offshore structures designed to limit wave energy by creating a barrier, most often underwater, between open water and the shoreline. While traditional breakwaters may be made from stone, concrete, or other building materials, a living breakwater is a breakwater that is intentionally designed to incorporate natural habitat components while still providing protection to the coastline. In Guam, living breakwaters consist of our coral reefs, which is a natural habitat that provides opportunities for settlement and colonization hard corals or by creating complex structural components that also provide shelter and habitat for various marine and aquatic species.

More than 5,100 species inhabit Guam's coastal waters, including nearly 400 species of stony corals and over 1,000 nearshore fishes. In addition to the value of their biodiversity, coral reefs provide and support numerous ecosystem services, including commercial and subsistence fisheries, tourism, coastal protection, research and education opportunities, and support for social and cultural activities. In the past, nearshore fishing provided a large portion of the CHamoru diet in Guam. Although locally caught fish are no longer a significant source of food for most residents, Guam's coral reefs are still used for subsistence fishing, some commercial fishing, and recreation by both locals and tourists. Calculating the monetary value of an ecosystem is complex and, in many cases, controversial; however, these evaluations provide important metrics for natural resource managers and decision-makers. In 2007, the total economic value of Guam's coral reefs was estimated at \$169 million per year.

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Previous Occurrences

Records and research indicate that the global sea level has been steadily rising at a rate of 0.04 to 0.1 inches per year since 1900. Much of the rise in sea level over this time period has been related to the concurrent rise in global temperature with the consequent thermal expansion of the oceans and accounting for approximately 0.79-2.75 inches of the observed sea level rise while the observed melting of the land-based ice accounting for about 0.79-1.96 inches.

See coastal erosion and high surf. As sea level rises, waves and storm surges will produce greater inundation, even if the strength of events does not change. Most scientists expect a 1- foot rise by 2050. This will at least double the frequency of inundation events from distant storms. However, for tropical cyclone-induced storm surge, the coastal erosion and inundation would more than double.

See high surf and coastal erosion. However, more structures, roads, and other infrastructure would be affected. The port and marinas could be impacted as well. All non-cliff coastal areas, but more destructive on more populated west side coastal areas than east side coastal areas.

Around one-fifth of all coral reefs have already been lost and over one-quarter of surviving reefs are in danger of imminent decline. Guam's coral reef ecosystems face an array of threats, encompassing both local stressors and the impacts of global climate change and ocean acidification. Stressors include fishing pressures and loss of herbivores, land-based sources of pollution, recreational use and misuse, and impacts of climate change and ocean acidification.

Probability of Future Events

According to NOAA, the mean sea level rise trend for Guam is 0.33 inches/year with a 95 percent confidence interval of +/- 0.35 inches/year based on monthly mean sea level data from 1993 to 2006. This sea level rise trend for Guam is equivalent to a change of 2.77 feet in 100 years. Guam is highly likely to experience a decline in coral health in the future. Actions outlined 2018 Guam Coral Reef Resilience Strategy provide a framework for management and mitigation options to protect this natural infrastructure.

Climate Change Impact

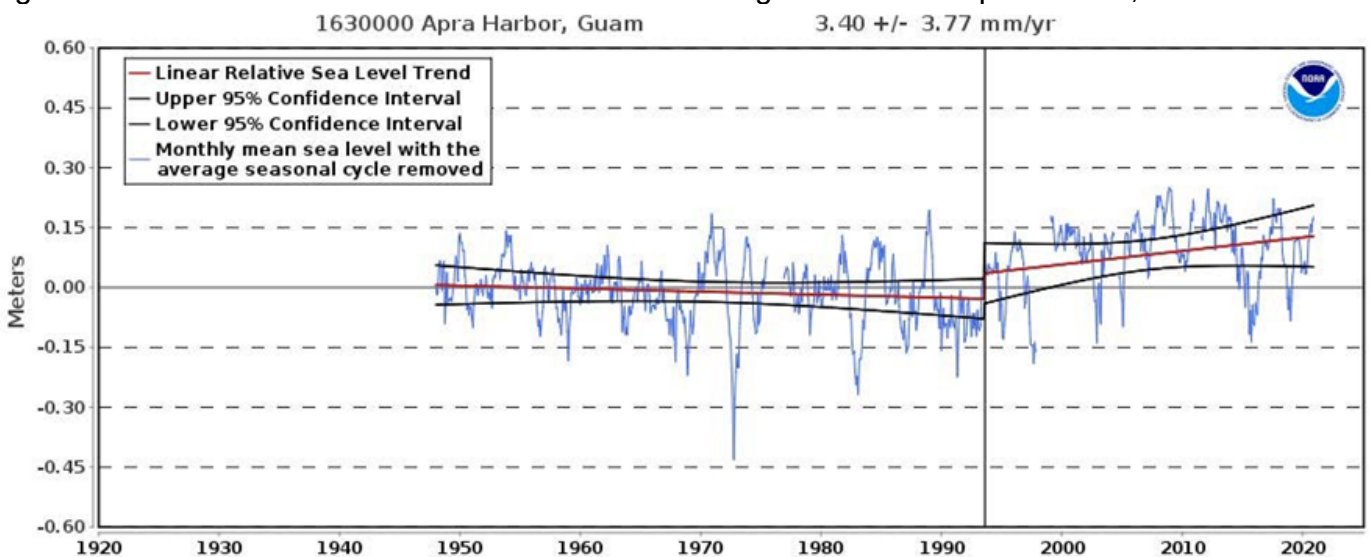
Relative sea level change (SLC) is the local change in sea level relative to the elevation of the land at a specific point on the coast, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. Relative SLC is a combination of both global and local SLC caused by changes in estuarine and shelf hydrodynamics, regional oceanographic circulation patterns (often caused by changes in regional atmospheric patterns), hydrologic cycles (river flow), and local and/or regional vertical land motion (subsidence or uplift). Thus, relative SLC is variable along the coast.

To incorporate the direct and indirect physical effects of projected future sea level change on design, construction, operation, and maintenance of coastal projects,

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USACE has provided guidance in the form of Engineering Regulation, ER 1110-2-8162 (USACE 2013). ER 1110-2-8162 provides both a methodology and a procedure for determining a range of sea level change estimates based on global sea level change rates, the local historic sea level change rate, the construction (base) year of the project, and the design life of the project. Three estimates are required by the guidance, a Baseline (or “Low”) estimate, which is based on historic sea level change and represents the minimum expected sea level change, an Intermediate estimate (NRC Curve I), and a High estimate (NRC Curve III) representing the maximum expected sea level change.

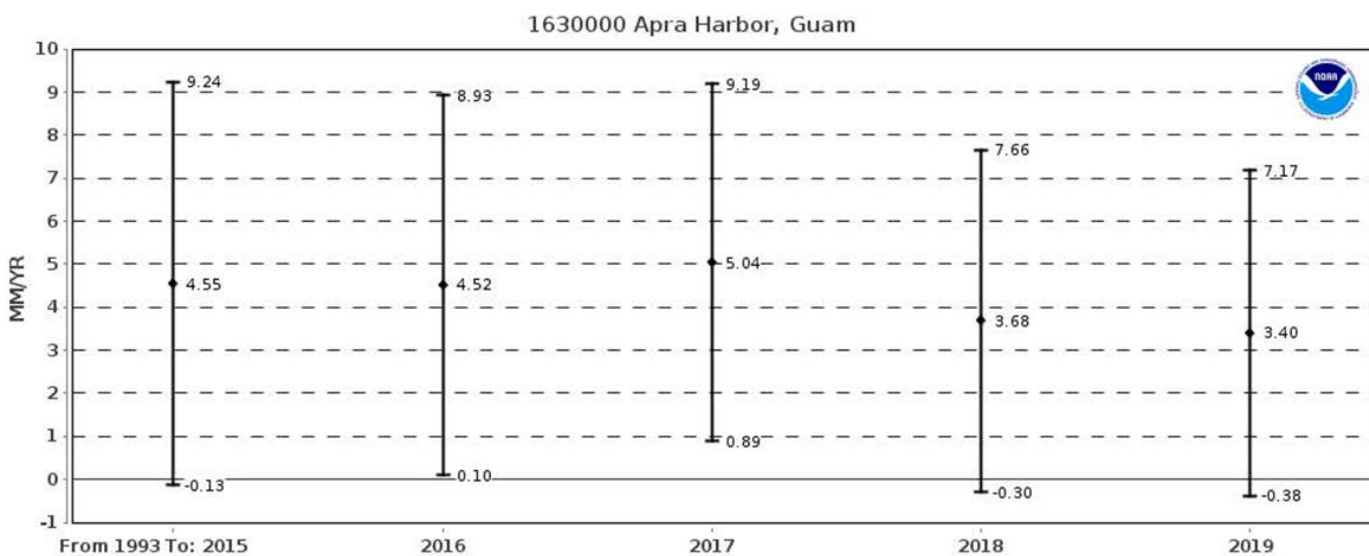
Figure 17: Mean Sea Level Trend from NOAA Tide Gage 1630000 – Apra Harbor, Guam



Local sea level rise accounts for the eustatic change (e) (1.7mm/year or 0.0056 ft/year) as well as uplift, subsidence, and other effects (M) and is generally available from the nearest tide station. The tide station for Guam is the National Oceanic and Atmospheric Administration (NOAA) Station 1630000 at Apra Harbor, which has a tidal record of approximately 40 years.

Over the past two decades, sea level trends have increased in the western tropical Pacific Ocean with rates that are approximately three times the global average. Several papers including Merrifield and Maltrud (Merrifield 2011) have shown that the high rates of SLC recorded are caused by a gradual intensification of Pacific trade winds since the early 1990s. Multi-decadal tradewind shifts in the Pacific (1950-1990 had weak tradewinds, while 1990- present have shown strong tradewinds) are likely related to the Pacific Decadal Oscillation (Merrifield et al. 2012), a recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin. These low frequency tradewind changes can contribute on the order of 1 cm variations in sea level in western tropical Pacific. Multi-decadal variations such as these can lead to linear trend changes over 20 year time scales that are as large as the global SLC rate, and even higher at individual tide gauges, such as Apra Harbor, Guam (Merrifield 2011, Merrifield et al. 2012).

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In addition, higher frequency inter-annual variations in Pacific water levels can be caused by the effect of the El Niño Southern Oscillation; the climate phenomenon in the Pacific evidenced by alternating periods of ocean warming and high air pressure in the western Pacific (El Niño) and cooler sea temperatures accompanied by lower air pressure in the western Pacific (La Niña). In fact, it is known that the largest inter-annual variability of sea level around the globe occurs in the tropical Pacific, due to these climate patterns (Widlansky 2015). During El Niño years, sea level in the western tropical Pacific is known to drop by 20 to 30 cm, while La Niña phases cause an average sea level rise of about 10 cm. Additionally, and throughout the tropical Pacific, prolonged inter-annual sea level inundations are also found to become more likely with greenhouse warming and increased frequency of extreme La Niña events, thus exacerbating the coastal impacts of the projected global mean sea level rise (Widlansky 2015).

Anecdotal reports have suggested a possible recent reversal in the 20+ year trend of dramatically rising sea levels in the western tropical Pacific, possibly due in part to the strong El Niño cycle documented in 2015/2016; however, analysis and published research supporting this change in trend is not yet available. These phenomena are documented here to emphasize the large variability in sea level that is experienced in the western tropical Pacific, and to indicate that sea level trends reported by the nearest NOAA tide gage at Apra Harbor, Guam are likely affected by this variability.

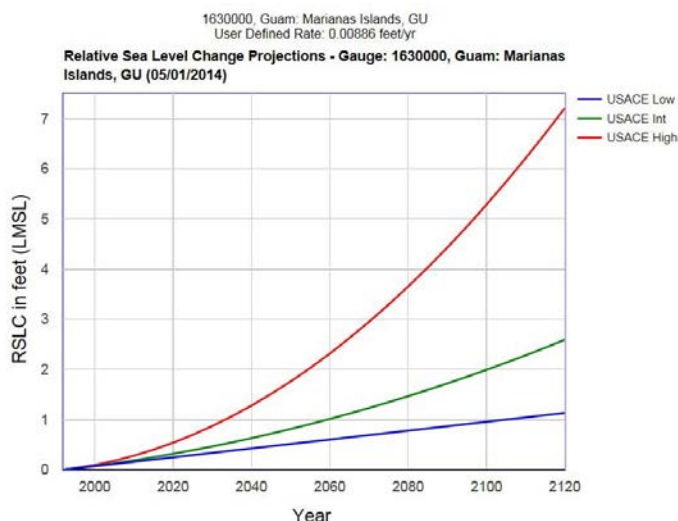
The mean sea level trend reported by NOAA at Apra Harbor Station 1630000 is 3.4 mm/year (+/- 3.77 mm/year 95% confidence interval), as shown in Figure 17. The two trend lines in the figure are indicative of rates prior to and following the 1993 earthquake in Guam. The land elevation experienced an approximately 10 cm drop during the earthquake and is now slowly subsiding, which affects the local relative SLC rate. In addition, the division of the MSL trend into pre- and post-earthquake results in a shorter period of record of approximately 24 years (1993 – present), which is less than the suggested 40-year period of record required by ER 1110-2-8162.

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NOAA also provides information on the historical Mean Sea Level trend, shown in Figure 18. This figure gives additional information on the variability of the average rate of change, as it is basically a look at the historical “trend of the trend”. The figure shows that as recently as 2017, the MSL trend was as high as 9.19 mm/year, over 2 mm/year higher than its present rate, a significant difference that would be amplified when calculating the “intermediate” and “high” curves of potential accelerated SLC.

Due to the variability in MSL trends in the western Pacific over recent years outlined

for
the
+1.7
rate



above, in addition to the short post-earthquake trend at Apra Harbor, Guam, a different approach was taken for determination of the rate of relative SLC in Guam. The rate Guam is estimated by using global eustatic rate of SLC, mm/year added to a measured of Vertical Land Movement (VLM) rate of -1.0 mm/year (as reported by the NASA Jet Propulsion Laboratory website

<https://sideshow.jpl.nasa.gov/post/series.html> – an average of two monitoring stations on Guam and one on Saipan). Since eustatic sea level is rising, and the land is subsiding, this results in a relative SLC rate of 2.7 mm/year (= +1.7 mm/year – (-1.0 mm/year)) or 0.0089 feet/year for Guam. As an example, the USACE SLC calculator was used to plot the three potential curves based on this rate, shown in Figure 19. The curves show that by 2030 relative SLC in the study area will be between 0.3 ft or 0.09 m (low curve) and 0.9 ft or 0.27 m (high curve). By 2070, sea level will have risen between 0.7 ft and 2.9 ft (0.23 m to 0.9 m); and by 2120, sea level will have risen between 1.1 ft and 7.2 ft (0.33 m and 2.2 m) relative to the existing MSL datum.

Summary of Potential Impacts

On December 30, 2019 A University of Guam Study titled “Vulnerability Assessment of Built Infrastructure near Coastal Bays using 3 Sea Level Rise Scenarios for Guam” for the Bureau of Statistics and Plans. <https://bsp.guam.gov/guamccva/>

This technical report focuses on one impact of climate change for Guam - SLR. A mixed-method approach was used to assess the vulnerability of Guam's built environment to three SLR scenarios (three, five, and ten-foot}, engage community participation, and obtain local knowledge and expertise. The approaches used are as follows:

1. GIS Analysis estimating the percentage of impacted infrastructure in each of the three SLR scenarios

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2. Participatory GIS exercise at All-Planners Climate Training Workshop¹ to obtain various perspectives and viable adaptation solutions regarding SLR from planners, engineers, developers, private citizens, local and federal employees, NGOs, and academics
3. Local Early Action and Planning (LEAP) exercise to engage community participation and understand what the community values and understands
4. Social Vulnerability index identifying the most vulnerable municipalities on Guam, by analyzing a series of variables from the US Census.

The results are as follows:

GIS Analysis

GIS SLR scenario analyses resulted with

- 58% of total infrastructure impacted by a 3-ft SLR (**Table 19** Guam CVVA),
- 74% impacted by a 5-ft SLR (**Table 20** Guam CVVA }, and
- 84% impacted by a 10-ft SLR (**Table 21** Guam CVVA }.

Of the villages, the greatest percentage of infrastructure impacted were southern villages:

- 3ft SLR - southern 73% and central 27% (**Figure 18** Guam CVVA);
- 5-ft SLR - 64% southern, 29% central, and 7% northern (**Figure 19** Guam CVVA }; and
- 10-ft SLR - 56% southern 31% central, and 13% northern (**Figure 20 Figure 19** Guam CVVA }.

The remaining villages with zero percent impact in the 13 infrastructure categories to all three SLR scenarios were Agana Heights, Barrigada, and Mangilao (**Figure 18, Figure 19, and Figure 20 Figure 19** Guam CVVA }.

Vulnerability of Infrastructure

Piti: With its critical infrastructure near the coastline, Piti faces significant risks from rising sea levels. Major utilities and transportation systems valued at hundreds of millions are directly exposed to increased flooding and erosion. This exposure threatens the structural integrity of these assets and jeopardizes the continuity of essential services like electricity and water supply. The economic repercussions of any disruption would be extensive, affecting not just Piti but potentially the wider region due to its strategic economic roles.

Hagatna: As the capital village, Hagatna is central to governmental functions and services, housing essential facilities and major utilities crucial for the administration and everyday operations of the island. The rise in sea levels directly threatens these facilities, potentially leading to significant operational disruptions. Furthermore, Hagatna's historical and cultural sites, integral to its identity and tourism, are also at risk, complicating conservation efforts and potentially leading to a loss of cultural heritage.

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Potential Losses Estimation

Piti: If vulnerable areas like Piti's utilities and transport sectors, valued at \$500.67 million and \$927.11 million, respectively, were to sustain damage from flooding, even a conservative estimate of a 10% loss could translate into a combined financial impact exceeding \$142 million. Such losses would not only affect the immediate replacement costs but lead to secondary economic impacts related to disruptions in logistics and trade, which are critical for Guam's economy. Planning for these potential outcomes is crucial for maintaining economic stability and ensuring the impacts can be managed without severe long-term consequences.

Hagatna: Given its critical role in governance and commerce, even minor damage to Hagatna's infrastructure could disproportionately impact public services and economic activities. If 10% of Hagatna's essential facilities and transportation systems were damaged by sea level rise, the losses could exceed \$8 million. This estimate underscores the need for investments in resilience to safeguard against potential financial and operational disruptions. Protecting these assets is about preserving physical infrastructure and ensuring the continuity of government operations and services vital to the populace.

Analysis of Recovery Implications

Piti: Recovery efforts in Piti would involve extensive coordination across multiple sectors, focusing on restoring utilities and transportation routes to minimize disruption in supply chains and ensure the timely delivery of goods and services. Investment in robust infrastructure capable of withstanding future sea level changes is crucial. Additionally, the community must enhance its adaptive capacities to respond swiftly and recover from these disruptions, minimizing economic losses and maintaining community resilience.

Hagatna: Recovery in Hagatna must be multifaceted, addressing the physical restoration of damaged infrastructure and the preservation of cultural heritage. Specialized restoration techniques might be required to repair historic buildings and sites affected by flooding, which could be costly and time-consuming. Moreover, the government would need to implement temporary measures to ensure that essential services remain uninterrupted during the recovery period, maintaining public trust and operational continuity.

Jurisdiction-Specific Risk Mitigation

Mitigation Measures

Piti: Strategic long-term measures for Piti could include elevating critical infrastructure, constructing sea barriers, and improving stormwater management systems to handle higher runoff volumes. These efforts would protect the village's physical assets and contribute to the sustainability of its economic activities. Moreover, community engagement in resilience-building activities and emergency preparedness can significantly enhance the local capacity to handle impacts from sea level rise.

Hagatna: Critical steps in Hagatna are strengthening infrastructure against flooding and integrating sea-level rise scenarios into urban planning. This might involve retrofitting

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existing buildings to better withstand water damage and designing new structures with higher floor elevations. Public education campaigns can also raise awareness about the risks and preparedness strategies, ensuring that residents and businesses are better equipped to respond to emergencies.

Jurisdictions' Vulnerability

Guam's coastal areas are most threatened by the impacts of sea level rise, which can cause coastal flooding, erosion, and damage to infrastructure. Villages such as Hagatna, Agat, and Merizo are particularly at risk due to their low-lying locations and high exposure to coastal flooding. The anticipated intensity of sea level rise and the increasing probability of more frequent and severe flooding events due to climate change heightens the risk to these areas. **Table 40** shows the highest SVI of 1.00 and 443 individuals (8% of its population) exposed, Agat is one of the most threatened villages. Hagatna has an SVI of 0.89, with 626 individuals (57% of its population) exposed to sea level rise, making it highly susceptible to flooding and erosion. Merizo, with an SVI of 0.94 and 279 individuals (13% of its population) exposed, also faces significant vulnerability.

Due to social and economic factors, vulnerable populations are prone to experiencing adverse effects from rising sea levels: Mongmong-Toto-Maite, with an SVI of 0.83 and 906 individuals (16%) exposed, and Merizo, with an SVI of 0.94 and 279 individuals (13%) exposed, highlight areas where socially vulnerable and underserved communities are at significant risk. Further, critical facilities in Guam's coastal villages are at increased risk of damage and loss due to rising sea levels. Essential facilities such as healthcare centers, emergency services, and infrastructure in villages like Hagatna, Agat, and Merizo are particularly vulnerable. Hagatna, for instance, contains critical infrastructure, and a large percentage of its population is exposed to flooding hazards. Sea level rise threatens the infrastructure and community lifelines crucial for territorial resilience, including safety and security, food, water, shelter, health and medical services, energy, communications, transportation, and hazardous material management. Villages with high SVIs and substantial vulnerable infrastructure, such as Hagatna, Agat, and Mongmong-Toto-Maite, are particularly at risk. The potential losses to vulnerable structures in Guam due to rising sea levels are substantial. For example, Hagatna alone has an estimated 402 structures worth approximately \$139.8 million exposed to flood hazards. Similarly, Agat and Merizo have 364 and 372 structures exposed, respectively.

In summary, the most vulnerable Guam villages prone to sea level rise's adverse effects are Hagatna, Agat, Merizo, and Mongmong-Toto-Maite. These areas are highly vulnerable due to their geographic location, high SVI scores, substantial exposed populations, and critical facilities.

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Table 40. SVI

Village	Village SVI	Vulnerable Exposed	Vulnerable Exposed
Agana Heights	0.28	22	1%
Agat	1	443	8%
Asan/Maina	0.11	5	0%
Barrigada	0.44	5	0%
Chalan Pago-Ordot	0.33	139	2%
Dededo	0.78	77	0%
Hagatna (Agana)	0.89	626	57%
Inarajan	0.39	70	2%
Mangilao	0.72	140	1%
Merizo	0.94	279	13%
Mongmong- Toto-Maite	0.83	906	16%
Piti	0	0	0%
Santa Rita	0.06	43	1%
Sinajana	0.56	322	11%
Talofofo	0.22	47	1%
Tamuning/Tumon	0.17	295	2%
Umatac	0.67	29	3%
Yigo	0.61	93	0%
Yona	0.5	133	2%
Total		3,674	

Summary of Recent and Project Developments in the Hazard Prone Area

Guam is experiencing significant impacts from sea level rise, which is exacerbated by climate change. The island has already seen about four inches of sea level rise since 1993, and projections indicate that sea levels could rise by one to three feet over the next century. This increase in sea level poses a substantial threat to coastal areas, increasing the frequency and severity of coastal flooding, amplifying erosion, and endangering coastal infrastructure, homes, and businesses. Here is a detailed analysis of how recent and potential developments in Guam are affected by rising sea levels. Recent development trends in Guam mentioned earlier in the Flood Hazard Profile include constructing residential and commercial buildings in coastal areas particularly vulnerable to rising sea levels. Specifically, Hagatna, Agat, and Merizo have significant portions of their built environment within the SFHA. Hagatna, has 402 structures (64% of the village's general building stock) exposed to flood hazards, worth approximately \$139.8 million. Similarly, Agat and Merizo have 364 and 372 structures exposed, respectively. The increasing number of structures within these flood-prone areas highlights the urgent need for enhanced flood mitigation measures.

Population changes in Guam, particularly in villages with high SVI scores, have affected vulnerability to sea level rise and related hazards. Mongmong-Toto-Maite and Tamuning/Tumon have seen significant population increases, well above the island average. Mongmong-Toto-Maite's population increased by 16.8%, and Tamuning/Tumon's by 9.3%. High SVI villages such as Agat (SVI: 1.00) and Merizo (SVI: 0.94) have substantial vulnerable populations exposed to sea level rise and flood

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hazards. Further, 21% of Agat's and 27% of Merizo's populations are vulnerable. These demographic changes necessitate targeted interventions to protect socially vulnerable and underserved communities from the impacts of sea level rise.

Territorial assets, including essential facilities and critical infrastructure, are increasingly vulnerable to sea level rise. In Hagatna, 35 essential facilities worth \$26.0 million are exposed to flood hazards. Piti and Tamuning/Tumon have 21 exposed facilities each, with Piti's valued at \$99.0 million and Tamuning/Tumon's at \$73.8 million. The concentration of essential facilities in these flood-prone areas underscores the critical need for resilient infrastructure to ensure the continuity of essential services during flood events.

New developments in Guam, particularly in high-risk jurisdictions, have increased the exposure to sea level rise and flooding. The construction of new residential and commercial buildings in villages like Dededo and Tamuning/Tumon, which have the highest building stock and value, adds to the flood risk. A notable example is the infrastructure project such as relocating the Ukudu Power Plant from a coastal flood zone to a less vulnerable area demonstrate efforts to mitigate sea level rise in concurrence with flood risks.

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5.5.9 Severe Wind

Nature

The severe wind is often the most destructive part of a typhoon. The strongest winds of a typhoon are generally near the center of the storm. Winds during these storms occur at a sustained level and in gusts. Due to the counter-clockwise rotation of tropical cyclones in the North Pacific Ocean, the speed of storm movement is added to the right side of the storm with respect to its motion. This occurrence creates a semicircle on the right side of the storm, referred to as the “dangerous semicircle,” that has stronger winds, and the destructive winds extend farther from the center of the storm on its right side. Therefore, if a typhoon moving from east to west passes to the south of an island, the island will be exposed to the dangerous semicircle and will receive stronger winds than if the same storm were to pass to the north of the island by the same distance.

When tropical cyclones have sustained winds of about 60 mph, an “eye” begins to form at the very center of the storm. Since the winds of a tropical cyclone are circulating around the eye of the storm, the eye has relatively calm winds. The eye-wall is the ring of deep thunderstorm-like clouds that surrounds the eye of a tropical cyclone. The strongest and most destructive winds of a typhoon are in the eye-wall of a storm. The passage of an eye of a typhoon over a particular location produces the greatest possible destructive winds of that typhoon. An eye passage results in the most destructive winds for several reasons:

The eye-wall contains the maximum winds and most active wind gusts. The location of an eye passage will be exposed to nearly the maximum duration of the strongest winds because the eye is at the center of the circulating typhoon and has the maximum diameter of circulation. As the eye moves across a location, the winds change in direction, exposing buildings to winds from multiple directions. The terrain of a landmass can alter the wind patterns of a tropical cyclone. When a tropical cyclone makes landfall on an island such as Guam, generally the speed of the sustained winds of the storm decrease, but the potential peak gusts remain the same speed. The frequency of peak gusts can vary over a landmass and depends on whether the terrain of the landmass is smooth or rough. Smooth terrain experiences a higher frequency of peak gusts than rough terrain. Isolated hills, ridges, and escarpments constitute abrupt changes in the general topography (which is common in several locations in Guam) and cause approaching winds to speed up as they flow up and over the terrain features. The speedup results in increased pressures on buildings. This increase in pressure can reach twice what it will be without the topographic influence.

The American Society of Civil Engineers (ASCE) Standard 7-02, Minimum Design Loads for Buildings and Other Structures (ASCE 2002), has a procedure to account for some degree of topography; however, the standard states that the effects of topography for large mountains should be analyzed and modeled by specific location. The modeling of the wind speedup in the mountainous regions of Guam has been proposed by a number of the reports evaluating the typhoon risk and post-disaster effects of storms on Guam.

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The western North Pacific Ocean is in an episodal monsoon regime. This monsoonal event occurs when the low-level wind flow in the tropics of this region becomes organized into a defined monsoon trough. This southwesterly low-level wind flow can stretch from the Philippines eastward to the International Date Line. The movements of this monsoonal wind flow is referred to as surges.

Monsoon surges in the area are characterized as weak, medium, or strong. Weak monsoon surges have sustained southwesterly winds of less than 15 mph and a few episodes of heavy rain per day, which often take the form of thunderstorms, over a location. Moderate monsoon surges have more intense southwesterly winds, ranging from 15 to 30 mph, several (three to six) episodes of heavy rain per day, extensive periods of light rain, and heavy overcast skies containing thunderstorms. Strong monsoon surges have gale-force winds (35 to 60 mph), frequent (6 to 12) episodes of heavy rain per day, nearly continuous light rain, and little to no lightning. A strong monsoon surge also has an eastward-moving monsoon squall line, which contains the zone of highest winds and the most extensive monsoon cloudiness. Strong monsoon surges can last from a few days to more than 2 weeks. Weak monsoon surges are the most common, and strong monsoon surges are least common.

Monsoon surges in the western North Pacific Ocean commonly occur in tandem with tropical cyclones. Although neither weather event is necessarily associated with the other, the superposition of a monsoon surge on a tropical cyclone can increase the amount of rain delivered by the tropical cyclone and extend the size of the area that the tropical cyclone affects. This type of event is more common with weaker tropical cyclones that are more unorganized and may extend much farther from their centers.

Location

Any location on the island has virtually the same chance of experiencing the center of a tropical storm or typhoon and peak wind gusts up to 200 mph. For storms passing south of the island, winds on the east coast (winds blowing toward the coast) would be stronger than winds on the west coast (winds blowing away from the coast). For storms passing north of the island, winds on the west coast (blowing toward the coast) would be stronger than winds on the east coast (blowing away from the coast).

The cliffs on northwest Guam tend to enhance the eyewall convection and cause winds to be a little more intense than would be expected. Thus, while winds in the south-semicircle of the tropical cyclone would normally be weaker than those in the northern semicircle, the orographic effects of the island seem to allow the strongest winds to exist in two semicircles: one over Guam and the other in the Rota Channel.

The strongest winds will be in the eye-wall cloud near the windward coast. The winds will generally be weaker on the lee-side coast. Also, as the winds move inland, they weaken. The rougher the terrain, the more the sustained (1-minute average) winds diminish. The vegetation, especially large trees, helps to reduce the winds at the surface. Although the potential peak gust remains the same, the frequency with which the gust gets to the surface is greatly reduced at inland locations. Winds will be stronger

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along all coasts, at high elevations, along ridgelines, in valleys between hills and mountains, and on sloping terrain.

A simplified wind hazard map (see Figure D-22), shows that severe-winds occur in all areas within 500 feet of the coast and at elevations equal to or greater than 300 feet. All other portions of the island are assumed to be in a high-wind hazard zone.

Previous Occurrences

The most destructive winds in Guam have occurred during typhoons and super typhoons. During Guam's most intensive storms, wind-measuring devices tend to fail. However, the strongest wind gust experienced in recent history in Guam is estimated to be nearly 200 mph during Super Typhoon Karen. **Table 41** shows high wind speeds recorded or estimated during typhoon events passing near or over Guam.

Table 41. High Wind Speeds Recorded or Estimated during Typhoons, 2019-2024

Typhoon Name	Date	Recorded or Estimated Wind Speeds
Super Typhoon Wutip	2/23/2019	155 mph sustained with higher gusts
Super Typhoon Hagibis	10/8/2019	160 mph sustained with higher gusts
Typhoon Bualoi	10/22/2019	100 mph sustained with higher gusts
Typhoon Kammuri	11/27/2019	45 mph sustained with higher gusts
Typhoon Champi	6/22/2021	35 mph sustained with higher gusts
Tropical Storm Omais	8/17/2021	25 mph sustained with higher gusts
Super Typhoon Mawar	5/24/2023	140 mph sustained with higher gusts
Super Typhoon Bolaven	10/10/2023	80 mph sustained with higher gusts

Source: NWS 2024

Table 42 provides a detailed account of the recorded or estimated sustained wind speeds of typhoons that affected Guam between 1950 and 2024. The table includes events such as Super Typhoon Hagibis on October 8, 2019, with sustained winds of a staggering 160 mph, and Super Typhoon Mawar on May 24, 2023, with sustained winds of 140 mph. These records highlight the severity and wind intensity of these tropical systems.

Table 42. Tropical Cyclones within Radius of 180 Nautical Miles from Guam and with Minimum Intensity of 39 mph, 2010-2024

Typhoon Name	Date	CPA Dist.	CPA Intensity	Max Intensity within Radius

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Super Typhoon Wutip	2/23/2019	144.1 NM	155 mph	155 mph
Super Typhoon Hagibis	10/8/2019	178 NM	160 mph	160 mph
Typhoon Buali	10/22/2019	156 NM	100 mph	120 mph
Typhoon Kammuri	11/27/2019	126 NM	45 mph	65 mph
Typhoon Champi	6/22/2021	52 NM	35 mph	40 mph
Tropical Storm Omais	8/17/2021	25 NM	25 mph	25 mph
Super Typhoon Mawar	5/24/2023	17 NM	140 mph	170 mph
Super Typhoon Bolaven	10/10/2023	70 NM	80 mph	85 mph

Table 42 provides a comprehensive list of tropical cyclones that passed within a 180-nautical-mile radius of Guam, specifying the closest point of approach (CPA), CPA intensity, and maximum intensity within the radius. For instance, Super Typhoon Mawar had a CPA of 17 nautical miles, with wind speeds reaching 140 mph at the CPA and a maximum intensity of a staggering 170 mph within the radius. This data highlights the immediate proximity and intensity of tropical cyclones impacting the island.

Probability of Future Events

The risk of severe wind events in Guam remains high due to its location in the western North Pacific, an area frequently impacted by tropical cyclones. Historically, Guam experiences several tropical cyclones annually, with severe winds exceeding 150 mph. The probability of future severe wind events continues to be significant, with tropical cyclones expected to remain a common hazard. The projected changes due to climate change are anticipated to affect the location, range of anticipated intensities, frequency, and duration of these events.

Severe winds from tropical cyclones primarily impact coastal and low-lying areas of Guam, but due to the island's small size, the entire region is susceptible. The range of anticipated intensities is expected to increase, with more intense tropical cyclones likely. Climate change models predict that while the overall number of tropical cyclones may not significantly increase, the intensity of these storms is projected to rise. This means that Guam could face more frequent Category 4 and 5 storms, which bring higher wind speeds and more destructive potential.

Although tropical cyclones' frequency might not dramatically increase, the storms that do occur are likely to be more severe. This is linked to rising sea surface temperatures, which provide more energy to developing storms, potentially leading to longer lasting and more intense tropical cyclones. The duration of severe wind impacts may also increase, with storms possibly slowing down as they pass over the island, leading to prolonged exposure to high winds and related hazards such as heavy rainfall and flooding.

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Note: Modeling of the recurrence intervals for typhoon-induced sustained wind speeds shows that 75 mph wind speeds occur every 4.1 years, 115 mph wind speeds occur every 16.5 years, 150 mph wind speeds occur every 64 years, and 173 mph wind speeds occur every 175 years.

Climate Change Impacts

Climate change is likely to affect the patterns and intensity of severe winds associated with tropical cyclones. Although the overall frequency of cyclones may decrease, the intensity of those that do occur is expected to increase. Higher wind speeds and more intense storms can cause extensive damage to buildings, infrastructure, and vegetation. This trend underscores the need for robust building codes, wind-resistant construction practices, and effective emergency response plans to mitigate potential damage from severe winds. Historical data from Super Typhoon Paka in 1997, which caused extensive wind damage across the island, illustrate the potential impact of severe wind events on Guam.

Summary of Potential Impacts

Guam's vulnerability to severe winds, particularly those associated with tropical cyclones, poses significant risks to state assets, including critical facilities, buildings, infrastructure, and community lifelines. Severe winds from tropical cyclones can cause extensive damage, impacting the functionality and resilience of these assets. The severe winds associated with tropical cyclones are often the most destructive component, especially near the center of the storm where the strongest winds occur. Due to Guam's location in "Typhoon Alley," the island experiences frequent and intense tropical cyclones with winds exceeding 150 mph. These winds can cause significant damage to buildings and infrastructure, necessitating robust mitigation measures and resilient construction practices.

State-owned or operated critical facilities such as healthcare centers, emergency services, and government buildings are crucial for community resilience during and after severe wind events. The table below illustrates Guam's 19 villages' essential facilities, major utilities, transportation systems, and GBS, tailored to address severe wind damage (associated with tropical cyclones). For instance, Dededo has 29 critical facilities valued at \$49,791,364, including the Guam Memorial Hospital and the Northern Regional Community Health Center, essential for healthcare services. Hagatna contains 13 critical facilities valued at \$9,778,188, including key government buildings and emergency services, while Agat hosts 10 critical facilities valued at \$57,607,655, serving as essential hubs for emergency response and community support.

Utilities are critical for maintaining essential services such as electricity, water supply, and telecommunications. The impact on these utilities can have widespread consequences. Dededo houses major utilities valued at \$824,902,167, including power plants and water distribution systems. Piti contains major utilities valued at \$231,174,042, essential for energy supply and distribution. Transportation infrastructure is vital for evacuation, supply distribution, and emergency response. Dededo's transportation systems are valued at \$18,736,169, facilitating movement and logistics,

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while Piti's transportation infrastructure is valued at \$920,615,173, critical for connectivity and commerce. General buildings, including residential, commercial, and public buildings, represent significant investments and are crucial for housing, commerce, and services. Dededo's GBS is valued at \$250,402,402, including residential and commercial properties, while Barrigada's GBS is valued at \$279,896,573, hosting a mix of residential, commercial, and public buildings. The potential dollar losses to state assets from severe winds are considerable. For instance, Dededo faces significant risk, with major utilities valued at \$824,902,167 and a general building stock of \$250,402,402. If severe winds impact these utilities and buildings with a damage ratio of 15%, the potential loss could be approximately \$161,485,366 for utilities and \$37,560,360 for buildings. Barrigada's transportation systems, valued at \$75,681,659, could face a potential financial loss of around \$11,352,249 with a 15% damage ratio. Piti's major utilities, valued at \$231,174,042, could see potential losses of approximately \$34,676,106 at a 15% damage ratio, and Agat's critical facilities, valued at \$57,607,655, could face potential losses of around \$8,641,148 with a 15% damage ratio.

The most vulnerable assets include healthcare facilities such as the Guam Memorial Hospital in Dededo and health centers in other high-risk villages, utilities like power plants and water systems in Dededo and Piti, transportation infrastructure in Piti and Barrigada, and critical government buildings in Hagatna and Agat, which are essential for emergency response and public administration. These figures underscore the need for robust mitigation strategies and financial planning to protect and recover state assets from severe wind impacts .

Guam's state assets, including critical facilities, utilities, transportation systems, and general building stock, are highly vulnerable to severe winds associated with tropical cyclones. The potential dollar losses are significant, highlighting the need for targeted mitigation efforts, resilient infrastructure development, and comprehensive disaster management strategies to protect these vital assets and ensure the island's resilience to severe wind hazards .

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Amount			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	116	0	0	0	0	0	0	0	0
Agat	2.19	3,574	10	57,607,655	5	26,546,474	33	3,826,745	331	44,453,964
Asan/Maina	2.66	1,415	2	13,329,855	5	23,661,762	12	9,252,396	230	34,673,571
Barrigada	2.12	3,246	2	14,811,232	5	12,359,828	11	75,681,659	1,331	279,896,573
Chalan Pago-Ordot	0.74	115	2	2,223,415	1	11,938,970	0	0	20	3,202,838
Dededo	2.56	36,279	29	49,791,364	80	824,902,167	58	18,736,169	10,537	250,402,402
Hagatna (Agana)	0.43	300	13	9,778,188	2	13,204,685	29	17,960,700	135	86,635,308
Inarajan	6.11	1,173	7	2,563,222	7	36,867,602	25	26,337,211	348	40,135,051
Mangilao	0.81	6,282	6	35,975,991	18	59,929,943	24	4,118,561	628	132,197,694
Merizo	1.74	814	4	1,824,950	11	13,046,993	27	9,365,191	171	19,693,650
Mongmong-Toto-Maite	0.51	129	0	0	1	1,265,509	0	0	7	2,103,467
Piti	1.17	630	8	8,893,796	8	231,174,042	34	920,615,173	214	45,825,638
Santa Rita	4.19	2,275	0	0	6	34,243,393	4	815,456	118	16,796,158
Sinajana	0	0	0	0	0	0	0	0	0	0
Taloforo	5.15	1,823	4	3,085,409	5	34,086,166	17	539,934	484	75,472,933
Tamuning/Tumon	1.74	2,749	24	490,477,240	5	55,498,854	18	14,928,314	120	90,183,967
Umatac	2.28	475	6	4,025,644	16	82,922,719	20	9,143,821	67	7,008,574
Yigo	7.48	18,017	12	20,098,671	33	113,389,313	50	14,641,606	4,757	690,909,073
Yona	3.61	291	6	103,602,444	8	80,385,169	16	9,367,300	313	62,559,267
Total	45.86	79,405	135	818,089,067	215	1,655,423,589	376	1,135,330,237	19,812	1,882,150,128

%			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	2.91	2.94	0	0	0	0	0	0	0	0
Agat	63.18	63.19	45	84.23	55.56	54.24	100	93.71	20.99	20.99
Asan	67.72	67.71	40	88.31	50	50	66.67	73.76	45.69	45.69
Barrigada	37.53	37.52	8.33	33.13	29.41	51.77	20	8.39	28.49	28.49
Chalan Pago	1.95	1.95	25	21.75	5.26	46.02	0	0	2.81	2.81
Dededo	84.4	84.41	77.14	78.14	83.33	95.37	38.89	36.79	74.21	74.21
Hagatna	27.06	27.31	30	21.65	50	95.39	50	38.77	40.13	40.13
Inarajan	38.42	38.45	46.67	8.17	41.18	44.12	66.67	74.33	55.64	55.64
Mangilao	47.18	47.19	21.43	37.43	64.29	78.87	40	28.06	47.4	47.4
Merizo	37.58	37.62	40	28.04	68.75	48.03	100	98.07	44.81	44.81
Mongmong	2.2	2.2	0	0	14.29	13.83	0	0	1.82	1.82
Piti	37.82	37.83	42.11	46.66	69.23	41.14	81.82	99.27	40.94	40.94
Santa Rita	30.33	30.33	0	0	50	59.03	20	6.81	26.86	26.86
Sinajana	0	0	0	0	0	0	0	0	0	0
Taloforo	47.36	47.38	50	71.42	55.56	84.48	100	58.95	50.57	50.57
Tamuning	15.26	15.26	30.12	60.09	21.74	37.46	13.33	15.4	7.64	7.64
Umatac	53.53	53.58	66.67	82.35	84.21	88.27	66.67	51.19	48.11	48.11
Yigo	92.51	92.52	100	100	100	100	100	100	99.98	99.98
Yona	41.53	4.49	50	96.24	47.06	50.99	50	42.83	18.74	18.74
Total	55.22	52.84	36.9	57.55	59.94	59.57	39.1	76.95	46.57	23.46

Jurisdictions' Vulnerability

Guam's vulnerability to tropical cyclones is not just significant, it is alarming. Located in the western North Pacific, one of the world's most active regions for tropical storms, Guam is constantly under threat. Tropical cyclones, including tropical depressions, tropical storms, and super typhoons, pose severe threats due to destructive winds, heavy rainfall, storm surges, and associated flooding. Tropical cyclones in Guam can produce sustained winds over 150 mph, powerful storm surges, and torrential rains, sometimes exceeding 20 inches in a single day. Villages such as Dededo, Yigo, and Mangilao are particularly threatened due to their large populations and extensive built environments. The probability of intense tropical cyclones is expected to increase with climate change, leading to higher wind speeds and increased rainfall rates during these events. **Table 43** showcases Dededo, with an SVI of 0.78 and 28,298 individuals (66% of its population) exposed, is one of the most threatened villages. Yigo, with an SVI of 0.61 and 10,991 individuals (56% of its population) exposed to tropical cyclone hazards, and Mangilao, with an SVI of 0.72 and 4,523 individuals (34% of its population) exposed, also indicate significant vulnerability.

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Table 43

Village	Village SVI	Vulnerable Exposed	Vulnerable Exposed
Agana Heights	0.28	32	1%
Agat	1	3,574	63%
Asan/Maina	0.11	156	7%
Barrigada	0.44	1,428	17%
Chalan Pago-Ordot	0.33	38	1%
Dededo	0.78	28,298	66%
Hagatna (Agana)	0.89	267	24%
Inarajan	0.39	458	15%
Mangilao	0.72	4,523	34%
Merizo	0.94	765	35%
Mongmong-Toto-Maite	0.83	107	2%
Piti	0	0	0%
Santa Rita	0.06	136	2%
Sinajana	0.56	0	0%
Talofofo	0.22	335	10%
Tamuning/Tumon	0.17	467	3%
Umatac	0.67	318	36%
Yigo	0.61	10,991	56%
Yona	0.5	146	2%
Total		52,040	

The impact of tropical cyclones on socially vulnerable and underserved communities in Guam is severe. Villages with high SVIs, such as Agat and Merizo, are home to significant populations that are likely to be disproportionately affected by these hazards. Agat, with an SVI of 1.00 and 3,574 individuals (63% of its population) exposed, is a prime example of a village with a high concentration of vulnerable populations. Similarly, Merizo, with an SVI of 0.94 and 765 individuals (35% of its population) exposed, highlights the heightened vulnerability of these communities. Critical facilities in Guam's high-risk villages are also at significant risk. Essential facilities such as healthcare centers, emergency services, and infrastructure in villages like Dededo, Yigo, and Hagatna are particularly vulnerable. Dededo, with numerous critical facilities, is highly susceptible to structural damage and operational disruptions during tropical cyclones. Hagatna, with an SVI of 0.89 and 267 individuals (24% of its population) exposed, also contains significant infrastructure at risk.

Tropical cyclones pose a significant threat to the infrastructure and community lifelines that are crucial for Guam's resilience, including safety and security, food, water, shelter,

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health and medical services, energy, communications, transportation, and hazardous material management. Villages like Mongmong-Toto-Maite, with an SVI of 0.83 and 107 individuals (2% of its population) exposed, have essential lifelines that could be severely impacted by tropical cyclones. Tamuning/Tumon, with an SVI of 0.17 and 467 individuals (3% of its population) exposed, also have significant infrastructure at risk. The potential losses to vulnerable structures in Guam due to tropical cyclones are substantial. The estimated value of structures and infrastructure at risk in highly vulnerable villages such as Dededo, Yigo, and Mangilao indicates significant financial impacts. Dededo, with 28,298 individuals exposed, highlights the scale of potential human and structural loss. Similarly, Yigo and Mangilao have large populations and critical facilities at risk, necessitating robust mitigation strategies to protect these assets. Furthermore, the potential dollar losses from tropical cyclones are significant. For instance, Barrigada's transportation systems have a high value of approximately \$902,046,000; if a tropical cyclone impacts this infrastructure with a conservative damage ratio of 15%, the potential financial loss could be around \$135,306,900. Similarly, Dededo has utilities valued at \$864,949,321 and GBS totaling \$3,374,695,451, indicating a high concentration of assets that could sustain considerable financial losses in a severe cyclone.

Summary of Recent and Project Developments in the Hazard Prone Area

Recent developments in Guam have seen significant changes in land use and the built environment, particularly in areas prone to severe wind hazards such as those from tropical cyclones. The construction boom driven by civilian and military projects has increased the number of buildings and infrastructure across the island. The tables from Section 4.9.1 highlights that Dededo and Yigo have seen the highest numbers of building permits issued for new structures, indicating substantial growth in these areas. This development includes residential, commercial, and public buildings that enhance the built environment and increase exposure to severe wind hazards.

Guam's population dynamics have evolved, with certain villages experiencing significant demographic changes that impact vulnerability to severe wind events. Dededo, Mangilao, and Yigo are among the most populated villages, with Dededo alone having a population of 44,908. These areas have higher concentrations of socially vulnerable and underserved communities, such as low-income households and elderly populations, which are more susceptible to the impacts of severe wind hazards. The SVI further highlights villages like Agat and Merizo as having high vulnerability scores, indicating the presence of populations that might face more significant challenges during severe wind events.

State assets, including critical facilities, major utilities, and transportation systems, have also seen changes in their vulnerability due to recent developments. The construction of new facilities, such as the Ukudu Power Plant in Dededo and various healthcare centers, has expanded the infrastructure base. However, this expansion increases the potential impact of severe wind events on these assets. Table F-1 from Section 4.9.1 provides a detailed assessment of the value of these assets, highlighting substantial investments in areas prone to severe winds. For instance, the new power plants and

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treatment facilities are essential but vulnerable components of Guam's infrastructure, necessitating robust mitigation measures to withstand severe winds.

The increase in development activities, especially in high-risk jurisdictions such as Dededo, Yigo, and Tamuning/Tumon, has heightened the exposure to severe wind hazards. These areas, identified through local risk assessments as being highly susceptible to severe winds due to their geographical location and built environment, are witnessing significant growth. The anticipated increase in tropical cyclone intensity due to climate change further exacerbates the risk. With new residential and commercial buildings, along with critical infrastructure projects underway, the potential for damage and loss from severe winds is substantial.

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5.5.10 Terrorism

Human-Caused

The definition of terrorism encompasses various forms, including assassinations, kidnappings, cyber-attacks, and the use of chemical, biological, nuclear, and radiological weapons. Concerns about bioterrorism and emerging infectious diseases persist. While Guam has not experienced any of these types of major terrorist events, Guam holds a strategic position as a territory in the United States. Its proximity to Asia and North Korea necessitates constant vigilance in monitoring regional developments. Domestic and foreign adversaries will likely continue to target our critical infrastructure over the next year, in part because they perceive targeting these sectors would be detrimental to US industries and the American way of life. While cyber-attacks seeking to compromise networks or disrupt services for geopolitical or financial purposes continue apace, we noted an uptick over the last year of physical attacks on critical infrastructure. Climate change, natural disasters, and technological advances have the potential to compound many of these threats. Climate-related disasters, such as heat waves, droughts, wildfires, coastal storms, and inland flooding, have the potential to disrupt regional economies, foster health crises like disease outbreaks, and tax law enforcement resources.

Location

The Department of Homeland Security's National Planning Scenario continues to identify potential terrorist strike locations. Places in Guam judged to be at risk include cities, such as Dededo and Tamuning/Tumon; places that have economic and symbolic value, such as Agana Heights and Yigo; places with hazardous facilities; and areas where large groups of people congregate, such as office buildings and sports arenas. However, it is also believed that terrorists may begin to target small rural communities, to target pesticide facilities, chemical plants, the water supply, dams, energy sectors, or agriculture. The possibility of a missile attack on Guam underscores the critical importance of hazard mitigation planning. By assessing vulnerabilities, enhancing infrastructure resilience, and fostering community preparedness, hazard mitigation planning aims to minimize the consequences of such events. By implementing mitigation measures, we protect both people and critical infrastructure.

This includes cybersecurity threats to critical infrastructure and services such as healthcare, utilities, education, and public safety. In the digital age, cybersecurity has become a critical aspect of national security. Cyber-attacks can disrupt essential services, compromise sensitive data, and cause significant economic damage. Various actors can carry them out, including terrorists, nation-states, criminal organizations, enterprises, or even human error.

Recognizing this threat, the Offices of Guam Homeland Security and Civil Defense (GHS-OCD), the Mariana Regional Fusion Center, and the Guam Office of Technology developed the Island-wide Cybersecurity Plan. This plan was approved by the U.S. Department of Homeland Security's Cybersecurity & Infrastructure Security Agency (CISA) in November 2023. The approval signifies that the plan has met the FY22 State and Local Cybersecurity Grant Program (SLCGP) statutory requirements outlined in the Homeland Security Act of 2002, § 2220A(i).

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The government of Guam, a key player, provides guidance and supports many critical services, such as healthcare, utilities, education, and public safety, all of which own or manage sensitive data. Protecting Guam's information assets from an intentional attack or unintentional misuse is paramount to the government's ability to continue to provide critical services to the people of Guam. This underscores the necessity and importance of the Island-wide.

Cybersecurity Plan in our daily operations. As a crucial entity, the government of Guam offers direction and assistance across vital sectors such as healthcare, utilities, education, and public safety, all of which handle sensitive data. Safeguarding Guam's information resources from deliberate attacks or inadvertent misuse is essential for the government to sustain its provision of critical services to the populace. This highlights the vital role and significance of the Island-wide Cybersecurity Plan in our day-to-day activities.

The essence of Guam's cybersecurity plan embodies the Governor of Guam's fundamental obligation and commitment to safeguard the lives and assets of the island community in the pursuit of national security. Collaborating closely with federal partners, the government of Guam remains dedicated to bolstering the resilience of Guam's critical infrastructure post-Typhoon Mawar. This includes exploring potential measures to enhance cybersecurity and fortify the resilience of key infrastructures like energy, water, homeland defense, finance, and health.

Previous Occurrences

In 2024, we expect the threat of violence from violent extremists radicalized in the United States will remain high but largely unchanged from the threat as described in the May 2023 National Threat Advisory System (NTAS) bulletin. Over the past year, both domestic violent extremists (DVEs) and homegrown violent extremists (HVEs) inspired by foreign terrorist organizations have engaged in violence in reaction to sociopolitical events. These actors will continue to be inspired and motivated by a mix of conspiracy theories; personalized grievances; and enduring racial, ethnic, religious, and anti-government ideologies, often shared online.

Foreign terrorist groups like al-Qa'ida and ISIS are seeking to rebuild overseas, and they maintain worldwide networks of supporters that could seek to target the Homeland. Among state actors, we expect Iran to remain the primary sponsor of terrorism and continue its efforts to advance plots against individuals in the United States.

Foreign terrorists continue to engage with supporters online to solicit funds, create and share media, and encourage attacks while their affiliates in Africa, Asia, and the Middle East prioritize local goals. Since the US withdrawal from Afghanistan, ISIS's regional branch—ISIS-Khorasan—has garnered more prominence through a spate of high-casualty attacks overseas and English-language media releases that aim to globalize the group's local grievances among Western audiences. Individuals with terrorism connections are interested in using established travel routes and permissive environments to facilitate access to the United States.

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In addition to targeting US critical infrastructure for destructive and disruptive attacks, adversaries continue to use cyber and physical espionage tactics to access and steal sensitive information from US critical infrastructure networks. Such information enables pre-positioning for future attacks, gaining insight into our attack response capabilities, and exfiltrating sensitive data for criminal profit or follow-on intelligence activities.

Chinese government cyber actors likely will continue to target key critical infrastructure sectors in the United States, including healthcare and public health, financial services, the defense industrial base, government facilities, and communications. Beijing's expansion of maritime logistics capabilities and the use of commercial Chinese logistics technologies increase the risk of espionage and potential disruption operations at ports.

Probability of Future Events

With terrorism evolving swiftly and cyber threats becoming more prevalent, it's crucial to remain vigilant and continuously improve our efforts to mitigate these risks. The approval and execution of Guam's Island-wide Cybersecurity Plan represent significant achievements in this ongoing endeavor. Considering the current cybersecurity landscape, the unpredictable and widespread nature of cyber-attacks could seriously jeopardize Guam's critical infrastructure. Therefore, it's imperative to continually monitor, rigorously assess, and promptly update our mitigation strategies to ensure Guam's safety and security. Hazard mitigation planning remains our cornerstone, fortifying resilience against all forms of threat. It involves proactive measures to reduce risks and enhance our ability to respond effectively to any threat, including all forms of terrorism.

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5.5.11 Tropical Cyclone

Nature

A tropical cyclone is a general term for an intense, circulating storm that covers all of the following terms: tropical depression, tropical storm, typhoon, and super typhoon.

Tropical cyclones occur over tropical and subtropical oceans. These storms are low-pressure weather systems that range in size from 120 to 1,500 miles across. In the northern hemisphere, the low-level winds of a tropical cyclone blow counter-clockwise around a center of organized, deep thunderstorms, where the strongest winds generally reside. The various names or classifications for tropical cyclones relate to the intensities of the storms:

- A tropical depression has maximum sustained winds of 38 mph. A tropical depression has a closed circulation. The Joint Typhoon Warning Center generally issues warnings when the circulation reaches 29 mph.
- A tropical storm has maximum sustained winds in the range of 39 to 73 mph.
- A typhoon has maximum sustained winds in the range of 74 mph or greater.
- A super typhoon is a special class of typhoon that has maximum sustained winds of 150 mph or greater.

The size and intensity of a tropical cyclone are not related. Small, very intense typhoons and large, relatively weak typhoons are possible. A large-diameter tropical cyclone may miss a landmass by a large distance and still result in heavy rains and high winds on the landmass, but the center of the storm, which is where the storm is most intense, would have missed the landmass. A small-diameter tropical cyclone of the same intensity needs to make a direct or nearly direct hit on a landmass to cause substantial damage. In this situation, the center of the small-diameter tropical cyclone would have hit or nearly hit the landmass, likely resulting in heavy damage.

Tropical cyclones can occur at any time in the western North Pacific Ocean, and the route or track that a tropical cyclone follows can vary. These storms can intensify rapidly or remain at relatively low intensity (i.e., remain a tropical depression) for their whole existence. To a certain extent, meteorologists can forecast the track that a tropical cyclone will likely take, the intensity of a tropical cyclone when it makes landfall, and the amount of time a tropical cyclone will take to make landfall, but many exceptions and errors can occur in forecasting for a tropical cyclone.

The disastrous effect of tropical cyclones on islands in the western North Pacific Ocean can be subclassified into several hazards causing widespread damage. Each of the following hazards that may be associated with a tropical cyclone is addressed separately and can be found in the following sections.

- Section 5.5.1 (Coastal Erosion)
- Section 5.5.4 (Flooding)
- Section 5.5.5 (High Surf)
- Section 5.5.8 (Severe Wind)

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Location

All of Guam is susceptible to a tropical cyclone. Most tropical cyclones that pass near Guam are moving in a westward direction. 60 percent have approached Guam from the east through the southeast, 19 percent have approached from the southeast through the south, and 7 percent have approached from the northeast through the east.

Anticipated Intensity

The intensity of tropical cyclones and their impacts are systematically assessed using the Saffir-Simpson Tropical Cyclone Scale, specifically modified for the Pacific region. This adaptation allows for a detailed categorization of typhoons based on their sustained wind speeds, essential for predicting potential damage and storm surge levels. The scale classifies tropical cyclones into various categories, starting from “Severe Tropical Storm” with winds of 74-95 mph, which can cause moderate damage; it progresses to a “Catastrophic” Category 5 typhoon with wind speeds exceeding 156 mph, where damage is often extensive and devastating. Each category is linked to expected levels of structural damage and elevated water levels over reefs, providing vital information for disaster response and preparedness.

Previous Occurrences

Guam, situated in the western North Pacific Ocean, is part of the infamous “Typhoon Alley,” where a third of the world’s tropical cyclones form. From 1900 to 2013, Guam has experienced a staggering 202 tropical cyclones. While records before 1946 may be incomplete, it’s estimated that about 85 of these cyclones, including at least 61 typhoons or super typhoons, have made landfall in Guam, bringing with them severe winds, heavy rainfall, and flooding.

Historical records from 1900 to 2013 have accounted for 86 fatalities and 461 injuries related to tropical cyclone and monsoon-related hazards. Significant events include Presidential Disaster Declarations for six tropical cyclones: Typhoon Russ, Super Typhoon Yuri, Super Typhoon Paka, Typhoon Chata’an, Super Typhoon Pongsona, and Typhoon Tingting.

In this context, Typhoon Mawar is a recent and powerful reminder of the potential for severe typhoon impacts on Guam. Typhoon Mawar landed on May 24, 2023, bringing winds exceeding 150 mph and torrential rains. As a Category 4 typhoon on the Saffir-Simpson scale, it was one of the most powerful storms to hit the island in recent history. The storm’s path left widespread damage, severely affecting nearly all villages, particularly Dededo, Barrigada, and Mangilao. The storm surge and heavy rainfall caused extensive flooding, especially in low-lying areas. Dededo, housing significant state assets, experienced severe infrastructure damage, including essential facilities, major utilities, and transportation systems. Barrigada saw extensive damage to government buildings and services, while Mangilao faced significant disruptions due to utility outages and transportation system failures.

Guam’s history with typhoons is long and marked by significant events such as Typhoon Pongsona in 2002 and Typhoon Dolphin in 2015. Typhoon Pongsona, a Category 4 storm, caused widespread destruction and prolonged power outages. Typhoon Dolphin,

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a Category 2 storm, brought significant rainfall and flooding, although it was less intense than Typhoon Mawar. These events serve as reminders of the potential for severe weather and the importance of preparedness. In summary, Guam's vulnerability to tropical cyclones, highlighted by Typhoon Mawar and historical data, highlights the necessity for ongoing risk assessments and effective mitigation measures.

Probability of Future Events

Overview of Future Hazard Events

Historical data show 12 typhoons passing over Guam between 1923 and 2002 in which the eye of the storm passed over the island. This methodology assumes that the most devastating typhoons to have struck Guam occur when the eye of a typhoon passes over the island. However, several of the typhoons with very high recorded wind speeds on Guam did not have their eye pass over the island. For instance, the eye of Typhoon Dale (1996) did not pass over Guam, but it produced 98 mph sustained winds. Typhoon Kim in 1977, whose eye passed over Guam, had sustained winds recorded at 89 mph.

In WERI (1999), a risk assessment was conducted for the probability and magnitude of tropical cyclones to occur on Guam primarily using the HURISK (Hurricane Risk) Model. The HURISK Model was developed in 1987 for the NWS-WFO Tropical Prediction Center in Miami, Florida. The model uses multiple inputs (including the historical tracks of tropical cyclones, the radius of their maximum winds, the time and location of their landfall, and the rate of storm decay afterlandfall). HURISK has been modified for the western North Pacific Ocean and is currently the most developed and comprehensive model for tropical cyclone risk for the area. WERI used a relatively comprehensive dataset of 1,469 storms that occurred near Guam during the period 1945 through 1997. WERI (1999) determined that a 73.8 percent chance existed that a tropical storm or typhoon will come within 86 miles of Guam with sustained winds of readily 40 mph for any year and a 46.3 percent chance of a typhoon for any given year. Within any 5 years, a 99.9 percent probability exists that a tropical cyclone will come within 86 miles of Guam with at least sustained winds of 40 mph and a 95.6 percent probability of a typhoon occurrence for any given year.

In expressing typhoon recurrence through wind speeds, the average return period for minimally strong typhoon-induced sustained winds to be experienced on Guam (i.e., approximate sustained wind speeds of 75 mph) will be 4.4 years. The approximate sustained wind speed of a 100-year storm on Guam was calculated to be approximately 160 mph, a 50-year storm was calculated to have approximate sustained wind speeds of 150 mph, and a 20-year storm was calculated to have a sustained wind speed of approximately 120 mph. Therefore, a 20-year storm would carry the intensity of Typhoon Omar in 1992 and a 50-year storm would roughly carry the intensity of Super Typhoon Paka in 1997 or Super Typhoon Pongsona in 2002.

In summary, WERI (1999) indicated a high probability of tropical cyclones affecting Guam due to its geographic location in a highly active typhoon zone. The evaluation utilizes historical data, climatological studies, and the HURISK model to project changes in tropical cyclones' frequency, duration, and intensity. Also, it highlights that Guam

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faces a continuous threat from tropical cyclones, with varying impacts based on the strength and path of individual storms. The study categorizes typhoons based on the modified Saffir-Simpson scale, which outlines the range of anticipated intensities from severe tropical storms to catastrophic Category 5 typhoons.

It should be noted that the risk assessment performed by WERI did not include storm events from more recent years, such as Typhoon Chaba, Typhoon Tingting, Typhoon Chata'an, Typhoon Halong, and Super Typhoon Pongsona. It is likely that the inclusion of these more recent intense typhoon events would change the probability and magnitude calculations performed by WERI. However, currently, the risk assessment performed by WERI is the best and most comprehensive forecast performed to date.

Probability and Consideration of Changing Future Conditions

In considering future conditions, the study acknowledges the impacts of climate change, which include rising average temperatures, changes in long-term weather patterns, and rising sea levels. These factors likely influence tropical cyclones' type, location, and intensity. Warmer sea surface temperatures could increase typhoons' intensity and frequency, leading to more severe weather events impacting Guam. Additionally, rising sea levels could exacerbate the effects of storm surges associated with these events, increasing the risk of flooding and coastal erosion.

The risk assessment integrates these aspects by predicting longer and more intense typhoon seasons and a possible shift in the paths that typhoons might take as they approach Guam. This anticipatory approach allows for better planning and preparedness for potential future scenarios that could affect the island. Based on these projections, adjustments to building codes, infrastructure resilience, and evacuation plans are recommended.

Climate Change Impacts

In considering future conditions, the WERI study acknowledges the impacts of climate change, which include rising average temperatures, changes in long-term weather patterns, and rising sea levels. These factors likely influence tropical cyclones' type, location, and intensity. Warmer sea surface temperatures could increase typhoons' intensity and frequency, leading to more severe weather events impacting Guam. Additionally, rising sea levels could exacerbate the effects of storm surges associated with these events, increasing the risk of flooding and coastal erosion.

The risk assessment integrates these aspects by predicting longer and more intense typhoon seasons and a possible shift in the paths that typhoons might take as they approach Guam. This anticipatory approach allows for better planning and preparedness for potential future scenarios that could affect the island. Based on these projections, adjustments to building codes, infrastructure resilience, and evacuation plans are recommended.

Summary of Potential Impacts

The vulnerability of territorial assets in Guam to tropical cyclones is significant, as these assets include state-owned or operated critical facilities, buildings, infrastructure, and

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community lifelines essential for the island's resilience. Critical facilities such as healthcare centers, emergency services, government buildings, and schools are necessary for the functioning of communities and the provision of critical services during and after tropical cyclone events. Data on Guam's 19 villages' essential facilities, major utilities, transportation systems, and GBS are used for the following assessment analysis. For example, Dededo has 29 critical facilities valued at \$49,791,364, including the Guam Memorial Hospital and the Northern Regional Community Health Center, which are crucial for providing healthcare services. Hagatna contains 13 critical facilities valued at \$9,778,188, including key government buildings and emergency services, while Agat hosts 10 critical facilities valued at \$57,607,655, serving as essential hubs for emergency response and community support.

Utilities are critical for maintaining essential services such as electricity, water supply, and telecommunications. The impact on these utilities can have widespread consequences. Dededo houses major utilities valued at \$824,902,167, including power plants and water distribution systems. Piti contains major utilities valued at \$231,174,042, essential for energy supply and distribution. Transportation infrastructure is vital for evacuation, supply distribution, and emergency response. Dededo's transportation systems are valued at \$18,736,169, facilitating movement and logistics, while Piti's transportation infrastructure is valued at \$920,615,173, critical for connectivity and commerce. General residential, commercial, and public buildings represent significant investments crucial for housing, commerce, and services. Dededo's GBS is valued at \$250,402,402, including residential and commercial properties, while Barrigada's GBS is valued at \$279,896,573, hosting a mix of residential, commercial, and public buildings.

The potential dollar losses to state assets from tropical cyclones can be substantial, affecting various aspects of the island's infrastructure and economy. For instance, Dededo faces significant risk, with major utilities valued at \$824,902,167 and a general building stock of \$250,402,402. If a tropical cyclone impacts these utilities and buildings with a damage ratio of 15%, the potential loss could be approximately \$161,485,366 for utilities and \$37,560,360 for buildings. Barrigada's transportation systems, valued at \$75,681,659, could face a possible financial loss of around \$11,352,249 with a 15% damage ratio. Piti's significant utilities, valued at \$231,174,042, could see potential losses of approximately \$34,676,106 at a 15% damage ratio, and Agat's critical facilities, valued at \$57,607,655, could face potential losses of around \$8,641,148 with a 15% damage ratio.

The most vulnerable assets include healthcare facilities such as the Guam Memorial Hospital in Dededo and health centers in other high-risk villages, utilities like power plants and water systems in Dededo and Piti, transportation infrastructure in Piti and Barrigada, and critical government buildings in Hagatna and Agat, which are essential for emergency response and public administration. These figures underscore the need for robust mitigation strategies and financial planning to protect and recover state assets from tropical cyclone impacts. Guam's state assets, including critical facilities, utilities, transportation systems, and general building stock, are highly vulnerable to tropical

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cyclones. The potential dollar losses are significant, highlighting the need for targeted mitigation efforts, resilient infrastructure development, and comprehensive disaster management strategies to protect these vital assets and ensure the island's resilience to tropical cyclone hazards.

Table F-31 Total in Tsunami Inundation Zone			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	116	0	0	0	0	0	0	0	0
Agat	2.19	3,574	10	57,607,655	5	26,546,474	33	3,826,745	331	44,453,964
Asan/Maina	2.66	1,415	2	13,329,855	5	23,661,762	12	9,252,396	230	34,673,571
Barrigada	2.12	3,246	2	14,811,232	5	12,359,828	11	75,681,659	1,331	279,896,573
Chalan Pago-Ordot	0.74	115	2	2,223,415	1	11,938,970	0	0	20	3,202,838
Dededo	2.56	36,279	29	49,791,364	80	824,902,167	58	18,736,169	10,537	250,402,402
Hagatna (Agana)	0.43	300	13	9,778,188	2	13,204,685	29	17,960,700	135	86,635,308
Inarajan	6.11	1,173	7	2,563,222	7	36,867,602	25	26,337,211	348	40,135,051
Mangilao	0.81	6,282	6	35,975,991	18	59,929,943	24	4,118,561	628	132,197,694
Merizo	1.74	814	4	1,824,950	11	13,046,993	27	9,365,191	171	19,693,650
Mongmong- Toto-Maite	0.51	129	0	0	1	1,265,509	0	0	7	2,103,467
Piti	1.17	630	8	8,893,786	8	231,174,042	34	920,615,173	214	45,825,638
Santa Rita	4.19	2,275	0	0	6	34,243,393	4	815,456	118	16,796,158
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	1,523	4	3,085,409	5	34,086,166	17	539,934	484	75,472,933
Tamuning/Tumon	1.74	2,749	24	490,477,240	5	55,498,854	18	14,928,314	120	90,183,967
Umatac	2.28	475	6	4,025,644	16	82,922,719	20	9,143,821	67	7,008,574
Yigo	7.48	18,017	12	20,098,671	33	113,389,313	50	14,641,606	4,757	690,909,073
Yona	3.61	291	6	103,602,444	8	80,385,169	16	9,367,300	313	62,559,267
Total	45.86	79,405	135	818,089,067	215	1,655,423,589	376	1,135,330,237	19,812	1,882,150,128
Table F-32 Proportion in Tsunami Inundation Zone			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	2.91	2.94	0	0	0	0	0	0	0	0
Agat	63.18	63.19	45	84.23	55.56	54.24	100	93.71	20.99	20.99
Asan	67.72	67.71	40	88.31	50	50	66.67	73.76	45.69	45.69
Barrigada	37.53	37.52	8.33	33.13	29.41	51.77	20	8.39	28.49	28.49
Chalan Pago-	1.95	1.95	25	21.75	5.26	46.02	0	0	2.81	2.81
Dededo	84.4	84.41	77.14	78.14	83.33	95.37	38.89	36.79	74.21	7.42
Hagatna	27.06	27.31	30	21.65	50	95.39	50	38.77	40.13	40.13
Inarajan	38.42	38.45	46.67	8.17	41.18	44.12	66.67	74.33	55.64	55.64
Mangilao	47.18	47.19	21.43	37.43	64.29	78.87	40	28.06	47.4	47.4
Merizo	37.58	37.62	40	28.04	68.75	48.03	100	98.07	44.81	44.81

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Mongmong-	2.2	2.2	0	0	14.2 9	13.83	0	0	1.82	1.82
Piti	37.82	37.83	42.1 1	46.66	69.2 3	41.14	81.8 2	99.27	40.94	40.94
Santa Rita	30.33	30.33	0	0	50	59.03	20	6.81	26.86	26.86
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	47.36	47.38	50	71.42	55.5 6	84.48	100	58.95	50.57	50.57
Tamuning/	15.26	15.26	30.1 2	60.09	21.7 4	37.46	13.3 3	15.4	7.64	7.64
Umatac	53.53	53.58	66.6 7	82.35	84.2 1	88.27	66.6 7	51.19	48.11	48.11
Yigo	92.51	92.52	100	100	100	100	100	100	99.98	99.98
Yona	41.53	4.49	50	96.24	47.0 6	50.99	50	42.83	18.74	18.74

Jurisdictions' Vulnerability

Guam's vulnerability to tropical cyclones is significant, given its location in the western North Pacific, one of the world's most active regions for tropical storms. Tropical cyclones, including tropical depressions, tropical storms, and super typhoons, pose severe threats due to destructive winds, heavy rainfall, storm surges, and associated flooding. Tropical cyclones in Guam can produce sustained winds over 150 mph, powerful storm surges, and torrential rains, sometimes exceeding 20 inches in a single day. Dededo, Yigo, and Mangilao are threatened due to their large populations and extensive built environments. The probability of intense tropical cyclones is expected to increase with climate change, leading to higher wind speeds and increased rainfall rates during these events. Shown in **Table 44**, Dededo, with an SVI of 0.78 and 28,298 individuals (66% of its population) exposed, is one of the most threatened villages. Yigo, with an SVI of 0.61 and 10,991 individuals (56% of its population) exposed to tropical cyclone hazards, and Mangilao, with an SVI of 0.72 and 4,523 individuals (34% of its population) exposed, also indicate significant vulnerability.

Table 44

Village	Village SVI	Vulnerable Exposed	Vulnerable Exposed
Agana Heights	0.28	32	1%
Agat	1	3,574	63%
Asan/Maina	0.11	156	7%
Barrigada	0.44	1,428	17%
Chalan Pago-Ordot	0.33	38	1%
Dededo	0.78	28,298	66%
Hagatna (Agana)	0.89	267	24%
Inarajan	0.39	458	15%
Mangilao	0.72	4,523	34%
Merizo	0.94	765	35%
Mongmong- Toto-Maite	0.83	107	2%
Piti	0	0	0%
Santa Rita	0.06	136	2%
Sinajana	0.56	0	0%
Talofofo	0.22	335	10%

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Tamuning/Tumon	0.17	467	3%
Umatac	0.67	318	36%
Yigo	0.61	10,991	56%
Yona	0.5	146	2%
Total		52,040	

During tropical cyclones, socially vulnerable and underserved communities in Guam are at heightened risk. Villages with high SVIs, such as Agat and Merizo, have substantial vulnerable populations that are probably disproportionately affected by these hazards. Agat, with an SVI of 1.00 and 3,574 individuals (63% of its population) exposed, has a high concentration of vulnerable populations. Similarly, Merizo, with an SVI of 0.94 and 765 individuals (35% of its population) exposed to tropical cyclone risks, emphasizes the heightened vulnerability due to demographic changes. These shifts necessitate focused mitigation and preparedness strategies to protect these vulnerable populations. Critical facilities in Guam's high-risk villages are particularly vulnerable to tropical cyclone damage. Essential facilities such as the Guam Memorial Hospital and the Northern Regional Community Health Center in Dededo, the Yigo Fire Station, Hagatna's emergency services, and government buildings are at increased risk. Dededo contains numerous critical facilities, making it highly vulnerable to structural damage and operational disruptions during tropical cyclones. Hagatna, with an SVI of 0.89 and 267 individuals (24% of its population) exposed, also contains significant infrastructure at risk.

Tropical cyclones threaten the infrastructure and community lifelines essential for Guam's resilience, including safety and security, food, water, shelter, health and medical services, energy, communications, transportation, and hazardous material management. Villages like Mongmong-Toto-Maite, with an SVI of 0.83 and 107 individuals (2% of its population) exposed, have essential lifelines that tropical cyclones could severely impact. Critical infrastructure, such as the Pacific Daily News building, the Governor's Complex, and the Agana Shopping Center in Hagatna, are crucial for maintaining community lifelines. Tamuning/Tumon, with an SVI of 0.17 and 467 individuals (3% of its population) exposed, has significant infrastructure at risk, including hotels and commercial centers crucial for tourism and economic stability.

The potential losses to vulnerable structures in Guam due to tropical cyclones are considerable. The estimated value of structures and infrastructure at risk in highly vulnerable villages such as Dededo, Yigo, and Mangilao indicates significant financial impacts. Dededo, with 28,298 individuals exposed, highlights the scale of potential human and structural loss. Similarly, Yigo and Mangilao have large populations and critical facilities at risk, necessitating robust mitigation strategies to protect these assets. Dededo's utilities are valued at \$864,949,321, and its GBS totals \$3,374,695,451. The financial implications of potential cyclone damage are substantial. Barrigada's transportation systems have a high value of approximately \$902,046,000. If a tropical cyclone impacts this infrastructure with a conservative damage ratio of 15%, the potential financial loss could be around \$135,306,900. This data underlines the significance of targeted mitigation efforts and financial planning for recovery to ensure the stability of Guam's economy and the safety of its residents.

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Summary of Recent and Project Developments in the Hazard Prone Area

Recent developments in Guam have seen significant changes in land use and the built environment, particularly in villages such as Dededo, Yigo, and Tamuning/Tumon. Dededo has experienced substantial residential growth, with new housing subdivisions such as Summer Estates and J524 Development LLC. Similarly, Yigo has seen the development of Songsong Hills, which increases the population density and potential vulnerability to tropical cyclones. In Tamuning/Tumon, commercial developments such as the Don Don Donki grocery store and the Tsubaki Tower Hotel reflect a growing commercial hub. These developments indicate an expansion into areas potentially vulnerable to tropical cyclones, increasing the overall risk profile of these villages. A detailed account of building permits issued from 2000 to 2023, illustrating the growth trends in these areas.

Population demographics in Guam have shifted, with an increase in both the young and elderly populations, who are particularly vulnerable during tropical cyclones. For instance, Dededo, with an SVI of 0.78 and 28,298 individuals (66% of its population) exposed, includes a significant number of socially vulnerable and underserved communities. Similarly, Agat, with an SVI of 1.00 and 3,574 individuals (63% of its population) exposed, and Merizo, with an SVI of 0.94 and 765 individuals (35% of its population) exposed, emphasize the heightened vulnerability due to demographic changes. These shifts necessitate focused mitigation and preparedness strategies to protect these vulnerable populations.

Territorial assets, including critical infrastructure and essential facilities, have seen changes in their vulnerability due to recent developments. For example, the Ukudu Power Plant in Dededo is a new development intended to replace the older Cabras power plants located in a coastal flood zone. Although this new location is less exposed to land-based hazards, it highlights the need to assess and mitigate vulnerabilities continually. Similarly, new healthcare facilities like the Village Kidney Care Centers in Dededo and Sinajana add to the critical infrastructure that needs to be safeguarded against tropical cyclone impacts.

Development in jurisdictions most threatened by tropical cyclones, such as Dededo, Yigo, and Tamuning/Tumon, has increased the exposure of these areas to potential hazards. The growing population and new infrastructure developments in these villages underscore the heightened risk. For instance, Dededo's utilities are valued at \$864,949,321, and its GBS totals \$3,374,695,451. The financial implications of potential cyclone damage are considerable. Climate change projections indicate an increase in the intensity of tropical cyclones, further exacerbating the risk to these high-growth areas. The potential consequences of inaction are severe, necessitating immediate and focused mitigation efforts on resilient infrastructure development and robust disaster management strategies to minimize the impact of future tropical cyclones.

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5.5.12 Tsunami Inundation

Nature

A tsunami is a series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Subduction zone earthquakes at plate boundaries often cause tsunamis. However, tsunamis can also be generated by submarine landslides, submarine volcanic eruptions, the collapse of volcanic edifices, and in very rare instances, large meteorite impacts in the ocean. As an oceanic plate is subducted beneath a continental plate, it sometimes brings down the lip of the Continental Plate with it. Eventually, too much stress is put on the lip, and it snaps back, sending shockwaves through the earth's crust; these shockwaves cause a tremor under the sea, known as an undersea earthquake. Factors that affect tsunami generation from an earthquake events include magnitude (generally, a 7.5 M and above), depth of event (a shallow marine event that displaces the seafloor), and type of earthquake (thrust as opposed to strike-slip).

In the deep ocean, the length of a tsunami from wave crest to wave crest may be a hundred miles or more but has a wave height of only a few feet or less. Thus, the wave period can be up to a little more than an hour, and wavelengths can exceed several hundred miles. Thus, tsunamis are unlike typical wind-generated swells on the ocean, which might have a period of about 10 seconds and a wavelength of up to 300 feet. Tsunamis cannot be felt aboard ships in the open ocean, nor can they be seen from the air in the open ocean. In deep water, the waves may reach speeds exceeding 700 miles per hour.

Tsunamis reaching heights of more than 100 feet have been recorded. As a tsunami wave approaches the shallow coastal waters, it appears normal, and its speed decreases. Then as the tsunami nears the coastline, it can grow to a great height, smash into the shore, and cause much destruction.

Tsunamis not only affect beaches that are open to the ocean, but also bay mouths, tidal flats, and the shores of large coastal rivers. Tsunami waves can also diffract or "wrap" around landmasses. Because tsunamis are not symmetrical, the waves can be much stronger in one direction than another, depending on the nature of the source and the surrounding geography. However, tsunamis propagate outward from their source, so coasts in the shadow of affected land masses are usually fairly safe.

Tsunamis can originate hundreds or even thousands of miles away from coastal areas. Local geography may intensify the effect of a tsunami. Areas at greatest risk are less than 50 feet above sea level and within 1 mile of the shoreline. Tsunamis arrive as a series of successive "crests" (high-water levels) and "troughs" (low-water levels). These successive crests and troughs can occur anywhere from 5 to 90 minutes apart. They usually occur 10 to 45 minutes apart.

Tsunami run-up occurs when a peak in the tsunami wave travels from the near-shore region onto the shore. The run-up is usually expressed in meters above normal high tide. Except for the largest tsunamis, such as the 2004 Indian Ocean event, tsunamis

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generally do not result in giant breaking waves (like normal surf waves at the beach that curl over as they approach shore). Rather, they come in much like very strong and fast-moving tides (i.e., strong surges and rapid changes in sea level). Much of the damage inflicted by tsunamis are caused by strong currents and floating debris. Tsunamis often travel much farther inland than normal waves. Most deaths during a tsunami result from drowning.

Location

Figure D-26 shows the potential areas for tsunami inundation. These areas include all landmasses below 16.4 feet in mean sea elevation and the inundation areas for the five bays (Apra Harbor, Tumon Bay, Pago Bay, Agana Bay, and Inarajan Bay) listed in the tsunami hazard assessment study completed by the Pacific Risk Management `Ohana, the Pacific Marine Environmental Laboratory Center for Tsunami Research, and the NWS-WFO Pacific Services Center (PSC) in October 2009.

Previous Occurrences

Historical data regarding tsunami events in Guam is minimal and likely incomplete. The general view is that tsunamis infrequently occur on the island and that the band of coral reefs surrounding the island forms a natural barrier against destructive tsunamis. It is likely that tsunami events are underreported because Guam frequently experiences large wave run-up during typhoon events, and the tsunami run-up in Guam may be less damaging than the wave run-up associated with typhoons.

Historical documentation shows that 12 tsunami events have affected Guam. **Table 45** shows the details of these recorded tsunami events. The largest documented tsunami was in 1849, with a vertical wave run-up of 11.4 feet. The most recently documented tsunami occurred after the August 8, 1993, earthquake. The only recorded damage was that a truck parked on the beach in Pago Bay was struck by a wave and a car in Yigo Bay was washed into the ocean. No other tsunami activity was recorded in Guam from this earthquake.

Table 45. Historical Tsunami Inundations on Guam, 1819-2019

Date	Vertical Run-up (feet)	Earthquake Location	Magnitude
1819	N/A	Mariana Islands	N/A
Date	Vertical Run-up (feet)	Earthquake Location	Magnitude
05/16/1892	N/A	Guam, Mariana Islands	7.5
02/1903	N/A	Philippines	N/A
12/09/1909	N/A	Guam, Mariana Islands	8
03/04/1952	0.3	Se. Hokkaido Island, Japan	8.1
10/04/1952	0.3	Kamchatka, Russia	8.2
03/09/1957	0.3	Central Aleutian Islands, Alaska	8.3

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05/22/1960	0.3	Central Chile	8.6
10/13/1963	0.3	Kuril Islands, Russia	8.1
03/28/1964	0.3	Gulf Of Alaska-Alaska Pen.	8.5
08/08/1993	3.0	Guam, Mariana Islands	7.8
02/27/2010	1.27	Maule, Concepcion, Talcahuano, Chile	8.8

Probability of Future Events

The probability of a tsunami is generally expressed as the potential of a return period and the wave run-up elevation with a 1 percent chance of being equaled or exceeded in any given year. Because of the limited historical data, a return period and the elevation of a tsunami with a one percent annual chance of occurring have not been and cannot be established for Guam. However, the available historical information and reported regional considerations, such as the band of coral reef around the island and the steep bathymetry surrounding the island, which would lower the risk of significant wave run-up, demonstrate that the possibility of a large tsunami causing extensive damage is generally low.

Climate Change Impacts

Since Tsunami's are triggered by seismic events, they are not a climate related hazard, thus climate change has no impact on future events.

Climate change does impact sea level rise and coastal erosion, so the impact of a tsunami will be greater as those 2 hazards change over time.

Summary of Potential Impacts

Similar to previous versions of this plan, a relatively low proportion of Guam's population (11,577 people or 7.5 percent) is exposed to tsunami inundation. The number of exposed EFMUTS is 93 Essential Facilities (26.2 percent, with a value of \$173.3 million), 46 Major Utilities (12.7 percent, with a value of \$282.4 million), and 52 Transportation Systems (39.1 percent, with a value of \$88.5 million). Of the GBS, 3,270 structures (8.2 percent), worth \$555.8 million are exposed.

As noted previously, the lands adjacent to Apra Harbor are likely to be almost completely inundated by a tsunami with a 16-foot run-up. This area includes several port and utility facilities. If permanent damage from a tsunami occurs to port facilities, the movement of goods on and off Guam would also be affected. A value for the normal and daily functions of these facilities has not been assessed for this analysis, but disruption to these functions would be a potential secondary effect of this hazard event.

A substantial secondary hazard of a tsunami can occur due to its impact on the functioning of certain utilities, particularly water treatment plants and potable water distribution facilities, which in turn may expose large portions of the population to hazards such as drought and disease.

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As shown in **Tables F-25 and F-26**, in terms of the village-level population exposed to tsunami hazards, Tamuning/Tumon and Mongmong-Toto-Maite have the largest two vulnerable populations with 2,210 (14.83 percent of the village population), and 1,012 (14.83 percent of the village population) exposed people, respectively. Both villages experienced an above-average change in population growth from 2000 – 2010. In fact, Mongmong-Toto-Maite experienced the greatest change in positive population growth (16.8 percent).

Exposure of the Essential Facilities is concentrated in Hagatna, Tamuning/Tumon, and Piti. Thirty-three Essential Facilities (worth \$22.5 million) are located in Hagatna, 19 in Tamuning/Tumon (worth \$82.2 million), and 13 in Piti (worth \$9.5 million). In terms of Major Utilities, 11 are located in Piti (worth \$245.8 million) and 11 in Merizo (worth \$6.8 million). In addition, Piti has 11 Transportation Systems in this hazard area that is worth \$75.3 million.

The largest number of GBS (568 structures worth \$197.5 million) exposed to tsunami inundation is located in Hagatna. Hagatna experienced very little GBS growth in 2018, with only 6 building permits (1.7 percent of all building permits) issued in this village.

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RISK ASSESSMENT AND HAZARD PROFILES

Table F-25 Total Affected by Tsunami Inundation			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.37	0	0	0	0	0	11	3,414	0	0
Agat	2.19	2,262	10	59,050,753	4	15,735,050	33	3,677,285	636	85,371,095
Asan/Maina	2.66	1,045	4	14,501,179	1	1,268,270	18	11,894,146	99	14,965,262
Barrigada	2.12	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.74	294	1	372,103	2	13,204,988	5	79,510	30	4,923,936
Dededo	2.56	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.43	885	36	35,368,588	3	13,455,241	46	33,998,860	305	195,269,464
Inarajan	6.11	214	7	2,409,492	3	2,916,318	31	34,667,466	149	17,189,401
Mangilao	0.81	298	1	13,004,413	0	0	0	0	0	83,669
Merizo	1.74	973	2	1,080,391	11	13,924,399	27	9,474,056	245	28,298,910
Mongmong- Toto-Maite	0.51	867	0	0	0	0	0	0	9	2,542,652
Piti	1.17	445	13	14,979,910	9	500,671,054	41	927,106,869	238	50,929,813
Santa Rita	4.19	964	0	0	1	104,418	9	423,893	61	8,623,195
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofoto	5.15	151	1	371,960	0	0	17	232,735	81	12,596,234
Tamuning/Tumon	1.74	2,023	18	129,047,182	7	10,059,723	44	33,443,300	148	110,841,289
Umatac	2.28	887	3	1,269,532	3	3,795,262	30	17,069,419	27	2,814,501
Yigo	7.48	0	0	0	0	0	0	0	0	0
Yona	3.61	269	1	376,775	0	0	23	17,396,102	17	3,371,657
Total	45.86	11,577	97	271,832,278	44	575,134,723	334	1,089,467,055	2,045	537,821,079

Table F-26 Proportion Affected by Tsunami Inundation			Essential Facilities		Major Utilities		Transportation Systems		GBS	
Village	Square Miles	Population	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0	0	0	0	0	0	100	1.61	0	0
Agat	6.59	40	45	86.34	44.4	32.15	100	90.05	40.31	40.31
Asan	4.06	50	60	96.07	10	2.68	100	94.82	19.72	19.72

SECTION 5 RISK ASSESSMENT AND HAZARD PROFILES

Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-	4.96	4.97	12.5	3.64	10.5 3	50.9	14.2 9	0.37	4.32	4.32
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna	80	80.49	82.5	78.31	75	97.2	80	73.39	90.4 5	90.45
Inarajan	6.99	7	46.6 7	7.68	17.6 5	3.49	83.3 3	97.84	23.8 3	23.83
Mangilao	2.24	2.24	3.57	13.53	0	0	0	0	0.03	0.03
Merizo	13.4	45	20	16.6	68.7 5	51.26	100	99.21	64.3 9	64.39
Mongmong-	14.84	14.83	0	0	0	0	0	0	2.2	2.2
Piti	26.67	26.69	68.4 2	78.59	84.6 2	89.1	100	99.97	45.5	45.5
Santa Rita	12.85	12.85	0	0	8.33	0.18	40	3.54	13.7 9	13.79
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	4.66	4.69	12.5	8.61	0	0	100	25.41	8.44	8.44
Tamuning/	11.23	11.23	22.8 9	15.81	30.4 3	6.79	33.3 3	34.5	9.39	9.39
Umatac	3.28	100	33.3 3	25.97	15.7 9	4.04	100	95.56	19.3 2	19.32
Yigo	0	0	0	0	0	0	0	0	0	0
Yona	4.15	4.15	8.33	0.35	0	0	75	79.54	1.01	1.01

SECTION 5 RISK ASSESSMENT AND HAZARD PROFILES

Jurisdictions' Vulnerability

Guam, situated in the seismically active Pacific region, faces a significant threat from tsunamis. While historical data suggest infrequent occurrences, the potential for severe impact remains alarmingly high. The risk assessment pinpoints Agat, Hagatna, and Merizo as the most vulnerable due to their low elevation and proximity to the coastline. The probability of future tsunami events, unaffected by climate change, is a constant concern due to the region's seismic activity.

The analysis of vulnerability highlights several key areas. Socially vulnerable and underserved communities are particularly at risk, as shown in **Table 46**. For instance, with a SVI of 1.00 and 40% of its population (2,262 individuals) exposed, Agat highlights the heightened vulnerability. Similarly, Hagatna has 72% of its population (788 individuals) exposed, while Merizo has 42% (915 individuals) exposed to tsunami hazards. These high exposure rates necessitate targeted interventions to protect these populations. Essential facilities, major utilities, and transportation systems are concentrated in the most vulnerable areas. Hagatna hosts several critical facilities crucial for emergency response and public administration, and damage to these facilities could severely impair Guam's resilience. Also, the vulnerability of structures is significant in villages like Agat and Merizo, where a considerable portion of the building stock is within the tsunami inundation zones.

Table 46

Village	Village SVI	Vulnerable Exposed	Vulnerable Exposed
Agana Heights	0.28	0	0%
Agat	1	2,262	40%
Asan/Maina	0.11	115	6%
Barrigada	0.44	0	0%
Chalan Pago-Ordot	0.33	97	2%
Dededo	0.78	0	0%
Hagatna (Agana)	0.89	788	72%
Inarajan	0.39	83	3%
Mangilao	0.72	215	2%
Merizo	0.94	915	42%
Mongmong- Toto-Maite	0.83	719	12%
Piti	0	0	0%
Santa Rita	0.06	58	1%
Sinajana	0.56	0	0%
Talofofo	0.22	33	1%
Tamuning/Tumon	0.17	344	2%
Umatac	0.67	594	67%
Yigo	0.61	0	0%
Yona	0.5	135	2%
Total		6,359	

The exposure of infrastructure and community lifelines, including safety and security services, food, water, shelter, health, and medical services, is a grave concern. For

instance, the disruption of Agat and Hagatna's critical infrastructure could lead to a halt in essential services. Transportation systems in these areas are crucial for evacuation and supply distribution during emergencies. The potential losses to identified vulnerable structures are staggering. For example, Hagatna's GBS, valued at approximately \$197.5 million, includes 568 structures exposed to tsunami inundation. The exposure of essential facilities, valued at \$173.3 million, and major utilities, valued at \$282.4 million, further underscores the financial implications of a significant tsunami. Regarding transportation systems, 52 facilities valued at \$88.5 million are at risk.

The vulnerability of state assets, including newly developed infrastructure, highlights the need for continuous assessment and adaptation of mitigation strategies. The construction of critical infrastructure, such as the Ukudu Power Plant in Dededo, while reducing exposure to land-based hazards, must consider the potential impacts of tsunamis. Similarly, new healthcare facilities and other essential services must incorporate resilient designs to withstand tsunami impacts.

Guam's tsunami hazard profile reveals significant vulnerabilities across various sectors, with particular emphasis on socially vulnerable populations, critical facilities, and essential infrastructure. Villages like Agat, Hagatna, and Merizo are particularly at risk due to their location and demographic characteristics. The potential losses from a tsunami event could be severe, affecting both human life and economic stability.

Summary of Recent and Project Developments in the Hazard Prone Area

There are 2 new development since the 2019 HMP that are exposed to a Tsunami. The Tsubaki Tower in Tumon Bay and the new Community First Credit Union HQ in Hagåtña.

5.5.13 Wildland Fire

Nature

A wildland fire is a type of fire that spreads through the consumption of vegetation. A wildfire, is a wildland fire that is unplanned, uncontrolled, and unpredictable in an area with combustible vegetation. It often begins unnoticed, spreads quickly, and is usually signaled by dense smoke that may be visible from miles around. Guam wildland fires can be caused by human activities (such as arson, unpermitted agricultural burning, youth starts, backyard burning, barbecues, campfires) or by natural events such as lightning. Wildland fires often occur in forests or other areas with ample vegetation. In addition to wildland fires, wildfires can be classified as urban fires, interface or intermix fires. The following three factors contribute significantly to wildland fire behavior and can be used to identify wildland fire hazard areas.

- **Topography:** As the slope increases, the rate of wildland fire spread increases. South-facing slopes are also subject to more solar radiation, making them drier and thereby intensifying wildland fire behavior. **Fuel:** The type and condition of vegetation plays a significant role in the occurrence and spread of wildland fires. Certain types of plants are more susceptible to burning or will burn with greater intensity. Dense or overgrown vegetation increases the amount of combustible material available to fuel the fire (referred to as the “fuel load”). The ratio of living to dead plant matter is also important. The risk of fire is increased significantly during periods of prolonged drought as the moisture content of both living, and dead plant matter decreases. This includes periods after typhoon/storm events when vegetation has been removed and the surrounding ground is covered with snapped branches and broken trees creating additional fuels which could become ladder fuels moving fire from the horizontal plane to the vertical plane (ground to canopy fires). Additionally, with the reduction of tree canopy, invasive grasses grow where they had once been shaded out creating new pockets for wildfire to spread easily within and along a disturbed forest edge and community. The fuel’s continuity, both horizontally and vertically, is also an important factor.
- **Weather:** The most variable factor affecting wildland fire behavior is the weather. Temperature, humidity, wind, and lightning can affect chances for ignition and spread of fire. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildland fire activity. By contrast, cooling and higher humidity often signal reduced wildland fire occurrence and easier containment. Strong winds can also carry burning embers farther downwind, igniting new fires. However, on Guam, wildland fires are known to occur at higher levels of humidity due to the composition of vegetation.

The frequency and severity of wildland fires are also dependent on other hazards, such as lightning, drought, and infestations. If not promptly controlled, wildland fires may grow into an emergency or disaster. Even small fires can threaten lives and resources and destroy improved properties. In addition to affecting people, wildland fires may severely affect livestock and pets. Such events may require emergency watering/feeding, evacuation, and shelter.

In addition to stripping the land of vegetation and destroying forest resources, large, intense fires can harm the soil, waterways, and the land itself. Soil exposed to intense heat may lose its capability to absorb moisture and support life. Exposed soils erode quickly and enhance siltation of rivers and streams, thereby enhancing flood potential, harming aquatic life, and degrading water quality. Lands stripped of vegetation are also subject to increased debris flow hazards.

Wildland fires begin at an ignition source. Ignition sources can be natural, such as lightning; intentional human activity, such as arsonists; or unintentional human activity, such as campfires and barbecues. Fires are not a natural occurrence in Guam. In Guam, lightning has the potential to start wildland fires, but is generally associated with heavy rain and high humidity, which is not meteorologically conducive to starting fires. Arson is a common cause of wildland fires on the island. Poachers use fire to clear sightlines and draw deer and pigs into the open, farmers sometimes burn fields to clear them, and homeowners will burn debris and vegetation in their backyards resulting in many escaped backyard fires. If not promptly controlled, wildland fires may grow into an emergency or disaster. Even small fires can threaten lives, resources, and destroy improved properties. In addition to affecting people, wildland fires can severely affect livestock and pets. Such events may require the emergency watering/feeding, shelter, evacuation, and even burying of animals.

The indirect effects of wildland fires can also be catastrophic. As stated above, fires are not a natural occurrence on the island, which means that the native ecosystem is poorly adapted to burning. Thus, the native forests can be devastated by a wildland fire because the native forest plants are not adapted to revegetate after a fire. Native forestlands that have been heavily burned are often revegetated by grassland savanna. Many of these grassland plant species are nonnative species that are well adapted to repeated burning. The introduction of fire-adapted grass species to Guam has resulted in the promotion of fire on the island. When the grasses become dry during the dry season, they develop into an excellent fuel source. In addition, when grasslands that are adjacent to forests burn, the forest edge is typically burned back, promoting revegetation by the nonnative fire-adapted grasses. This event results in an expansion of the spatial extent of the grassland and a reduction in the size of the native forest.

Wildland fires have also contributed to a chronic erosion problem on Guam, especially in the southern half of the island. Soil exposed to intense heat may lose its capability to absorb moisture and support life. Exposed soils erode quickly and enhance siltation of rivers and streams. Erosion and siltation enhance the potential for flooding, harming aquatic life (especially the coral reefs surrounding the island), and degrading water quality. Lands stripped of vegetation are also subject to increased landslide hazards and can become incapable of revegetating. The accumulation of upland sediment onto the coral reefs of Guam is believed to be a large threat to the viability of these reefs. The die-off on the reefs off southwestern Guam has been attributed to the covering of the reef by eroded topsoil. Due to the economic link between Guam's coral reefs and tourism, recreational fishing, subsistence fishing, and shoreline protection, the

degradation and loss of these coral reefs have been linked to the lowering of the quality of life on Guam.

Location

High and very high wildland fire hazard areas on Guam are shown in **Figure D-27**. This figure was developed using a fuel model, as shown in **Table 47**. For this model, the fuel type and critical weather frequency were determined to be the most important factors in influencing the location and severity of a wildland fire. Critical weather frequency was considered constant. As shown in **Figure D-27**, the most concentrated areas that are susceptible to wildfires are the northern and northwestern portion of the island. Priority areas for fuel treatments to reduce risk of fire damage to standing forests are shown in **Figure D-28**. Fire risk to forests and urban environments was determined by calculating a 300 ft. buffer distance from all forest edges.

These buffers were chosen as areas most likely to have “edge effects” for fire risk to standing forests. The total area of fire behavior risks (0-3) was calculated within each zone for all watersheds. Yellow and red colors highlight areas of moderate and high risk; their proximity to forest edges identifies these areas as high priority for fuel breaks and conversion to forest. At watershed scales, the eastern watershed management areas contribute the largest number of acres that pose a moderate or higher fire risk within this forest edge interface zone (8,187 acres), mostly relegated to the central uplands in Talofofo, Ylig, and Pago, with upper reaches of Apra in the western watershed management area. Though smaller in land area, the western watersheds all exhibit approximately one-quarter of the land area having moderate or higher fire risk to standing forests, including the Manell (Merizo) watershed, which contains a marine preserve at the outlet of the watershed.

Table 47. Wildland Fire Fuel Model

Fuel Type	Fuel Sources	Hazard Area
Heavy	Round wood 3-8 inches in diameter	Very High
Medium	Round wood consisting of 1/3 to 3 inches in diameter	High
Light	Herbaceous plants and round wood less than ¼ inch in diameter	Moderate

Source: BSP 2004.

Previous Occurrences

The NCDC's Storm Event Database documents significant wildland fire events occurring in January, February, March and April of 1998. The high number of fire incidents during this several month timeframe was attributed to a very wet El Niño season in 1997 that was followed by a meteorological drought and heavy fuel loads from trees damaged by Super Typhoon Paka. During this period, approximately 1,400 fires burned 13,000 acres. One thousand residents were forced to evacuate, one home was reported destroyed, and \$250,000 in damage was reported. On March 23, 1998, approximately 1,000 acres were burned. On March 23, 1998, the fire suppression efforts to fight the

Tiyan and Toto Complex fires were authorized by FEMA to receive fire suppression funding, under the declaration, FEMA-2197-DR-GU. The most recent wildland fire event documented on the NCEM's Storm Event Database in Guam is a wildland fire event in May of 2001 in Barrigada that led to one injury.

Climate change has been increasing the length of the fire season, the size of the area burned each year and the number of wildfires on Guam. Drier conditions and higher temperatures on Guam increase not only the likelihood of a wildfire to occur but also the duration and the severity of the wildfire. Fires can be beneficial for the ecosystems across the Continental U.S.A, however, fire is not an integral part of Guams,unique ecosystem.Wildfires pose risks to human life, property, and infrastructures. Forest fires directly kill plants and animals, also causing a loss of habitat.

Guam Department of Agriculture, Forestry and Soil Resources Division
Final 2015 - 2023 Guam Wildfire Mapped Data

Year	Fire Class Sizes (number of fires per class size)					No. of Fires	Acres Burned	% Land Area Burned
	0.25 acres or less	0.26-9 acres	10-99 acres	100-299 acres	300-999 acres			
2015*						329	4428	3.26%
2016	98	521	120	6	4	749	8,338.17	6.15%
2017	59	312	81	4	1	457	4,017.11	2.96%
2018	33	309	114	8	3	467	6,250.51	4.61%
2019	15	241	119	15	6	396	9,421.00	6.94%
2020	13	131	97	7	2	250	6,448.38	4.75%
2021	3	100	66	8	0	177	3,623.74	2.67%
2022	7	101	74	8	3	193	4,744.62	3.50%
2023	1	29	22	2	0	54	1,434.34	1.06%
TOTALS	229	1744	693	58	19	3,072.00	48,705.87	35.90%
AVERAGES	28.625	218	86.625	7.25	2.375	341.33	5,411.76	4.36%

total acreage = 135,680

543,933,775.894 square meters, (134408.96319 acres)

Data provided by: Mr. Julian Dendy, formerly - GIS Research Consultant, Institute of Pacific Islands Forestry (IPIF), USDA Forest Service. Data collected and prepared for the Guam Department of Agriculture, Forestry and Soil Resources Division (2015-2022) and Allyson Earl, Wildfire Mapping Technician, Hawaii Wildfire Management Organization (HWMO) (2022-Present).

*NOAA Fire Mapping Results

Probability of Future Events

Wildland fires are more likely to occur during the 6-month dry season from December to May. The number and size of fires are likely to increase during droughts that follow El Niño seasons.

Climate Change Impacts

Drought conditions on Guam are conducive to wildfire ignitions and spread. Drought is also associated with water stress for crops and ecosystems (Frazier et al. 2019). Drought conditions will likely be more frequent in the future. Drought conditions (defined here as more than 20% below mean annual historic rainfall) are projected to occur in 4 out of 10 years on average in 2080–2099 under the high scenario. This is an increase in drought frequency from the historic rate of 1.6 years out of 10 years on average (Gingerich et al.2019a; Zhang et al. 2016).

Any future changes in ENSO are likely to affect the frequency and intensity of drought (PEAC Center 2015). Recent studies show that the frequency of strong El Niño events has increased in the past 30 years as compared to previous centuries (Freund et al. 2019; Wang et al. 2019).

Climate change has been increasing the length of the fire season, the size of the area burned each year and the number of wildfires on Guam. Drier conditions and higher

temperatures in Guam increase not only the likelihood of a wildfire to occur but also the duration and the severity of the wildfire. Fires can be beneficial for the ecosystems, but changes in climatic conditions are allowing them to burn out of control. Wildfires pose risks to human life, property, and infrastructures. Forest fires directly kill plants and animals, also causing a loss of habitat.

Summary of Potential Impacts

As noted previously, for the 2019 Guam HMP, a vegetation-based fuel model was used to determine wildland fire hazard areas. This is the same model used in the 2011 Guam HMP which replaced the wildfire model (fuel type, slope, and ladder) used in the 2014 and 2019 Guam HMP.

Similar to the 2019 results, a relatively large portion of Guam's population, about 110,000 people (69.1 percent), is exposed to a very high or high wildland fire hazard. The EFMUTS exposed include 145 Essential Facilities (worth \$360.7 million), 239 Major Utilities (worth \$460.7 million), and 73 Transportation Systems (worth \$12.1 million). The smallest proportion of exposure is of the GBS, but these structures have the highest combined value, with 21,609 structures exposed, worth \$2.87 billion.

In terms of village-level population exposure, as shown in **Tables F-27 and F-28**, Dededo has the largest number of exposed population with 21,309 people residing in a very high wildland fire hazard area (and an additional 15,855 people residing in a high wildland fire hazard area). Yigo has the second highest number of exposed population with 11,074 residing in the very high hazard area and an additional 4,231 people residing in a high wildland fire hazard area. Though Sinajana's overall population is low, Sinajana has the highest proportion of exposure for a village population, with 81.8 percent of the village population of Sinajana very high and high wildland fire hazards. Exposure of the EFMUTS is concentrated in Tamuning/Tumon with 29 Essential Facilities (worth \$202.4 million) located in a very high or high wildland fire hazard area. Dededo has the most Major Utilities located in the very high wildland fire area (31 facilities worth \$30.3 million) as well as the high wildland fire area (43 facilities worth \$58.3 million). Transportation Systems located in very high or high wildland fire area are located in every village; the village with the highest number is Tamuning/Tumon, with 9 Transportation Systems worth \$1.8 million.

Exposure of the GBS to high and very high wildland fire hazards is concentrated in Dededo with 6,089 structures (61.6 percent of the village GBS), worth \$971.1 million. As noted previously, the largest number of building permits (93 permits or 25.8 percent of the total permits issued) was issued in Dededo in 2018.

Jurisdictions' Vulnerability

Village	High	Very High
Agana Heights	215	280
Agat	2,141	3,078
Asan/Maina	111	89
Barrigada	1,563	278
Chalan Pago-Ordot	384	1,045
Dededo	11,827	15,894
Hagatna (Agana)	70	209
Inarajan	660	374
Mangilao	3,890	2,331
Merizo	1,130	831
Mongmong- Toto-Maite	1,146	1,039
Piti	0	0
Santa Rita	181	153
Sinajana	126	1,181
Talofofo	319	319
Tamuning/Tumon	682	333
Umatac	359	223
Yigo	2,447	6,405
Yona	1,836	921
Total	29,087	34,982

Summary of Recent and Project Developments in the Hazard Prone Area

Only the New Solar Farm in Yigo, the Merizo Sewage Treatment Plant and the Sinajana Police Station are situated in areas considered high risk for wild fires.

5.5.14 Coral

Nature

Coral loss is the death or destruction of live corals, which are the foundation of diverse coral reef communities that are home to fishes, invertebrates, algae, and other marine life. Corals are slow-growing organisms, and their ecological functions cannot be easily replaced. Coral reefs provide food security, recreational opportunities, economic benefits from tourism, and shoreline protection from wave energy. Coral reefs act as natural breakwaters, dissipating wave energy and preventing flooding and coastal erosion.

The annual economic value of Guam's coral reefs for fishing and recreation was estimated to be around \$63 million in 2023, with an additional \$9.5 million in coastal protection value (NOAA National Ocean Service Office for Coastal Management Comprehensive Report: Ecosystem Services Valuation of Guam and Florida Coral Reefs). In 2021, the U.S. Geological Survey determined that coral reefs annually provide flood protection benefits for more than 400 people and \$13.9 million in averted damages to property and economic activity (FIGURE BELOW, links: https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/thumbnails/image/USGS_Report_Summary_CNMI_p1.png and https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/thumbnails/image/USGS_Report_Summary_CNMI_p2.png).

The importance of coral reefs in shoreline protection has received renewed interest following the impacts of Hurricanes Irma and Maria in Puerto Rico. In January 2024, the Legislature of Guam passed Resolution 207-37 recognizing coral reefs as essential infrastructure. In March 2024 the U.S. Coral Reef Task Force passed Resolution 47.2 recognizing coral reefs as national natural infrastructure.

As living creatures, corals are susceptible to disease outbreaks, predation (e.g., from crown-of-thorns sea stars), physical damage (e.g., from ship groundings), poor water quality (e.g., due to sediment runoff and high freshwater input in built-up areas), and coral bleaching due to warming ocean waters. While Guam has experienced several well-documented damaging outbreaks of corallivorous crown-of-thorns sea stars, most recent coral loss has been the result of coral bleaching. Additionally, the introduction of invasive species via ballast water poses a significant threat to Guam's coral reefs, such as the invasive soft coral *Unomia*, which has spread rapidly across the Caribbean and was documented in Hawai'i in 2023. Other threats include the transmission of coral diseases, such as Stony Coral Tissue Loss Disease, which was first documented in 2014 and has since devastated reefs throughout the Caribbean.

With coral reefs declining, Guam's reef managers have taken action to protect reef biodiversity, maintain live coral cover, and address rapidly changing ocean conditions. After Typhoon Mawar in 2023, dislodged coral colonies in Tumon Bay were re-attached to substrate to improve survival. Multiple ongoing coral reef restoration projects by the University of Guam, Guam Department of Agriculture, and National Park Service are growing resilient and/or heat-tolerant corals in nurseries, allowing them to grow in ideal conditions before being outplanted to restore denuded reefs. A dedicated working

group, the Guam Reef Restoration and Intervention Partnership, meets regularly to plan restoration activities and guide the goals and practices of reef restoration on Guam.

USGS Report Summary

The Value of U.S. Coral Reefs for Risk Reduction

FACTS FOR GUAM & THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

KEY POINTS

The social and economic benefits provided by U.S. reefs were assessed across **>3,100 km** of coastline using hydrodynamic models coupled with census data.

Annually, reefs in Guam and the CNMI provide flood protection benefits to more than **400 people** and **\$13.9 million** in averted damages to property and economic activity.

With a 1-m loss in reef height, the **100-year floodplain** would increase across Guam & the CNMI **by 1 km²**, imperiling **600** more people and **\$30 million** in property & economic activity.

This study provides a comprehensive set of flood risk maps across U.S. coral reef coastlines and the first national quantification of flood protection benefits from reefs.

The degradation of coral reefs raises flood risks by increasing the exposure of coastal communities to storms.

The coastal protection benefits of coral reefs and other natural defenses are not usually assessed in the same rigorous, economic terms as artificial defenses such as seawalls, and therefore often not considered as an option in hazard management decisions. In this study, we combine engineering, ecological, social, and economic data and tools to provide a rigorous valuation of the coastal protection benefits of U.S. coral reefs across Hawaii, Florida, Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands, and the Commonwealth of the Northern Mariana Islands (CNMI).

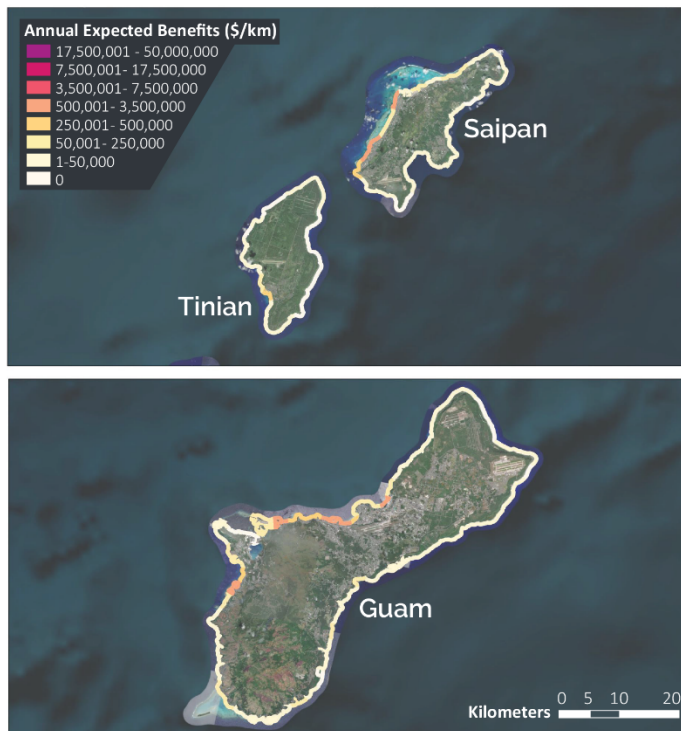
Coral reefs act like submerged breakwaters by breaking waves and dissipating their energy offshore before they flood coastal properties and communities. This is an enormously valuable function. In 2017, Hurricanes Harvey, Irma and Maria alone caused over \$265 billion in damage across the nation.



This map shows the simulated flooding for 100-year storm events with (blue) and without (red) coral reefs in Saipan, CNMI.

In this report, we demonstrate that coral reefs provide the U.S. with more than \$1.8 billion dollars in flood protection benefits every year. They reduce direct flood damages to public and private property worth more than \$800 million annually, and help avert other costs to lives and livelihoods worth an additional \$1 billion. Coral reefs annually protect \$184 million worth of buildings and economic activity in Puerto Rico, \$675 million in Florida and \$836 million in Hawaii.

These are not ‘back of the envelope’ numbers. Flood risk was assessed using sophisticated hydrodynamic models and more than 60 years of hourly wave data for U.S. coral reef coast lines – a total area of over 3,100 km (>1,900 miles) of shoreline. We developed flood risk maps projecting the extent and depth of flooding that would occur across a range of storms from the more commonly occurring to the catastrophic, with and without the top 1-m of coral reefs. These flood risk maps were combined with the latest information from the U.S. Census Bureau and the Federal Emergency Management Agency to identify people and properties at risk – and benefiting from the presence of coral reefs – in each location.



The annual expected benefits (\$/km) coral reefs provide in coastal flood reduction.

Rigorously valuing coral reef benefits in this way is a key step toward mobilizing resources to protect them. These maps and values can be used to inform:

- **storm response actions & recovery funding**
- **coral reef conservation areas**
- **public & private insurance incentives**
- **benefit : cost analyses for reef restoration**
- **the consideration of reefs as national infrastructure**

Storlazzi, C.D., Reguero, B.G., Cole, A.D., Lowe, E., Shope, J.B., Gibbs, A.E., Nickel, B.A., McCall, R.T., van Dongeren, A.R., Beck, M.W., 2019. Rigorously valuing the role of U.S. coral reefs in coastal hazard risk reduction: U.S. Geological Survey Open-File Report 2019-1027.

Find the report at: <https://doi.org/10.3133/ofr20191027>



UNIVERSITY OF CALIFORNIA
SANTA CRUZ



Location

Coral reefs surround the island of Guam on all sides. Indeed, the entire northern half of the island is composed of metamorphosed coral limestone, and the fossilized remains of ancient corals can easily be seen today well above sea level. Coral cover is higher on the west (leeward) side of the island,

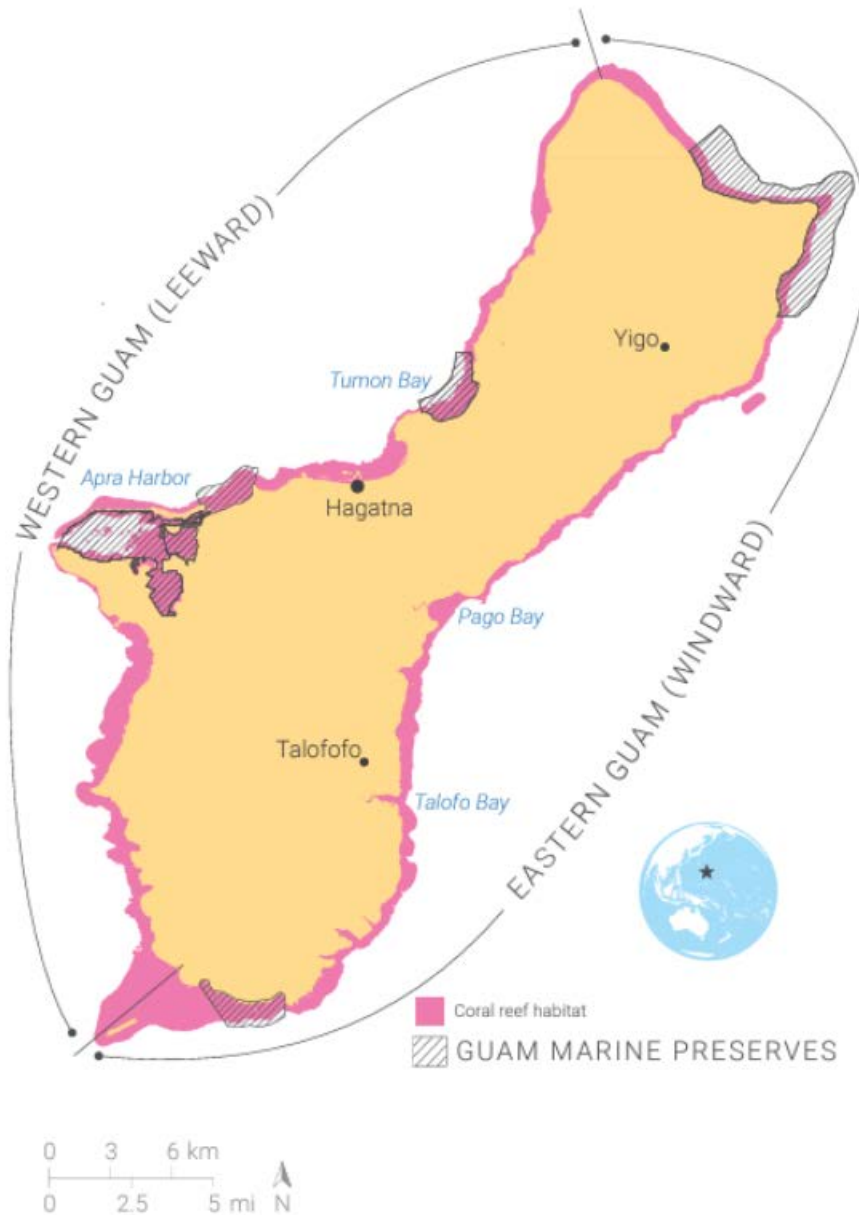


Figure 4. Map of coral reef habitat from NOAA Coral Reef Conservation Program 2018 coral reef condition status report.

(https://www.coris.noaa.gov/monitoring/status_report/docs/Guam_status_report_forweb.pdf)

Previous Occurrences

Coral bleaching has severely impacted Guam's coral reefs in recent years, with mass bleaching events causing widespread mortality, particularly on shallow reef flat areas. Elevated sea surface temperatures were documented to have caused island-wide coral

bleaching in 2013, 2013, 2016, and 2017. Additionally, extreme low tides triggered by El Niño in 2015 caused additional coral losses on shallow reef flats. Overall, live coral cover declined by 37% on shallow reef flat sites, and by 34% on shallow seaward slopes, around the island between 2013-2017. Populations of staghorn *Acropora* corals, which are highly rugose and effective in mitigating wave energy, declined by 60% during this period, with some species becoming at high risk for extirpation. In 2023, the fourth global bleaching event began, with at least 56% of the world's reefs experiencing bleaching-level heat stress. While the impacts of this event will not be understood until at least 1-2 years after the event ends, previous global bleaching events in 1998, 2010, and 2014-2017 resulted in the death of at least 22% of the world's corals. Reports of widespread coral bleaching and mortality have been reported in 55 countries spanning all ocean basins, and preliminary reports have documented mortality as high as 50-93% in the Mexican Pacific and total losses of *Acropora* corals in some areas of the Caribbean.

While coral bleaching has been the cause of most recent coral losses, there have been several major outbreaks of crown-of-thorns sea stars that have resulted in reef devastation. Between 1967 to 1969, an outbreak resulted in 90% coral loss along 38 km of coastline to a depth of at least 65 m. Another outbreak was documented beginning in 2004, with sites around Guam documented to have extensive predation mortality, including on less-preferred species, suggesting that populations of preferred coral prey species had already been depleted.

Probability of Future Events

Future losses of coral are extremely likely, particularly losses due to coral bleaching. With the world's oceans in the midst of the fourth global bleaching event, Guam is anticipated to experience severe coral bleaching in late 2024. Additional losses are also likely within several years due to the introduction of invasive species, major storm events, and post-bleaching disease outbreaks.

Climate Change Impacts

The impacts of climate are anticipated to create increasingly unfavorable conditions for corals. Warming ocean temperatures, increasing ocean acidity, and increased storm severity are all likely to cause further losses of corals on Guam.

Summary of Potential Impacts

Impacts from Coral Reef loss increase the impacts the risk of coastal erosion, wave inundation, and coastal flooding.

SECTION 6 – MITIGATION STRATEGY

6.1 PURPOSE

The purpose of this section is to present the Government of Guam's hazard mitigation strategy. Specifically, this section describes the processes used to create this strategy, including a capability assessment, a discussion of available mitigation funding sources, a description of mitigation goals, and a comprehensive list of mitigation actions, including an implementation strategy. For the purpose of mitigation planning, goals are defined as general guidelines that explain what the island community wants to achieve in terms of hazard and loss prevention. Mitigation actions, also referred to as projects, are specific activities that help a community reach its goals.

The following State Mitigation Planning Policy Guide requirements for the capability assessment and mitigation strategy do not apply to Guam because the Government of Guam is the only direct grant recipient on Guam.

- Local capability assessment (Requirement § 201.4[c][3][ii])
- Local funding and technical assistance (Requirement § 201.4[c][4][i])
- Local plan integration (Requirement § 201.4[c][4][ii])
- Prioritizing local assistance (Requirement § 201.4[c][4][iii])
- Mitigation actions (Requirement § 201.4[c][3][iii][Element E])

6.2 CAPABILITY ASSESSMENT

Government of Guam Pre-and Post- Disaster Hazard Mitigation Policies and Programs

A detailed list of the Government of Guam's pre- and post-disaster mitigation policies and programs are provided in **Table 48**. This table was revised during the 2019 and 2024 Guam HMP update process. **Table 48** contains the following information for each policy or program: category, responsible individual and agency (with contact information) for overseeing the policy or program; whether each policy or program is related to pre-disaster or post-disaster hazard mitigation; and whether each policy or program affects development in hazard-prone areas.

The Government of Guam's hazard mitigation funding capabilities are discussed in **Section 6.3** (Funding Sources).

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Table 48. Pre- and Post-Disaster Mitigation Policies and Programs

Capability Category	Primary Agency Contact Information	Pre/Post Disaster	Effects Development in Hazard-Prone Areas	Description
Management of the GHMGP	Guam GHS-OCD 221B Chalan Palasyo, Agana Heights, Guam 96910	Pre and post	No	The Governor of Guam signed Executive Order 2004-05 in 2004, formally incorporating the GHMGP and the Recovery Coordination Office (RCO) into GHS-OCD. Incorporating the GHMGP within GHS-OCD and empowering the GHMO to manage the GHMGP has provided for continuity and facilitated the selection of effective hazard mitigation projects.
Regulation of Building Construction	DPW 542 North Marine Drive Tamuning/Tumon, Guam 96911	Pre and post	Yes	DPW administers the Building Law and the Building Code, Chapters 66 and 67 of the Guam Code Annotated, Title 21. DPW conducts plan reviews for all building permit requests, ensuring that all buildings conform to the standards described in the Guam Building Code. In September 2010, Guam adopted the 2009 International Building Code/International Residential Code (IBC/IRC) through P.L. 30-199, which mandated that the 2009 IBC/IRC function as the applicable building code for all buildings within Guam and established a Guam Building Code Council. Before passage of this law, Guam used the outdated standards listed in the 1997 Universal Building Code. Adoption of the 2009 IBC/IRC has improved building construction practices within Guam, enabling buildings to better withstand hazards such as tropical cyclones and seismic events.

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Regulation of Land Use	DLM 590 South Marine Corps Drive Tamuning/Tumon, Guam 96913	Pre and post	Yes	DLM administers the codes and laws found in Chapters 60 through 63 of the Guam Code Annotated, Title 21. DLM is responsible for managing land use and ensuring consistency of existing and future uses with public goals and interests through management of zoning and subdivisions. The current zoning and subdivision ordinances are limited to regulating type of development allowed (i.e., within zones designated as residential, commercial, or industrial). In addition to the current zoning and subdivision ordinances, Guam should consider adopting hazard-specific overlay zoning ordinances to regulate development in high hazard areas.
Seashore Reserve Zone	BSP P.O. Box 2950 Hagatna, Guam 96910	Pre and post	Yes	The BSP is in the process of updating the seashore reserve zone ordinance base on technical studies done as a collaborative approach to understand our near shore areas. The update of the seashore reserve zone ordinance is likely to result in the extension of the reserve boundary and changes to land use permitted in the reserve. Extending the seashore reserve and limiting types of development within the seashore reserve zone would create an opportunity to further regulate inappropriate development in hazard-prone areas. The new seashore reserve plan is scheduled to be released in the spring of 2021.
Comprehensive Planning	BSP P.O. Box 2950 Hagatna, Guam 96910	Pre	Yes	The North and Central Guam Land Use Plan is an approved element of the Guam Comprehensive Development Plan. Building resilient communities is a fundamental tenant of the plan. BSP uses is planning authorities to leverage resource in order to create a greater impact.

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Comprehensive Planning	BSP P.O. Box 2950 Hagatna, Guam 96910	Pre and post	Yes	GCMP developed an Emergency Response for Impacts on the Environment from Natural Disasters reference guide the purpose of the study is to review the success and failures and level of action in responding to environmental impacts of natural disasters in the past and to develop information and ideas necessary for drafting comprehensive, response plan.
Floodplain Management / NFIP	DPW 542 North Marine Drive Tamuning/Tumon, Guam 96911	Pre and post	Yes	Guam's floodplain management ordinance was adopted in 1998 in Executive Order 98-30. Guam's floodplain management ordinance guides the management of all floodplain areas, as determined by FEMA maps for flood boundaries and flood insurance. The ordinance enables DPW to oversee management of floodplain areas in a manner that mitigates against tropical cyclone, flood and tsunami events. The floodplain management ordinance meets the minimum requirements of the NFIP, which is discussed below. The NFIP is a voluntary program, whereby a community adopts and enforces ordinances that meet or exceed the minimum floodplain management requirements of the NFIP to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. In addition, membership in the NFIP enables Guam to apply for capital-intensive hazard mitigation assistance grants from FEMA hazard mitigation programs, including the PDM, FMA, Severe Repetitive Loss (SRL), and Repetitive Flood Claim (RFC) Programs. Guam became a participating community in the NFIP in November 1985. Guam was placed on probation in April 1992 due to numerous structural and procedural violations. Guam remained on probationary status for 16 years due to numerous structural and procedural NFIP violations. In April 2008, FEMA lifted Guam's probationary status and reinstated Guam into the NFIP.

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Economic Impact Analysis	DPW 542 North Marine Drive Tamuning/Tumon, Guam 96911	Pre and post	Yes	Public Law 25-173 requires the government to conduct an economic impact statement of any proposed regulation change estimated to have an economic impact greater than \$500,000. Conducting an economic impact statement on proposed regulation changes as part of the decision-making process is a noble concept; however, in practice, this analysis is expensive and time-consuming. The public law does not provide any funding mechanism for conducting this analysis. As a result, this requirement can hinder regulation changes related to hazard mitigation activities.
Water Resources Management	GWA 578 N. Marine Corps Drive Tamuning/Tumon, Guam 96913	Pre	Yes	GWA published the Guam Water Resources Master Plan in 2007. The master plan contains a comprehensive analysis of wastewater and domestic water systems, improvement alternatives, and needs for the next 20 years. Implementation of the master plan allows GWA to identify critical facilities and vulnerable facilities and mitigate hazards to these assets appropriately, as funding becomes available. The master plan was funded with a combination of an EPA Consolidated Grant (for \$1.5 million), GWA CIP funding, and bonds.
Coastal Nonpoint Pollution Management	GEPA 17-3304 Mariner Ave. Tiyon, Guam 96913	Pre and post	No	In 2007, the U.S. EPA and NOAA determined that Guam's Coastal Nonpoint Pollution Control Program met the requirements of the Coastal Zone Act Reauthorization Amendments of 1990. Under the program, GEPA controls nonpoint pollution from agricultural areas, new urban development, existing development, construction sites, roads and bridges, marinas, waterways, and wetlands. The program enables GEPA to support hazard mitigation activities that reduce the potential of nonpoint pollution during floods or tropical cyclones.
Stormwater Management	DPW 542 North Marine Drive Tamuning/Tumon, Guam 96911	Pre	No	The CNMI/Guam Stormwater Management Manual was released in October 2006. In addition, DPW released a Stormwater Drainage Master Plan in 2010. The Master Plan outlines a systematic approach for identify existing stormwater runoff patterns and drainage system and prioritizing drainage improvements, especially in areas of development, for the island of Guam.

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Severe Acute Respiratory Syndrome (SARS) Response Management	DPHSS 123 Chalan Kareta, Route 10 Mangilao, Guam 96919	Pre and post	No	DPHSS, in cooperation with other local government agencies, the tourism industry, the medical community, and private industry, has prepared and implemented a SARS Response Manual addressing identification of a SARS case, clinician preparedness to deal with a case of SARS, medical facility preparedness to handle a SARS patient, community preparedness, and public education and awareness. The protocols and procedures that have been developed to respond to a potential SARS case can be applied to a future infectious respiratory disease threat. Agencies, organizations, and individuals that participated in the SARS response manual can be quickly set up as a working task force to respond to other diseases.
Rodent Control Program	DPHSS 123 Chalan Kareta, Route 10, Mangilao, Guam 96919	Pre	No	Title 10 of the Guam Code, Annotated provides DPHSS with the ability to control plague-infected rodents. DPHSS has established a Vector Control Program to implement and administer the rodent control requirements described in Title 10. The program enables DPHSS to enforce an international quarantine to control rodents, provide the public with rodent bait, and take steps to eradicate rodent harborages and breeding areas.
Drought Management	GWA 578 N. Marine Corps Drive Tamuning/Tumon, Guam 96913	Pre	No	GWA administers the drought management rules and comprehensive water conservation plan described in Title 12 of the Guam Code Annotated, Chapter 14. GWA implements steps for instituting conservation measures and the interruption of water supply, procedures for the protection of water resources pursuant to GWA's statutory role as operator of Guam's sole municipal water and wastewater systems, mandatory restrictions and procedures for control of water use during water shortages, and procedures to alert the community of severity alerts. As part of this program, WERI, in collaboration with USGS's Pacific Water Science Center conducts and administers a Comprehensive Monitoring Program regarding data collection on salt water intrusion, water lens thickness in the northern part of Guam, and stream flow data in the southern part of Guam.

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Wildfire Management	Department of Agriculture Forestry & Soils Resources Division 15, Mangilao, Guam	Pre	Yes	Guam Forestry oversees the Guam Forestry Program, which stresses increased planning efforts in all program areas, a step-down approach from an island scale to a watershed and site scale, and a need for increased resources to have the program capacity to carry out strategies as identified in the Guam Statewide Forest and Resource Strategy including: restoration, conservation of intact forests, reduce impacts to water quality and the reef system, mitigate the impacts of the military expansion, and address invasive species.

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6.3 FUNDING SOURCES

Generally, sources of funding for hazard mitigation activities on Guam can be separated into two categories — Federal sources and Government of Guam source. Also, private sources are not discussed in this document. Most hazard mitigation activities are funded with federal sources, primarily from FEMA. FEMA grants and most other federal sources are normally supplemented with Government of Guam funds. Sources that Guam is currently using (e.g., sources used during or since Super Typhoon Pongsona in 2002) are discussed in **Section 6.3.1** (Federal Funding Sources for Hazard Mitigation) and **Section 6.3.2** (Government of Guam Funding Sources for Hazard Mitigation). Mitigation funds that have been used to implement the mitigation actions identified in the 2011 and 2014 Guam HMP implementation strategy are discussed in **Section 6.3.3** (Funding Sources Used to Implement Mitigation Actions Identified in the 2014 Guam HMP).

6.3.1 Federal Funding Sources for Hazard Mitigation

The following discussion lists the potential federal funding sources for hazard mitigation activities. The sources are listed by the U.S. department or agency and the funding source.

Department of Agriculture

Natural Resources Conservation Service (NRCS) Emergency Watershed

Protection Program. For watersheds damaged by severe natural events, this program provides assistance to reduce hazards to life and property. If funds are available, NRCS can provide 100 percent of the cost of exigent situations and 80 percent of the cost of non-exigent situations. Examples of projects funded are construction or improvements of debris basins, installation of debris racks and other barriers, and revegetation. Although typically conducted as response activities, these projects can serve as mitigation against future disaster damage. Under the Emergency Watershed Protection Program, NRCS has authority for the repair of flood control works that is similar to that of the U.S. Army Corps of Engineers (USACE). The NRCS authority applies to drainage basins of 400 square miles or less.

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Department of the Army, U.S. Army Corps of Engineers

General Investigation Authority. This program is generally used for large flood damage reduction studies. The first \$100,000 is typically federally funded. If the study exceeds this amount, the remaining cost is evenly shared between the USACE and the applicant. Project implementation cost share is 65 percent federal and 35 percent non-federal match. General Investigation studies require specific congressional authorization.

Continuing Authorities. These programs allow the USACE to take a variety of actions on water resource projects. For these projects, a feasibility study is first performed. Applicant cost shares for these studies vary from 0 to 50 percent. Projects deemed cost-effective and in which a federal interest is established could qualify for up to 75 percent federal funding. Specific Continuing Authorities programs applicable to hazard mitigation include the following:

- **Section 204:** This program funds dredging associated with authorized navigation projects that protect, restore, and create aquatic or wetland habitats. Study costs include 100 percent federal funding for the initial appraisal and 65 percent federal funding for the feasibility study. The applicant funds up to 35 percent of project costs, including all necessary lands and relocations required for construction. The applicant is responsible for the operation and maintenance of the project.
- **Section 205:** This program funds general small flood control or drainage projects. The first \$100,000 of study costs are borne by USACE; additional study costs are shared equally between USACE and the applicant. The applicant incurs between 35 and 50 percent of project costs, including 5 percent in cash. The federal share of project costs is capped at 47 million. The applicant is responsible for the operation and maintenance of the project.
- **Section 206:** This program funds aquatic ecosystem restoration and protection projects, including design, planning, and construction. The federal share for both study costs and project costs is 65 percent, with a maximum of \$5 million for project costs. The applicant is responsible for the operation and maintenance of the project.
- **Section 208:** This program funds waterway clearing and snagging. USACE pays the first \$40,000 of project costs at 100 percent. Thereafter, the applicant is responsible for 35 percent. The applicant funds between 35 and 50 percent of project costs, including 5 percent in cash. The maximum federal share of project costs is \$500,000. The applicant is responsible for the operation and maintenance of the project.
- **Section 107:** This program funds small river and harbor improvement projects. USACE pays study costs in full for the first \$100,000; additional study costs are equally shared by the federal government and the applicant. The applicant is responsible for 10 percent of general navigation costs during construction and 10 percent of general navigation costs over a 30-year period. The maximum federal share for project costs is \$4 million.
- **Section 14:** This program funds emergency stream bank and shoreline protection projects. The USACE funds the first \$40,000 of study costs at 100 percent and

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funds 65 percent of additional study costs. The applicant funds up to 35 percent of project costs, including 5 percent in cash. The federal share for project costs is capped at \$1 million. The applicant is responsible for the operation and maintenance of the project.

- **Section 1135:** This program is limited to funding environmental restoration projects where a USACE project contributed to the deprivation of the environment. USACE bears 75 percent of both study costs and project costs, with a maximum contribution of \$5 million for project costs. The applicant is responsible for the operation and maintenance of the project.
- **Section 103.** This program funds hurricane and storm damage reduction protection activities. The federal share may not exceed \$3 million for each project. Work under this authority provides for protection or restoration of public shorelines by the construction of revetments, groins, and jetties and may include periodic sand replenishment.

Planning Assistance to States. This program assists states in the development of comprehensive plans relating to the development, use, and conservation of water and related land resources. The USACE funds 50 percent of study costs and \$25,000 to \$75,000 of project costs, with a maximum of \$500,000 annual allotment per state/territory. Currently, a waiver exists for initial study costs under this program.

Congressional Authorization (Major Civil Works Projects). Feasibility studies that USACE undertakes for major civil works projects that indicate federal interests (a benefit/cost ratio greater than unity) may be funded through Congressional Authorization of the proposed program.

National Flood Risk Management Program. The National Flood Risk Management Program was established in May 2006 for the purpose of integrating and synchronizing USACE flood risk management programs and activities, both internally and with the counterpart activities of FEMA, other federal agencies, state organizations, and regional and local agencies. This program provides education and planning services for flood hazards and floodplain management.

Department of Commerce, Economic Development Administration

Public Work and Economic Development Facilities Grants. These grants are given to public agencies and private nonprofit organizations for the building or expansion of facilities that are essential to industrial and commercial growth.

Technical Assistance Grants. These grants make funding available to communities and firms for economic feasibility studies of resource development in the establishment of jobs. The funding also provides on-site support for innovative economic development techniques.

Grants to Support Planning Organizations. Funding is available through planning grants to help pay for the expertise needed to plan, coordinate, and implement comprehensive economic development programs.

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University Center Economic Development Grants. These grants are awarded to colleges and universities to provide technical assistance and address the economic development problems and opportunities of their service area.

Economic Adjustment Assistance Grants. This program assists states, territories, and local governments in solving recent and anticipated severe adjustment problems that may result in abrupt and serious job losses and helping areas implement strategies to reverse and halt long- term economic deterioration, including natural disasters.

Department of Commerce, National Oceanic and Atmospheric Administration

Coastal Management Program. NOAA enters into partnerships (through cooperative agreements) with states and territories in which NOAA provides funding, technical assistance, and oversight to ensure compliance with the Coastal Zone Management Act. On Guam, the entire island is considered a coastal zone; therefore, the Coastal Management Program on Guam is called the Guam Coastal Management Program. Federal grants are provided on an equal cost- share basis with the state or territory under the following sections of the Coastal Management Program.

- Section 303: This program focuses on the protection of natural resources that mitigate wind and flooding impacts, including beaches, dunes, and barrier islands.
- Section 305: This program provides states and territories with funding to develop their Coastal Zone Management Programs (CZMPs).
- Section 306: This program provides grants for states and territories to administer their CZMPs, including staff salaries, equipment purchases, public education and outreach, enhancement of public access, and the undertaking of projects that monitor and/or enhance elements of the CZMP.
- Section 309: The Coastal Zone Enhancement Program allows states and territories to compete for funding by creating enhancements to the existing state or territory CZMP in eight priority areas, including coastal hazard mitigation, wetlands protection, and the control of cumulative and secondary impacts from development.

Small Business Administration

Physical Disaster Loans and Economic Injury Disaster Loans. The Disaster Division of the Small Business Administration (SBA) provides direct, guaranteed, and insured loans to assist homeowners and businesses suffering economic injury as a result of a disaster declared by the President, the SBA, or the Secretary of Agriculture. Funds under this loan program are not provided merely because of lost income or lost profits; rather, funds may be provided to pay liabilities that the business could have paid if the disaster had not occurred. Working capital can also be provided to allow a business to operate until conditions return to normal. The maximum loan amount is \$1.5 million and is based on need. A repayment period of up to 30 years may be granted. The interest rate is not to exceed 4 percent. Over and above the loan amount for the assessed damage, 20 percent in funds may be provided for hazard mitigation activities. Guam has previously used this funding source.

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The Concrete Upgrade Policy was instituted in Guam after Super Typhoon Paka in 1997. Pursuant to this policy, when a homeowner or business has more than \$10,000 in uncompensated losses for property damage from a declared disaster, the SBA will increase the disaster loan amount to cover the full cost of building a typhoon-resistant concrete or similar structure.

Department of Health and Human Services, Administration for Native Americans (ANA)
Social and Economic Development Strategies (SEDS). The SEDS program provides competitive financial assistance grants to American Indians, Native Americans, Native Alaskans, Native Hawaiians, and Pacific Islanders to promote lasting self-sufficiency and enhance self- government. SEDS promotes self-sufficiency by supporting native communities in their efforts to reduce dependency on public funds and social services by increasing community and individual productivity through community development. Guam currently uses funding from this program.

Environmental Regulatory Enhancement. Environmental quality has a direct impact on the ability of Native American (including Pacific Islander) communities to develop economic and social self-sufficiency. ANA provides grants to the Indian Environmental Regulatory Enhancement Act to assist tribes in the planning, development, and implementation of projects that were designed to improve their capacity to regulate environmental activities.

Department of Health and Human Services, Centers for Disease Control and Prevention
Public Health Emergency Preparedness Cooperative Agreement. This program is administered by the Coordinating Office for Terrorism Preparedness and Emergency. Funds are allocated through cooperative agreements intended to upgrade the preparedness and response capabilities of state and local public health jurisdictions to bioterrorism, outbreaks of infectious disease, and other public health threats and emergencies. To receive funding, state or local public health agencies are required to meet a list of preparedness outcomes, including participation in the Public Health Information Network (which replaced the previous Health Alert Network Program) and the development of ERPs and training. The cooperative agreement also lists allowable activities for which funding may be used. States are required to match 5 percent of funding in the first year of a cooperative agreement and 10 percent of funding in the second year and thereafter.

Department of Homeland Security, Federal Emergency Management Agency
Hazard Mitigation Grant Program. The HMGP provides grants to state/territory and local governments to implement long-term hazard mitigation planning and actions after a Presidentially declared disaster. For states and territories with a Standard State Mitigation Plan (Guam has such a plan), HMGP funding for a disaster is valued at 15 percent of the first \$2 billion of the total eligible costs associated with FEMA's PA Program and Individual Assistance (IA) Program for that disaster. HMGP funding is valued at 10 percent for the next portion of PA and IA Program costs (between \$2 billion and \$10 billion). Finally, for PA and IA Program costs of between \$10 billion and \$35.333 billion, HMGP funds are calculated at

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7.5 percent. The federal share of any project will not exceed 75 percent of the total eligible costs of that project. Guam currently uses the HMGP for hazard mitigation funding.

Building Resilient Infrastructure in Communities (BRIC). FEMA provides federal funds for the Building Resilient Infrastructures and Communities (BRIC) grant program to states, local communities, tribes, and territories for hazard mitigation activities. BRIC is a FEMA annual hazard mitigation program.

The BRIC program priorities are to:

- Incentivize natural hazard risk reduction activities that mitigate risk to public infrastructure
- Incorporate nature-based solutions including those designed to reduce carbon emissions
- Enhance climate resilience and adaptation
- Promote equity and prioritize disadvantaged communities as referenced in Executive Order (EO) 14008:
- Tackling the Climate Crisis at Home and Abroad
- Increase funding to applicants that facilitate the adoption and enforcement of the latest published editions of
- building codes

Public Assistance Program. The PA Program provides supplemental federal disaster grant assistance for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations. The federal share is not less than 75 percent of the eligible cost for emergency measures and permanent restoration of these facilities. The PA Program allows for funding to implement cost-effective hazard mitigation measures that restore a facility beyond its pre-disaster condition. PA Program hazard mitigation measures can only be applied to the damaged element of the facility. Further, hazard mitigation measures must be cost-effective (i.e., the hazard mitigation component may amount to no more than 15 percent of the total eligible cost of restoration work on the project, demonstrate a benefit- cost ratio of greater than unity, or meet other conditions). Guam currently uses the PA Program to fund hazard mitigation activities.

Flood Mitigation Assistance Program. The FMA Program provides funding to assist states, territories, and local communities to implement measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the NFIP. Grants are available for planning, projects, and technical assistance. States and territories are encouraged to prioritize grant applications that include RL properties identified in their Repetitive Loss Strategy and tracked by FEMA in BureauNet and NextGen. Examples of mitigation projects include acquisition, elevation, relocation, flood-proofing, and technical assistance. The enabling legislation specifically excludes large-scale structural flood control projects from receiving this type of funding.

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Severe Repetitive Loss Program. The SRL Program provides funding to reduce or eliminate the long-term risk of flood damage to SRL residential structures insured under the NFIP. SRL properties are determined by the number, value, and frequency of NFIP claims. The SRL program funds projects that directly mitigate residential SRL properties. Examples of these projects include elevation, acquisition, relocation, and flood-proofing.

Repetitive Flood Claim Program. The RFC Program provides funding to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payment for flood damages. RFC funds may only mitigate structures that are within a state or community that cannot meet the cost-share or management capacity requirements of the FMA Program. Typical projects include acquisition, elevation, relocation, and flood-proofing.

Homeland Security Grant Program. HSGP is a primary funding mechanism for building and sustaining national preparedness capabilities. HSGP grants enhance the ability of state, local, and tribal governments to prevent, protect against, respond to, and recover from terrorist attacks and other disasters. These grants fund a range of preparedness activities, including planning, organization, equipment purchase, training, exercises, and management and administrative costs. Guam currently uses this funding source.

Buffer Zone Protection Program. The Buffer Zone Protection Program (BZPP) provides grants to build security and risk-management capabilities at the state and local level to secure pre-designated Tier I and Tier II critical infrastructure sites, including chemical facilities, financial institutions, nuclear and electric power plants, dams, stadiums, and other high-risk/high-consequence facilities. The funds provided by BZPP are provided to increase the preparedness capabilities of jurisdictions responsible for the safety and security of communities surrounding high-priority critical infrastructure and key resource assets through allowable planning and equipment acquisition. Guam currently receives BZPP funding.

Port Security Grant Program (PSGP). The PSGP provides grant funding to port areas for the protection of critical port infrastructure from terrorism. PSGP funds help ports enhance their risk management capabilities; domain awareness; training and exercises; and capabilities to prevent, detect, respond to, and recover from attacks involving improvised explosive devices and other unconventional weapons. Apra Harbor is designated as a Group III port area.

Assistance to Firefighter Grants. Competitive grants are available to provide direct assistance to fire departments for the purpose of protecting the health and safety of the public and fire-fighting personnel against fire and fire-related hazards. Funding to any organization is limited to \$750,000 per FY.

Staffing for Adequate Fire and Emergency Response (SAFER) Grants. The SAFER Grant was created to provide funding directly to fire departments and volunteer firefighter interest organizations to help them increase the number of trained, “front-line”

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firefighters available in their communities. Funding is available for hiring new firefighters to meet Occupational Safety and Health Administration standards. A maximum level of funding of \$104,425 per position is provided over a 5-year period. SAFER Grant funding is also available for the recruitment and retention of volunteer firefighters. Funding for volunteer firefighters has no local funding match requirement and no maximum federal share limits.

Department of Housing and Urban Development, Office of Community Planning and Development

Community Development Block Grant Program. The Community Development Block Grant (CDBG) Program is a flexible program that provides communities with resources to address a wide range of unique community development needs. Relevant grant programs include the following:

Insular Areas CDBG Program. HUD annually allocates \$7 million of CDBG Program funds to Insular Areas on a formula basis in proportion to the populations of the eligible territories. Funds are provided to territories as a lump sum grant to be distributed by the recipient, within program rules, at the discretion of the territory government. Funding is expected to meet one of the following objectives; providing benefits to low- and moderate- income persons, to assist in the prevention or elimination of slums and blight, and to meet other community development needs having a particular urgency due to health or safety considerations. Typical activities funded include the construction of public facilities and improvements, such as water systems, streets, and community centers; rehabilitation of houses and landmark structures; assistance to carry out economic development activities; and the provision of public services. Hazard mitigation activities can be funded as part of CDBGs. Guam currently uses the CDBG Program to fund hazard mitigation activities.

Section 108 Loan Guarantee Program. Section 108 is the loan guarantee provision of the CDBG Program. Through this program, the recipient can transform a small portion of its CDBG funds into federally guaranteed loans large enough to pursue physical and economic revitalization projects. Governments borrowing funds guaranteed by Section 108 must pledge their current and future CDBG allocations to cover the loan amount as security for the loan. Loan commitments are often paired with Economic Development Initiative or Brownfield Economic Development Initiative grants, which can be used to pay predevelopment costs of Section 108-funded projects. They can also be used as a loan loss reserve (in lieu of CDBG funds), to write-down interest rates or to establish a debt service reserve. Section 108 guarantees can be used for projects, including hazard mitigation measures.

Disaster Recovery Initiative. This program provides grants to states and territories to find gaps in available recovery assistance after disasters. Mitigation activities are eligible as part of the Disaster Recovery Initiative. Guam currently uses this program to fund hazard mitigation activities. This funding is provided on a flexible basis, subject to need, and the availability of supplemental appropriations.

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Home Investment Partnerships Program. Like the CDBG Program, the Home Investment Partnerships Program provides formula grants to states, territories, and localities to fund a wide range of activities for communities. Home Investment Partnerships Program grants are often provided in partnership with local nonprofit groups. They fund activities relating to building, purchasing, and/or rehabilitating affordable housing for rent or ownership, including hazard mitigation projects. Guam currently uses this funding source.

Emergency Shelter Grants (ESGs). This program provides funding to grantees such as state governments on a formula basis. Funding is available for activities such as conversion, major rehabilitation, or renovation of buildings as emergency shelters and shelter operating expenses. Grantees receive ESG funds and distribute these funds to eligible recipients, which can be either local government agencies or private nonprofit organizations. Grantees, except for state governments, must match ESG funds dollar for dollar with their own locally generated funds. Guam currently receives funding from this program.

Office of Capital Improvements Capital Fund Emergency/Natural Disaster Funding. This program provides grants to public housing agencies for rehabilitation needs resulting from natural disasters or emergency situations. Activities funded under this program include elevation, floodproofing, and seismic retrofits.

Department of the Interior, Office of Insular Affairs

Compact Impact Aid. Compact Impact funding is a special appropriation, allocated by Congress on an annual basis, to provide compensation for and to offset the economic effects of immigration from the Federated States of Micronesia, the Republic of the Marshall Islands, and Palau. The Government of Guam receives \$16.8 million annually in Compact Impact Aid.

Disaster Assistance Grants. The Office of Insular Affairs of the U.S. Department of Interior may request up to \$2 million annually of Covenant grant funds in the annual budget process for disaster mitigation purposes. The Office of Insular Affairs does not have to identify specific projects or the recipients of this grant funding in the budget process.

Department of the Interior, U.S. Geological Survey

National Earthquake Hazards Reduction Program. The primary objective of National Earthquake Hazards Reduction Program project grants is to mitigate earthquake losses by providing earth science data and assessments essential for warning of imminent damaging earthquakes, land use planning, engineering design, and emergency preparedness decisions. Grants are provided through cooperative agreements and may be provided to colleges and universities, profit-making and nonprofit organizations, and state, territory, or local governments. Grants range in size from \$6,000 to \$1.1 million, with an average grant size of \$56,000.

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Examples of grants include projects for earthquake loss reduction, earthquake monitoring and forecasting experiments, fault zone studies, and seismic zonation and engineering studies.

Department of Transportation, Federal Highway Administration

Emergency Relief (ER) Program. The ER Program is special component of the Highway Trust Fund for the repair or reconstruction of federal-aid highways and roads on federal lands that have suffered serious damage as a result of (1) natural disasters or (2) catastrophic failures from an external cause. This program supplements the commitment of resources by states or territories to help pay for unusually heavy expenses resulting from extraordinary conditions. The total ER Program obligations for territories is limited to \$20 million in any FY. For a large disaster, Congress may pass special legislation lifting the cap for that disaster. Hazard mitigation activities, referred to as “betterments,” may be funded through this program. Guam currently uses this funding source.

Environmental Protection Agency, Office of Water

Wetland Protection Development Grants. These grants are provided to states and territories to support the development and enhancement of wetland protection programs.

Non-Point Source Implementation Grants (319 Program). These grants are provided to states and territories to implement non-point source pollution control programs, including support for non-structural watershed restoration activities.

Clean Water State Revolving Fund. This program provides loans at actual or below-market interest rates to help build, repair, relocate, or replace wastewater treatment plants.

Drinking Water State Revolving Fund. This program provides funds on a formula basis to states for consolidation or maintenance of drinking water supplies, the creation of new systems, drinking water storage/treatment and transmission costs, and drinking water security measures.

Water Security Training and Technical Assistance and Water Security Initiative Contamination Warning System Pilots. The objective of these grant programs is to provide financial assistance to improve water infrastructure security through both training and technical assistance for water utilities and cooperative agreements to address the risk of intentional contamination.

6.3.2 Government of Guam Funding Sources for Hazard Mitigation

Similar to most state governments, the Government of Guam establishes a general fund through a cooperative effort between the executive and legislative branches for each FY. Each Government of Guam agency submits a proposed budget to the Guam Bureau of Budget and Management Research (BBMR) annually. BBMR reviews the proposed budget requests, revises the proposals as it determines is necessary, and

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forwards the proposed budget to the Guam Legislature. The Guam Legislature then drafts a budget for a vote, makes revisions as necessary for a consensus, and passes the final budget to the Governor for signature or veto. Unless otherwise stipulated in the law promulgating the budget, each agency determines general fund expenditures based on its authorized budget. Hence, individual agencies have some discretion to determine the percentage of its general fund budget to apply to hazard mitigation activities.

Sources of income for the Government of Guam's general fund include property tax, corporate tax, gross receipt tax, licensing fees, and income tax. The Government of Guam distinguishes between line agencies and autonomous agencies. Line agencies rely completely on the general fund for their budgets; distribution of funds for line agencies occurs through the Department of Administration. Autonomous agencies (such as GPA or the Guam Economic Development Authority [GEDA]) have the potential to create revenue by providing services, goods, or other activities; their funding generally does not pass through the Department of Administration.

Government of Guam agencies can also issue bonds to generate revenue. GEDA and the Guam Legislature review proposals for bond flotation.

Individual agencies are responsible for preparing and submitting proposals for federal or other grants; however, BBMR reviews requests for federal grants. Agencies receiving grants that require matching funds are responsible for providing the matching funds as part of their general fund budgets.

By law, the Guam Legislature is authorized to expend up to \$250,000 from general fund appropriations for Government of Guam agencies on emergency activities, including those resulting from natural disasters.

6.4 MITIGATION GOALS

Six mitigation goals provide the foundation for the 2024 Guam HMP. Five of these six goals were originally developed for the 2005 Guam HMP through solicitation of the HMAAC and through various meetings with Government of Guam agencies and other organizations. Although additional hazards have been added to the Guam HMP in subsequent updates, the SHMO and HMAAC determined that the existing mitigation goals continue to address both existing and new hazards. During the 2024 Guam HMP update process, the sixth goal was added. The GHS-OCD HM Section team reviewed these goals and confirmed to keep them as written in the HMP. The goals are as follows.

- Goal 1: Improve the quality and comprehensiveness of information on assets and hazards
- Goal 2: Reduce risks of disaster damage to existing buildings and infrastructure, especially essential facilities, major utilities, and transportation systems (EFMUTS)
- Goal 3: Promote disaster-resistant development and disaster recovery

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- Goal 4: Develop institutional support of hazard mitigation within the Government of Guam agencies and the public
- Goal 5: Protect human health and safety
- Goal 6: Eliminate or reduce the damage to residential property and the disruption of life caused by repeated flooding

6.5 MITIGATION ACTIONS

6.5.1 Mitigation Actions

The SHMO, GHS/OCD Hazard Mitigation Section, and HMWG collaborated in the 2024 Guam HMP process to update the 2019 Mitigation Action projects, including how the GHS/OCD Hazard Mitigation Section evaluates and prioritizes mitigation action.

6.5.2 Evaluation and Prioritization of Mitigation Actions

GHS/OCD Hazard Mitigation Section prioritized mitigation actions in the 2024 Mitigation Strategy. Each action in the 2024 Guam HMP Update was ranked based on the following criteria:

- Life and Property Safety: Does the project save lives and protect property?
- Alignment with Priorities: Does it align with Typhoon Mawar priorities (Power, Water, Mass Care, Communication)?
- Essential Facilities and Utilities: Does it protect critical facilities and utilities?
- Cost-Effectiveness: Is the project cost-effective?
- Climate Change Mitigation: Does it address climate change effects?
- Funding Availability: Is funding possible?
- Environmental Impact: Does it positively impact the environment?
- Vulnerable Communities: Will it benefit socially vulnerable communities?
- Multi-Hazard Reduction: Does it reduce risk for more than one hazard?
- Timeliness: Can it be completed in less than five years?
- Local Benefits: Does it support local capital improvements, economic growth, and environmental quality?

The GHS/OCD Mitigation staff will work with various members of the HMWG and stakeholders to prioritize identifying mitigation actions ranking using the following criteria for the next Guam Hazard Mitigation Plan update:

- Life Safety: Will the action enhance life safety?
- Property Protection: Does it protect vulnerable state assets?
- Cost-Effectiveness: Future benefits exceed costs.
- Technical Feasibility: Is it technically feasible?
- Climate Resilience: Does it mitigate climate change impacts?
- Legal Authority: Can Guam implement it?
- Funding Availability: Is funding available?
- Environmental Impact: Positive impact on the natural environment.
- Administrative Capability: Can Guam execute it?
- Multi-Hazard Reduction: Reduces risk for multiple hazards.
- Timeliness: Completion within five years.
- Local Champion: Agency/department support.

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- Local Objectives: Aligns with other local plans and programs.

Scoring and Prioritization:

Answers to each question are weighted (Yes = 3 points, Not sure = 2 points, No = 1 point).

Priorities assigned based on total scores:

- 31 or more = High Priority
- 15 to 30 = Medium Priority
- 0 to 14 = Low Priority

Furthermore, the GHS/OCD Hazard Mitigation Section evaluates and prioritizes cost-effective, environmentally sound, and technically feasible actions. For flood, erosion, high surf, and, to some extent, sea level rise hazards, the Government of Guam has partnered with the USACE and the University of Guam to perform thorough risk assessments and studies. These risk assessment reports and studies are followed by a risk mitigation feasibility study that evaluates a range of risk management alternatives that are commonly used to address the specific hazard. Using data from prior risk assessments and studies, GIS, and modelling, those alternatives are ranked based on their effectiveness and useful life. Each alternative deemed as feasible and effective are also evaluated by their impact to the environment, cultural resources, and to the public. Effective alternatives that minimize the impact or improve the environment are then ranked. The top three projects are then deemed as “tentatively selected plans”. Site specific draft designs, and cost estimates for those three tentative plans are developed. The cost of the design is ranked from lowest to highest cost. The lowest cost plan and draft design is selected. Due to limited local resources, the Government of Guam funds mitigation actions that are federally funded, or that employ the services of the USACE. Capital project grant costs typically exceed federal matching waivers, and there is always a cost share with USACE Civil Works projects, so the Government of Guam chooses the lowest cost option that minimizes their share or match.

In future HMP updates, additional considerations for the prioritization process can include:

- Guam Plans and Regulations: Encouraging risk reduction (building codes, planning regulations).
- Structure and Infrastructure Projects: Modifying or constructing to reduce hazard impact.
- Natural Systems Protection: Preserving/restoring natural systems’ function.
- Education and Awareness Programs: Long-term programs informing citizens about hazards and mitigation.

Table 46 provides a detailed status update on each mitigation action removed from the 2019 Guam HMP to the 2024 Guam HMP. Also, it includes descriptions of ongoing projects, their current status, responsible agencies, estimated time frames, associated hazards, and priority levels. The first two columns are labelled “Action” and “Notes on Removal or Change,” describing if the 2019 mitigation project was either removed, replaced (updated), changed, or completed. A total of 34 mitigation projects were

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completed or removed; specifically, 21 projects were completed, and 13 projects were removed.

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Table 49. 2019 Mitigation Strategy

Action	Notes on Removal or Change	No.	Source	Description	Primary Agency	Estimated Cost	Potential Funding Source	Estimated Time Frame	Project Status	Hazard	Priority Level	Goal	EHP (High, Medium, Low)
Remove and Replace	Re-Evaluation report was completed, and will convert into a General Investigation Study by USACE. 22 new should replace this project https://www.poh.usace.army.mil/Portals/10/docs/projectreviewplans/Agana%20River%20General%20Reevaluation%20Report_Review%20Plan.pdf?ver=oB908LZfbxbTfxtXN5xb4A%3D%3D	1	Other Funding	Agana River Flood Control Project with the the USACE. The project was originally authorized under the WRDA of 1986 but was admitateively de-authorized in April 2002. A General Reevaluation Rquest is being considered by USACE	Bureau of Statistics and Plan (BSP)	\$10,000,000.00	DOI OIA IRA Funds	4 Years	Not Started	Flooding	High	2, 3	High
Replacement	Updated projected information and parameters for #1.	#1 new	Other Funding	Hagatna River Flood Feasibility Study: A General Investigatin Study will be conducted by the USACE for flood control solutions. A General Re-evaluation was completed in 2020. https://www.poh.usace.army.mil/Portals/10/docs/projectreviewplans/Agana%20River%20General%20Reevaluation%20Report_Review%20Plan.pdf?ver=oB908LZfbxbTfxtXN5xb4A%3D%3D	Bureau of Statistics and Plan (BSP)	\$945,000.00	DOI OIA IRA Funds	3 Years	Not Started	Flooding	High	2, 3	High
Removed	After further evaluation of the land records and official maps, it was found that the proposed site of the mitigation was primarily on private property. Not feasible to execute the project.	2	2019 HMP	Namo River Feasible Study: Develop a proposal to initate flood and erosion mitigation option as proposed by USACE under Section 205 Flood Damage Reduction of the Continuing Authorities Program for Umatac River, and Namu River.	Bureau of Statistics and Plan (BSP)	\$10,000,000.00	USACE	4 Years	In Progress	Flooding	High	2, 3, 5, 6	High
Completed	This assessment was completed in 2020 https://bsp.guam.gov/wp-bsp-content/uploads/2024/07/Agat-Bay-Regional-Shoreline-Assessment.pdf	3	2019 HMP	Agat Bay Regional Shoreline Assessment: Phase 1: Implement mitigation actions indicated in the Agat Bay Regional Shoreline Assessment	Bureau of Statistics and Plan (BSP)	\$980,000.00	HMGP	4 Years	Funding Application Submitted	Coastal Erosion	High	2, 5	High
Remove	Department of Parks and Recreation is seeking Public Assistance Funds to repair the shoreline	4	Othr Funding	Nimitz Beach Shoreline Stabilization: Utilizing naturebase solutions to regain lost shoreline on a public park cause of strong wave action and increased sea level.	Bureau of Statistics and Plan (BSP)	\$1,500,000.00	HMGP DR-4495	5 years	Funding Application Submitted	Coastal Erosion	Medium	1,2,3, 4	High

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Remove and Replace	Replaced with #5 new	5	Other Funding	Manell River Flow Path Restoration: Restoring the Manell River's Natural Flowpath: Restoring Manell River's Natural Flow Path 1. Drainage Analysis 2. Design and construction of flood control	Bureau of Statistics and Plan (BSP)	\$992,250.00	BRIC 2021	3 Years	In Progress	Flooding	Medium	1,2,3,6	High
Replacement	Updated projected information and parameters for #5.	#5 new	Other Funding	The Merizo Flood Risk Management Project: Is currently in the feasibility study phase. The study area is located on the southern coast of Guam in the village of Merizo and is authorized by Section 205 of the Flood Control Act of 1948, as amended. This authority allows for study, design, and construction of small flood risk management projects in partnership with non-federal government agencies. The Non-Federal Sponsor is the Government of Guam. The Corps is investigating alternatives to reduce flood risk in the area caused by the Nelansa River, also known as the Manell River. Previous man-made alterations to Manell River cause it to surge as it approaches Manell Channel which has resulted in increased flooding of Route 4 and numerous private residences. A Feasibility Cost Share Agreement (FCSA) is expected to be executed in May 2023.	Bureau of Statistics and Plan (BSP)	Feasibility Study Cost \$900k, pending estimate for construction	DOI OIA IRA Funds	3 years	Ongoing	Flooding	High	1,2,3,6	High
Completed	Completed	6	2019 HMP	Comprehensive inventory and update all EFMUTS: To identify assests at risk from hazards in order to provide emergency responders with accurate information about critical facilities. Inventory information should include exact location, facility type, owner/operator, replacement/insured value, year built, primary structural system, secondary building system/redundancy, building material, roof material/type,	Bureau of Statistics and Planning (BSP)	\$200,000.00	Internal Funding	2 years	Completed	All-Hazard (state all that are profiled Typhoon, Earthquake, Flooding, Coastal Errosion)	Medium	1	Low

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				mitigation upgrades (e.g., shutters, seismic retrofit), potential secondary impacts due to failure, and prior disaster impacts.									
Completed	Completed	7	2019 HMP	School Shelter Vulnerability Assessment: Develop and implement a process for assessing the hazard vulnerability of school buildings and grounds designated as storm shelters. Upon completion of vulnerability assessment, retrofit buildings and grounds by installing typhoon shutters or replacing windows and doors. This project will mitigate against multiple hazards, including tropical cyclone, severe wind, and disease events	GDOE	\$196,402.00	HMGP DR-4224	3-Years	Completed	Typhoon	High	1, 2, 3	Medium
Removed	Not a actionable project, irrelevant.	8	2019 HMP	Ensure that within GHS/OCD, the GHMO position is a fulltime position and the Guam HMP is reviewed and updated by the GHMO and HMAC and adopted by the Governor every 5 years.	Guam Homeland Security (GHS)	Undetermined	Undetermined	Ongoing	Completed	Irrelevant	Irrelevant	Irrelevant	Irrelevant
Completed	Completed	9	2019 HMP	Update Guam's Threat and Hazard Identification and Risk Assessment (THIRA): following guidance issued in the second edition of the Comprehensive Preparedness Guide 201. Consider integrating Desired Outcomes into the existing Guam Comprehensive Emergency Management Plan. In addition, through the THIRA process, identify opportunities to employ mitigation projects to reduce the loss of life and damage to property thereby reducing the impacts needed to manage, and hence reduce the resources needed to achieve capability targets.	GHS/OCD	\$150,000.00	State Homeland Security Program	3 years	Not Started	All-Hazard (state all that are profiled Typhoon, Earthquake, Flooding, Coastal Errorsion)	High	1,2,4	Low

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Removed	This project is in GMH's Capital Improvement Plan., which they are exploring internal funding sources HMGP ineligible activity.	10	2019 HMP	Emergency Water Supply System: Design and build a rooftop, gravity flow type emergency water supply system (to include 4 rooftop water tanks approx. 5,000 gallons each) to be located on rooftop areas of the Guam Memorial Hospital. As the Guam Memorial Hospital is a critical infrastructure, this emergency water supply is needed to sustain GMHA's operations for a period of 4 to 5 days when tropical cyclones cause a temporary GWA water outage or disruption that may negatively impact GMHA.	Guam Memorial Hospital (GMH)	\$400,000.00	Internal Funding	12-18 months	In Progress	Typhoon, Earthquake	Low	3, 5	Low
Removed	Replacing the building. Putting the cost that would have been put into the repair into rebuilding for public assistance claim.	11	2019 HMP	Warehouse and Facilities Maintenance Buildings Hardening: From high winds, earthquakes and heavy rain.	Guam Water Authority (GWA)	\$5,000,000.00	PA Mitigation DR-4715	2 Years	In Progress	Typhoon, Earthquake (high winds, heavy rain)	Low	2, 3	Low
Completed	Completed	12	2019 HMP	Water Tank/Reservoirs Concrete Conversion: In order to mitigate against multiple hazards, including flood events and tropical cyclones. GWA has a total of thirty-eight tanks for this project with various capacity, totaling 37.8 million gallons of capacity.	Guam Water Authority (GWA)	\$124,000,000.00	Internal Funding	15-20 Years	Completed	Flood, Typhoon	Medium	2, 3, 5	Low/Medium
Removed	The project's facility is no longer in operations.	13	2019 HMP	Public Health Facility Roof Hardening: Provide concrete roofing for 5 air handling units which service the public health facility in Mangilao in order to mitigate against tropical cyclones or other disasters.	Dept. of Public Health and Social Services (DPHSS)	Undetermined	HMGP/BRIC	6 months – 1 year	Completed	Typhoon	Low	1,2,3, 5,6	High
Remove	The project's facility is no longer in operations.	14	2019 HMP	Public Health Facility 7 Double Door Shuttering: Retrofit seven (7) double doors at the public health facility in Mangilao with panel/accordion shutters to withstand typhoon strength winds.	Dept. of Public Health and Social Services (DPHSS)	Undetermined	HMGP/BRIC	TBD	Completed	Typhoon	Low	1,2,3, 5,6	Medium

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Completed	Completed	15	2019 HMP	Department Service Buildings Back Up Generators: Acquire, retrofit and install back-up power for all department service buildings such as our Youth Correctional Facility, Cottage Homes Facility, and the three resource centers in Agat, Mangilao, and Dededo centers.	Dept. of Youth Affairs (DYA)	Undetermined	BRIC	TBD	Completed	Typhoon	Low	3, 5	Low
Removed	SHMO will request status update from DYA specifically about water systems, if it is still a priority. Some work has been done over the years outside of HM funding.	16	2019 HMP	Department Service Building Back Up Water Tanks: Acquire, retrofit and install water systems for all department service buildings such as our Youth Correctional Facility, Cottage Homes Facility, and the three resource centers in Agat, Mangilao, and Dededo centers.	Dept. of Youth Affairs (DYA)	\$85,000.00	US Dept. of Education/ Dept. of Corrections	TBD	Not Started	Typhoon, Earthquake	Low	3, 5	Low
Removed	The project's facility is no longer in operations.	17	2019 HMP	Central Facility Wooden Office Hardening: Harden one wooden office (structure) at the DPHSS central facility in Mangilao from class D (wooden) to class A (concrete).	Dept. of Public Health and Social Services (DPHSS)	Undetermined	HMGP/ BRIC	1-2 years	Not Started	Typhoon	Low	1,2,3, 5,6	Low
Removed	GCC retracted the projected.	18	2019 HMP	Building 900 Hardening: Retrofit Building 900 to harden Butler-tin structure by replacing with concrete envelope and to mitigate against storm strength wind events, to bring building up to electrical code, and to reduce loss of life, damage to surrounding buildings on campus from storms and typhoons, and to prevent disruption of educational training and services.	Guam Comm. College (GCC)	\$4,000,000.00	HMGP/ BRIC	3 Years	Completed	Flooding, Typhoon	Medium	1,2,3, 5,6	High
Completed	Completed	19	2019 HMP	Clara St. Underground Conversion (Mongmong) Distribution: Primary and secondary power lines overhead to underground conversion in a system of manholes, handholes, and underground power cables and accessories.	Guam Power Authority (GPA)	\$250,000.00	Internal Funding	1 Year	In Progress	Typhoon	High	2, 3, 5	High
Completed	Completed	20	2019 HMP	Wooden Pole Concrete Conversion: Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$5,000,000.00	PA Mitigation DR-4715	2 Years	In Progress	Typhoon	High	2, 3, 5	Medium

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Completed	Completed	21	2019 HMP	Kaiser Hybrid Wooden Pole Concrete Conversion: (Chichirica, Sta Barbara, Amates) Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$6,000,000.00	PA Mitigation DR-4715	2 Years	Not Started	Typhoon	High	2, 3, 5	High
Completed	Completed	22	2019 HMP	Kaiser Hybrid Wooden Pole Concrete Conversion (San Antonio Avenue) : Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$1,300,000.00	PA Mitigation DR-4715	5 Years	Funding Application Submitted	Typhoon	High	2, 3, 5	Medium
Completed	Completed	23	2019 HMP, HMGP DR-4715	Liguan Terrace Hybrid Wooden Pole Concrete Conversion: Phase I Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$23,650,000.00	HMGP DR-4715	5 Years	Funding Application Submitted	Typhoon	High	1,2,3, 4,5,6	High
Completed	Completed	24	2019 HMP, HMGP DR-4715	Liguan Terrace Hybrid Wooden Pole Concrete Conversion - Phase II: Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$12,000,000.00	HMGP DR-4715	5 Years	Not Started	Typhoon	High	1,2,3, 4,5,6	High
Completed	Completed	25	2019 HMP, HMGP DR-4715	Barrigada Village Wooden Pole Concrete Conversion - Phase I: Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$13,000,000.00	HMGP DR-4715	5 Years	Funding Application Submitted	Typhoon	High	1,2,3, 4,5,6	high
Completed	Completed	26	2019 HMP	Agana Heights Wooden Pole Concrete Conversion- Phase I: Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$26,400,000.00	PA Mitigation DR-4715	5 Years	Funding Application Submitted	Typhoon	High	1,2,3, 4,5,6	High
Completed	Completed	27	2019 HMP	Yigo Village Wood Pole Concrete Conversion- Phase I : Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$26,400,000.00	PA Mitigation DR-4715	5 Years	Funding Application Submitted	Typhoon	High	1,2,3, 4,5,6	High
Completed	Completed	28	2019 HMP	Agana Village Wooden pole Concrete Conversion - Phase I : Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$18,451,000.00	PA Mitigation DR-4715	5 Years	Funding Application Submitted	Typhoon	High	1,2,3, 4,5,6	High
Completed	Completed	29	2019 HMP	Tamuning Village Wooden Pole Concrete Conversion - Phase I: Hardening of overhead primary lines to replace existing wood poles with concrete poles.	Guam Power Authority (GPA)	\$19,440,000.00	PA Mitigation DR-4715	5 Years	Completed	Typhoon	High	1,2,3, 4,5,6	High

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Completed	Completed	30	2019 HMP	PAG Buildings and Facilities Shuttering: With new windows, typhoon shutters and coiling doors, to conform to wind speed requirements found in the 2012 International Building Code.	Port Authority of Guam (PAG)	\$750,000.00	Internal Funding	3 Years	Funding Application Submitted	Typhoon	Low	2,3,5	Low
Removed	Was determined that the project was ineligible in the HM grant specifications.	31	HMGP DR-4715	Gas Oxygen Trailer: The purchase of a mobile med gas trailer with medical oxygen will ensure continuity of healthcare operations and prevent patient surge to hospitals for low-level care.	Department of Public Health and Social Services (DPHSS)	\$300,000.00	HMGP DR-4715	2 years	Completed	Typhoon	Low	1	Low
Completed	Completed	32	HMGP DR-4398	Facility Warehouse Roll Up Doors: Installation of roll-up doors protecting port assess and commodity storages.	Port Authority of Guam (PAG)	\$400,000.00	HMGP DR 4398	6 Months	Completed	Typhoon	Low	1,2	Low
Completed	Completed	33	HMGP DR-4398	Outreach Media Campaign: Based on multiple hazards, educating community on typhoons, earthquakes, and tsunamis.	Guam Homeland Security (GHS)	\$50,000.00	HMGP DR 4398	Completed	Completed	All-Hazard (state all that are profiled Typhoon, Earthquake, Flooding, Coastal Errosion)	Low	1,2	Low
Completed	Completed	34	HMGP DR-4398	Rainfall Study: University of Guam (UOG) Conducted study on rainfall increases to support 2019 HMP for flood risk.	University of Guam (UOG)	\$220,000.00	HMGP DR 4398	Completed	Completed	Flood, Typhoon	Medium	1,6	Low

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Table 50. 2024 Mitigation Strategy (as of 7/11/2024)

No.	Source	Description	Primary Agency	Estimated Cost	Potential Funding Source	Estimated Time Frame	Project Status	Hazard	Priority Level	Goal	EHP High Medium Low
1	2019 HMP	Bridge and Road Protection Scoping Project: Conduct a study (scoping project) to evaluate the need to elevate, retrofit, or otherwise protect essential bridges and road segments, (e.g., those provide ingress and egress to essential facilities) that are susceptible to tsunami, flooding, landslides, and earthquakes.	Department of Public Works (DPW)	\$90,000,000.00	HMGP/BRIC	10 years	Not Started	Flooding	Medium	2, 3, 5	Low
2	2019 HMP	Forrestry Fire Prevention and Management Project: Implement applied and emerging vegetation management activities along the interface and intermix hazard areas to mitigate against fire or severe wind events.	Dept. of Agriculture (DOAg)	\$400,000.00	Internal Funding	5 years	In Progress	Wildfire	Medium	2, 5	Medium High
3	2019 HMP	Upgrade Stormwater Drainage System: At Harmon Industrial Park in order to resolve documented flooding problems.	Guam Water Authority (GWA)	\$875,000.00	US EPA OSG program	5 Years	In Progress	Flooding	High	2, 3, 4, 5	High
4	2019 HMP	Rain and River Guage Improvment Project: Expand/Improve the network of available rain gauges and river gauges in order to enable improved mitigation against erosion. There is a need for 10 additional rain gauges and 5 additional stream gauges. These gauges should have both data-logging and real-time telemetry capability.	University of Guam (UOG)	\$200,000.00	BRIC/HMGP	1-2 years	Not Started	Flooding	Medium	2, 5	Low
5	2019 HMP	Wave Censor Project: Install a (Local Buoy) wave-rider ocean wave buoy in southwestern Guam off-shore waters to mitigate against coastal erosion.	Dept. of Agriculture (DOAg)	\$125,000.00	NOAA	6 months	In Progress	Coastal Erosion, High Surf	Low	2	Low

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6	2019 HMP	Central Atrium Hardening Project: Remove the large storefront windows located at the Front & Middle Courtyard Areas of the Guam Memorial Hospital. The project scope will also include installation of smaller windows; upgraded aluminum, accordion-type typhoon shutters; plaster and metal stud type wall restoration; lowering affected corridor ceiling systems; replacing affected flooring systems; and electrical and mechanical appurtenances.	Guam Memorial Hospital (GMH)	\$700,000.00	Internal Funding	12-18 months	Not Started	Tropical Cyclone	High	2, 5	Low
7	2019 HMP	Captive Holding and Breeding Cages Hardening: of Endangered Guam rail and Guam Micronesian kingfishers to continue efforts and its noninterruption before, during and after a typhoon or earthquake.	Dept. of Agriculture (DOAg)	\$50,000.00	PA Mitigation DR-4715	2 Years	Not Started	Typhoon Earthquake	Low	3	High
8	2019 HMP	Captive Breeding Facility Hardening: Weatherize operating controls, pumps, and generators for the potable water and wastewater facilities (e.g., upgrade electrical equipment to include storm rate electrical cabinets) for the captive breeding facility.	Dept. of Agriculture (DOAg)	\$150,000.00	HMGP/BRIC	2 Years	Not Started	Typhoon Earthquake	Low	3	High
9	2019 HMP	Plant Inspection Facility and Plant Nursery and Tissue Culture Facility Shuttering: with typhoon shutters for doors and windows and weatherize the roof.	Dept. of Agriculture (DOAg)	\$175,000.00	PA Mitigation/HMGP/BRIC	3 Years	Not Started	Typhoon Earthquake	Low	3	Low
10	2019 HMP	Harden of Endangered and Threatened Bird Cage Facilities: against tropical cyclones. Remove and replace current wooden cages with concrete structure and typhoon shutters which will provide shelter and safe haven for the endangered birds.	Dept. of Agriculture (DOAg)	\$75,000.00	HMGP/BRIC	2 Years	Not Started	Typhoon Earthquake	Low	3	Low
11	2019 HMP	Law Enforcement Boat House and Storage Annex Hardening: to withstand typhoon/earthquake.	Dept. of Agriculture (DOAg)	\$85,000.00	HMGP/BRIC	2 Years	Not Started	Typhoon Earthquake	Low	3	Low

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12	2019 HMP	Wet Flood Proofing 7 Sewage Pump: Evaluate protection from flooding through "wet-flood proofing" and/or "elevating" electrical control equipment to reduce at 7 Sewage Pump Stations. Equipment is existing and located internal and external to the facility. It includes motor control center, generator or housing construction, battery charger, day tank, bubbler level control system, transformer, and junction box. (combine with action #21)	Guam Water Authority (GWA)	\$6,300,000.00	Internal Funding	5 Years	In Progress	Flooding	Medium	2, 3, 5	Low
13	2019 HMP	Wet Flood Proofing Booster Pump Stations: Design and install new weather proof components and to elevate electrical controls for flood management purposes of all existing internal and external electrical equipment at the booster pump station and deepwells.	Guam Water Authority (GWA)	\$10,800,000.00	Internal Funding	5 Years	In Progress	Flooding	Medium	2, 3, 5	Low
14	2019 HMP	Sewer Pump Station Power Conditioner: Voltage Regulator at all deep wells and sewer pump stations to eliminate substandard electricity brought on during and after heavy winds and rains that cause frequent brownouts and power fluctuations.	Guam Water Authority (GWA)	\$18,000,000.00	Internal Funding	10 years	Not Started	Flood, Typhoon	Low	3	Low
15	2019 HMP	Mooring System Upgrade: Repair and upgrade the anchor blocks, chains, and moorings systems at all 52 moorings in the PAG's Harbor of Refuge.	Port Authority of Guam (PAG)	\$500,000.00	HMGP/BRIC	5 Years	Not Started	Typhoon, Storm Surge	High	2	Low
16	2019 HMP	Route 11 Shoreline Seawall Scoping Project: to evaluate increasing height of concrete wall along the shoreline of Route 11 to increase of the existing wall to a design wave height of 8.1 feet and prevent future flooding.	Port Authority of Guam (PAG)	\$2,000,000.00	HMGP/BRIC	10 Years	Not Started	Coastal Erosion, Flooding	High	2, 3	High
17	2019 HMP	Repetative Loss Property Strategy: to verify loss information, collect information about flood risks, and implement a mitigation program mitigate these properties. Mitigation efforts may include: retrofitting, elevating, and floodproofing structures.	Dept. of Public Works (DPW)	\$200,000.00	BRIC/FMA	1-2 years	Not Started	Typhoon, Flooding	High	1, 6	Low
18	2019 HMP	Lada Rental Unit Shuttering: Mitigate the damages to GHC's rental units (50 to 60 units) by providing typhoon shutters to all units within GHC's purview (i.e. Lada Estates, Sagan Linahyan and Guma As-Atdas).	Guam Housing Corp. (GHC)	\$820,000.00	HMGP/BRIC/HUD	5 Years	Not Started	Tropical Cyclone	High	2, 3, 5	Medium

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19	2019 HMP	Lada Estate Flooding Scoping: mitigate flooding issues at Lada Estates, Dededo, due to the ponding basin being closed off to Lada Estates.	Dept. of Public Works (DPW)	\$280,000.00	HMGP/BRIC/Internal	2-5 Years	Not Started	Flooding	Low	2, 3, 5	Medium
20	2019 HMP	Primary and Secondary Power Line Underground Conversion: to convert existing overhead distribution primary and secondary power lines to an underground electrical system composed of manholes, handholes, conduits, underground power cables, splices, and accessories to eliminate typhoon hazard.	Guam Power Authority (GPA)	\$8,900,000.00	PA Mitigation DR-4715	30 years	Funding Application Submitted	Tropical Cyclone	High	2, 3, 5	High
21	2019 HMP	Tumon Bay Power Line Lateral Conversion Distribution: primary and secondary power lines overhead to underground conversion in a system of manholes, handholes, and underground power cables and accessories.	Guam Power Authority (GPA)	\$5,000,000.00	Internal Funding	2 Years	In Progress	Tropical Cyclone	High	2, 3, 5	High
22	Other Funding	Manell River Feasible Study: Develop a proposal to initiate flood and erosion mitigation option as proposed by USACE under Section 205 Flood Damage Reduction of the Continuing Authorities Program for Manell River.	Bureau of Statistics and Plan (BSP)	\$3,000,000.00	BRIC FY21	4 Years	In Progress	Flooding	High	2, 3, 5, 6	High
23	2019 HMP	Coral Reef Resilience Strategy: Implement adaptive management interventions based on the best available science and reduce local pressured and increase coral reef resilience to climate change as describes in the 2018 Coral Reef Resilience Strategy	Dept. of Agriculture (DOAg)	\$5,000,000.00	NOAA, DOAg, CRI, CRCP, DOI, BSP	4 Years	Not Started	Storm Surge	High	2, 3	High
24	HMGP DR-4715	Southern Health Storage Facility Hardening{ SRCHC): Wind/Rain Retro fit: The SRCHC Retrofit project will procure and install three electrical roll-up doors and 1 window shutter in order to prevent disruptions to daily operations. The facility supports the continuity of healthcare operations and efforts to prevent patient surge to hospitals on island.	Department of Public Health and Social Services (DPHSS)	\$50,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Tropical Cyclone	Medium	2,3,5	Low
25	HMGP DR-4715	Northern Health Clinic Generator Fuel Tank: The Northern Regional Community Health Center Retrofit will procure and install an on-site diesel fuel tank to ensure continuity of healthcare operations and prevent patient surge to hospitals for low-level care.	Department of Public Health and Social Services (DPHSS)	\$53,325.00	HMGP DR-4715	3 years	Funding Application Submitted	Tropical Cyclone	Medium	1,2,3,5	Low

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26	HMGP DR-4715	RR Cruz Street Flooding Feasibly Study: Department of Public Works (DPW) needs to mitigate these flood events by performing a feasibility study to include hydrologic and hydraulic analysis and engineering design to address the existing flooding issues at the southern end of RR Cruz Street	Department of Public Works (DPW)	\$150,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Flooding	High	1,6	Low
27	HMGP DR-4715	Traffic Signal Back Up Power Feasibly Study: Guam DPW will prioritize the main thoroughfare traffic signals identified in the 2019 Traffic Safety and Operations Study which were reviewed for crash history, existing and future operating conditions and list of feasible intersection improvements. feasibility study and develop a design of the identification and installation for redundant power	Department of Public Works (DPW)	\$250,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Typhoon, Power Loss, Seismic	Medium	1,2,3	Low
28	2019 HMP, HMGP DR-4715	14 Village Mayors Office Generators: Project will include housing protection of the generator, electrical installation and extended diesel fuel tank to extended usage for a minimum 5 days it is imperative that the Mayor's Office has a reliable alternate power source so that we can continue to provide the residents of Humåtak with services, resources and aid during emergency situations.	Mayors' Council Offices of Guam (MCOG)	\$2,280,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Flooding, Typhoon, Earthquake	High	2, 3, 5	High
29	HMGP DR-4715	Clinic Facility Generator: The Adventist Clinic Storm Resilience Improvement Project aims to install a new 500 kW diesel generator, two 2000-gallon diesel storage tanks,	Seven Day Adventist Clinic	\$552,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Typhoon, Power Loss, Seismic	Low	1,2,3,5,6	Medium
30	2019 HMP, HMGP DR-4715	UOG Dormitory Shutters: Project Description: The scope of work encompasses the installation of accordion-type typhoon shutters on all windows and doors of 3 dormitory building. These shutters are designed to withstand extreme weather conditions, including typhoons and high winds of up to 185 mph while offering the convenience of locking and unlocking from both inside and outside.	University of Guam (UOG)	\$665,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Tropical Cyclone	Medium	2, 3, 5	Low
31	HMGP DR-4715	UOG Fieldhouse Generator: The objective of this project is to procure and install five generators each equipped with Automatic Transfer Switches (ATS) and fuel tanks, ensuring a reliable and uninterrupted power supply for a duration of up to 2 weeks in the event of a power outage to the UOG Fieldhouse.	University of Guam (UOG)	\$880,000.00	HMGP DR-4715	3 years	Funding Application Submitted	Typhoon, Power Loss, Seismic	High	1,2,3,5	Medium

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32	2019 HMP, HMGP DR-4715	14 Substation Transmission line Underground Conversion: Project is designed to convert the existing overhead transmission system to an underground system from the substation to substation in various parts of the Island. This project will provide an underground system that will remain intact in the event of a typhoon, consequently eliminating restoration efforts in the project area. In addition, forced outages will be reduced and safety conditions for crews who maintain the lines will improve.	Guam Power Authority (GPA)	\$180,000,000.00	DR-4715 HMGP / PA Mitigation	3 years	Funding Application Submitted	Tropical Cyclone	High	2, 3, 5	High
33	HMGP DR-4715	39 Priority Pumps Generators: The work involves the installation of standby generator, power conditioners, variable frequency drives, 7-day 24-7 fuel storage tanks for thirty-eight (39) <i>(*undamaged)</i> water/sewer critical facilities throughout the island. Project staging area will be minimal as this work will involve work mainly within the existing hardened structure of the facility.	Guam Water Authority (GWA)	\$20,227.50	HMGP DR-4715	4 years	Funding Application Submitted	Typhoon, Power Loss, Seismic	High	1,2,3,4,5,6	Meduim
34	HMGP DR-4715	3 Mobile Generators: The intent of this strategy is to ensure that emergency back-up power is available at the Port Authority of Guam (PAG), which provides an essential service to the island of Guam. It is unacceptable for this critical infrastructure to be without power, especially in times of natural disasters.	Port Authority of Guam (PAG)	\$1,041,863.00	HMGP DR-4715	4 years	Funding Application Submitted	Tropical Cyclone	Medium	1,2,3,4	Low
35	2019 HMP, HMGP DR-4715	Load Capacity Hardening: PAG has a total of five (5) LCs that house eight (8) Prime Power generators. These LCs play a vital role in ensuring the Port remains operational post-typhoon and thus must be protected during typhoon conditions.	Port Authority of Guam (PAG)	\$1,282,759.00	HMGP DR-4715	4 years	Funding Application Submitted	Typhoon, Storm Surge	High	2, 3	Low
36	HMGP DR-4715	The Shoreline Power Pits Hardening: Shoreline Power lines bring power to the edge of the wharves and are mainly used to supply power to the Ports three (3) operating Ship-To-Shore (STS) gantry cranes and vessels that call on the Port.	Port Authority of Guam (PAG)	\$563,856.00	HMGP DR 4715	4 years	Funding Application Submitted	Typhoon, flooding,	High	2, 3,	High

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37	HMGP DR-4715	15 Emergency School Shelter Generators: Provide community access to backup water and generator power during States of Emergencies as a result of natural disasters declared by the Governor of Guam at fifteen (15) public school sites identified as primary emergency shelters.	Guam Dept. of Education (GDOE)	\$2,529,000.00	HMGP DR 4715	4 years	Funding Application Submitted	Tropical Cyclone	High	2, 3, 5,	Medium Low
38	HMGP DR-4715	Emergency Backup Generator: Currently, the hospital's emergency power system is vulnerable due to aging equipment, non-compliance with current codes, lack of redundancy, and the potential proximity of critical components to hazards.	Guam Memorial Hospital (GMH)	\$4,865,708.00	HMGP DR 4715	4 years	Funding Application Submitted	Typhoon, Earthquake	High	3, 5	Low
39	HMGP DR-4715	Power Distribution System Upgrade: Guam Memorial Hospital requires a steady, reliable, and well-maintained electric power system to ensure that it continues to provide life-saving support to its patients. However, this is currently not the case because the hospital's electrical system is vulnerable due to outdated main switchgear, non-compliance with current code, lack of system redundancy, and close proximity of the switchgear to the water storage tank.	Guam Memorial Hospital (GMH)	\$12,312,713.00	HMGP DR 4715	4 years	Funding Application Submitted	Typhoon, Earthquake	High	3, 5	Low
40	2019 HMP, HMGP DR-4715	Agat Police Precinct Facility Generator: Maintain operations of the police station during power outages by hardening the facility Generator as well as protecting the equipment from specific hazards such as typhoons, flooding and earthquakes.	Guam Police Department (GPD)	\$165,000.00	HMGP DR 4715	4 years	Funding Application Submitted	Typhoon, Earthquake	High	3, 5	Low
41	2019 HMP, HMGP DR-4715	Tumon Precinct Facility Generator: Maintain operations of the police station during power outages by hardening the facility Generator as well as protecting the equipment from specific hazards such as typhoons, flooding and earthquakes.	Guam Police Department (GPD)	\$165,000.00	HMGP DR 4715	4 years	Funding Application Submitted	Typhoon, Earthquake	High	3, 5	Low
42	HMGP DR-4398	26 Warf Fender Replacement:	Port Authority of Guam (PAG)	\$850,000.00	HMGP DR 4398	4 years	In Progress	Tropical Cyclone	High	2, 3	High

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43	2019 HMP, HMGP DR-4433	7 Fire Stations Shuttering: Install typhoon shutters on all emergency services buildings such as fire stations not equipped with these features.	Guam Fire Department (GFD)	\$189,000.00	HMGP DR-4433	4 years	In Progress	Typhoon, Severe Wind	High	2, 3, 5	Low
44	2019 HMP, HMGP DR-4495	Fire Stations Shuttering: Install typhoon shutters on all emergency services buildings such as fire stations not equipped with these features.	Guam Fire Department (GFD)	\$350,000.00	HMGP DR-4495	3 Years	Funding Application Submitted	Typhoon, Severe Wind	High	1,2,3,5	Medium
45	HMGP DR-4495	Yona Emergency Tier 2 Gym Shelter Generator:	Yona Mayors Office	\$380,000.00	HMGP DR-4495	3 Years	Funding Application Submitted	Tropical Cyclone	Medium	1,2,3,5	Medium
46	2019 HMP, HMGP DR-4495	11 Fire Station Generators: Acquire, retrofit, and install back-up power and water systems for all emergency services buildings such as fire and police stations not equipped with these features.	Guam Fire Department (GFD)	\$950,000.00	HMGP DR-4495	4 Years	Funding Application Submitted	Tropical Cyclone	High	1,2,3,5	Medium
47	HMGP DR-4495	Catholic Social Service Facility Shutter: Both main office and Adult Day Care Center to protect from severe wind and rain events. Further protect life and property from Typhoon events.	Catholic Social Services (CSS)	\$56,000.00	HMGP DR-4495	3 Years	Funding Application Submitted	Tropical Cyclone, Severe Wind	Medium	1,2,3,5	Medium
48	HMGP DR-4495	Facility Generator: Back up power to the facility during long duration grid power caused by severe storms. This will allow continued Judiciary service.	Judiciary of Guam	\$900,000.00	HMGP DR-4495	3 Years	Funding Application Submitted	Tropical Cyclone	Low	1,2,3,5	Low
49	BRIC 2021	Underground Utility Infrastructure Relocation and Power Generation Project Scoping: Project scoping for the relocation of overhead electrical infrastructure to underground electrical distribution at the A.B. Won Pat International Airport Authority.	International Airport Authority	\$370,139.98	BRIC 2021	5 Years	In Progress	Tropical Cyclone	High	1,2,3,5	High

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50	BRIC 2020	GHS/OCD Facility Lobby Shuttering: Implement added security to the lobby entrance of the Homeland Security Office to withstand strong typhoon winds (this includes upgrading doors, windows and shutters to maintain building code).	Guam Homeland Security (GHS)	\$157,358.00	BRIC 2020	3 Year	In Progress	Tropical Cyclone	Low	1,2,3,5	Low
51	2019 HMP, BRIC 2022	GCC Building 600 Hardening: Wind retrofit for Guam Community College Building 600 to better withstand typhoons, tropical storms and other wind related events.	Guam Comm. College (GCC)	\$1,384,532.90	BRIC 2022	1-2 years	Funding Application Submitted	Wind	Low	2, 3, 5	Low
52	BRIC 2020	Finile River Feasibility Study: Feasibility study on flooding of Finile Creek	Bureau of Statistics and Plan (BSP)	\$189,000.00	BRIC 2020	3 Years	In Progress	Flooding	Low	1,2,6	Low
53	BRIC 2020	E-UNIT Shutter: Typhoon shutter installation on Juvenile Corrections Facility	Dept. of Youth Affairs (DYA)	\$13,377.73	BRIC 2020	3 Years	In Progress	Tropical Cyclone	Medium	1,2,3,5	Low

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54	Other Funding	Manell River Flow Path Restoration: The Merizo Flood Risk Management Project is currently in the feasibility study phase. The study area is located on the southern coast of Guam in the village of Merizo and is authorized by Section 205 of the Flood Control Act of 1948, as amended. This authority allows for study, design, and construction of small flood risk management projects in partnership with non-federal government agencies. The Non-Federal Sponsor is the Government of Guam. The Corps is investigating alternatives to reduce flood risk in the area caused by the Nelansa River, also known as the Manell River. Previous man-made alterations to Manell River cause it to surge as it approaches Manell Channel which has resulted in increased flooding of Route 4 and numerous private residences. A Feasibility Cost Share Agreement (FCSA) is expected to be executed in May 2023.	Bureau of Statistics and Plan (BSP)	\$992,250.00	BRIC 2021	3 Years	In Progress	Flooding	High	1,2,3,6	High
55	2019 HMP, BRIC 2023	DPW Polaris Point Flood Feasible Study: Study will determine possible solution to eliminate the flooding issues with considering a nature based solution and avoid environmental disturbance to near by Watershed.	Department of Public Works (DPW)	\$1,000,000.00	BRIC 2023	3 years	Funding Application Submitted	Flooding	High	2, 3	Low
56	BRIC 2023	PAG Microgrid Feasibility Study: The purpose of this study is to evaluate alternative power sources and modifications of the existing electrical system to provide PAG with a hardened, resilient and sustainable grid.	Port Authority of Guam (PAG)	\$245,000.00	BRIC 2023	5 Years	Funding Application Submitted	Infrastructure Failure	Medium	1,2	Low
57	BRIC 2023	Underground Utility Infrastructure Relocation /Power Generation Phase II: This is a follow up project to implement the electrical infrastructure project as a result of the scoping project (EMF-2021-BR-086-0006)	International Airport Authority	\$356,480.00	BRIC 2023	5 Years	Funding Application Submitted	Tropical Cyclone	High	1,2,3	High
58	BRIC 2023	DPW Storm System Mapping: Comprehensively locate, identify, and assess the systems condition their enclosed drainage system throughout the entire island of Guam. The purpose of this assessment is to identify critical improvements and/or are at risks from hazards, such as peak event floods.	Department of Public Works (DPW)	\$796,875.00	BRIC 2023	3 Years	Funding Application Submitted	Flooding	High	1,2,3,4,5,6	Low

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59	2019 HMP, BRIC 2023	Building 500 Hardening: The overall goal of the project is to structurally fortify the Guam Community College Building 500 to better withstand typhoons, tropical storms and other wind related events.	Guam Comm. College (GCC)	\$3,650,452.00	BRIC 2023	1-2 years	Funding Application Submitted	Tropical Cyclone	High	2, 3, 5	Low
60	2019 HMP, BRIC 2023	Enhancing Critical Infrastructure for School Safety and Resilience To upgrade and reinforce critical infrastructure in schools to ensure the safety of students and staff, maintain continuity of operations, and enhance resilience to natural and artificial hazards, including structural reinforcements, installation of emergency systems, and comprehensive safety upgrades.	Guam Dept. of Education (GDOE)	\$29,040,000.00	2019 HMGP, BRIC 2023	2-5 years	Not Started	Earthquakes, Hurricanes, Flooding, Fires	High	3, 4	Moderate
61	2019 HMP, BRIC 2023	Clearing of Hazard Materials in Primary Routes: This project involves removing hazardous materials (e.g., vehicles, metallic waste, tires) from Guam’s primary routes and surrounding areas to ensure safe and unobstructed access during emergencies. Also, it includes the identification, collection, and proper disposal of hazardous substances to mitigate health and safety risks to the public and emergency responders.	Guam Environmental Protection Agency (GEPA)	\$2,400,000.00	2020 HMGP, BRIC 2023	1 year	Not Started	Tropical Cyclone, Severe Wind	High	2 ,3, 5	Low
62	2019 HMP, BRIC 2023	Hardening of Existing, Enclosed Recreational Facilities: This initiative focuses on upgrading existing recreational facilities (e.g., village gyms, community centers, sports complexes) to enhance their structural integrity and equip them to function as emergency shelters (Tier 1, 2, or 3 shelters).	Department of Parks and Recreation (DPR)	\$120,000,000.00	2021 HMGP, BRIC 2023	1-2 years	Not Started	Tropical Cyclone	High	1, 2, 3, 4, 5	Low
63	2019 HMP, BRIC 2023	Construction of Tier 1, 2, and 3 Shelters: This project entails the development of multi-tiered emergency shelters in the form of public, daily-use facilities (e.g., village gyms, community centers, and sports complexes) designed to offer varying levels of support during disasters. Tier 1 shelters provide immediate, short-term refuge; Tier 2 shelters offer more comprehensive services for longer durations; and Tier 3 shelters are equipped for extended stays, providing full-scale support including, healthcare, food, and long-term accommodation.	Guam Office of Homeland / Office of Civil Defense (GHS/OC D)	\$40,000,000.00	2022 HMGP, BRIC 2023	2-5 years	Not Started	Tropical Cyclone	High	1, 2, 3, 4, 5	High
64	2019 HMP, BRIC 2023	Construction of Storm Drain Systems: This project involves constructing and enhancing storm drain systems and ponding basins to mitigate flooding risks, which includes installing new drainage infrastructure, upgrading existing systems, and regular maintenance to ensure effective water management and reduce the impact of heavy rainfall and storm events on communities.	Department of Public Works (DPW)	\$5,600,000.00	2023 HMGP, BRIC 2023	2-5 years	Not Started	Flooding	High	2, 3, 4, 5	Moderate

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65	2019 HMP, BRIC 2023	Land Acquisition for Erosion Control: The project aims to acquire land in erosion-prone areas to implement erosion control measures; specifically, purchasing at-risk properties and constructing infrastructures such as retaining walls, vegetation buffers, and other stabilization techniques to prevent soil erosion and protect surrounding properties and ecosystems.	Departme nt of Land Managem ent (DLM)	\$2,732,500.00	2023 HMGP, BRIC 2023	2-5 years	Not Started	Coastal Erosion	High	2, 3, 5	High

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66	Other Funding	East Hagatna Shoreline Protection The East Hagatna Shoreline Protection Project is currently in the feasibility study phase. The study area is located on the west central coast of Guam between the villages of Asan and Tamuning. This study is authorized by Section 14 of the Flood Control Act of 1946, as amended. The Government of Guam, represented by the Bureau of Statistics and Plans (BSP) and the Department of Public Works (DPW) is the local non-federal sponsor. A feasibility cost share agreement (FCSA) was executed on 18 August 2021. The study area is located north of downtown Hagatna, adjacent to Marine Corps Drive (Highway 1) along approximately 2,100 feet of Trinchera Beach at Hagatna Bay. There is a significant shoreline erosion problem at Hagatna Bay that has been ongoing for many years. A seawall constructed in the 1990s, intended to mitigate for this erosion, is being undercut by erosion and is on the verge of collapse. Marine Corps Drive is the primary roadway connecting Andersen Air Force base and Navy Base Guam as well as the primary access to many local villages, including downtown Hagatna, the capitol and major cultural center of Guam. Damage to the highway and utilities would result in major traffic delays, economic loss to businesses in the Hagatna area and disruption of public services. Additionally, the bay is used for recreational activities by both residents and tourists. The Tentatively Selected Plan (TSP) consists of a 2,100 linear feet revetment to replace the existing seawall. This design involves the removal and replacement of 2,100 ft of existing seawall with revetment. The revetment would consist of compacted fill as the foundation and base grade, a geotextile filter fabric, a double layer of underlayer stone, a double layer of armor stone, and anchoring by an oversized toe stone. Depending on the cost and availability of local stone, use of pre-cast concrete armor units (tribar) may be considered. This design will meet USACE coastal engineering criteria for expected design life and adaptability to relative sea level change (RSLC). The TSP is the least cost alternative with a project first cost estimate of \$11 million.	Bureau of Statistics and Plan (BSP)	\$15,000,000.00	USACE CAP 14	3 years	Ongoing	Shoreline Erosion	High	2,5,6	High

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67	Other Funding	The Agat (Hagat) Shoreline Protection Project is currently in the feasibility study phase. The study area is located on the west central coast of Guam in the village of Agat and is authorized by Section 14 of the Flood Control Act of 1946, as amended. This authority allows for the planning and construction of emergency stream bank and shoreline protection projects for public facilities in imminent danger of failing. The Non-Federal Sponsor is the Government of Guam. The Corps is investigating alternatives to protect the municipal government headquarters of Agat which is under threat of coastal erosion. This collection of buildings located along approximately 450 feet of shoreline includes the mayor's office, emergency shelter and evacuation facility, post office, and community gathering space. A Feasibility Cost Share Agreement (FCSA) was executed in February 2023.	Bureau of Statistics and Plan (BSP)	\$3,500,000	USACE CAP 14	3 years	Ongoing	Shoreline Erosion	High	2,5,6	High
68	Other Funding	Umatac River Flood Risk Mitigation Project: Design and implement flood control features in and around the Umatac River (Project will be performed by USACE civil works but will be funded by DOI)	Bureau of Statistics and Plan (BSP)	\$2,700,000	DOI OIA IRA Funds	3 years	Ongoing	Flooding	High	1,2,3,6	High
69	Other Funding	Stormwater Management Manual Update	Bureau of Statistics and Plan (BSP)	\$0 Funded under USACE Silver Jackets Budget	DOI OIA IRA Funds	3 years	Ongoing	Flooding	High	1,2,3,6	High

*Tables to be updated through plan maintenance process and may undergo revisions over time

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6.5.3 Contribution to the Overall State Mitigation Strategy

As noted in Section 6.4 (Mitigation Goals), the goals identified for the 2024 Guam HMP serve as the foundation of the Government of Guam's overall mitigation strategy. The 36 "high priority" mitigation measures identified in **Table 50** contribute to the Government of Guam's overall mitigation strategy by addressing all the six mitigation goals.

- 5 mitigation actions (#1, 3, 13, 21, and 32) will help improve the quality and comprehensiveness of information on assets and hazards
- 31 mitigation actions (#2, 3, 4, 8, 9, 10, 12, 16, 19, 28, 21, 33, 37, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 57, and 58) will help reduce risks of disaster damage to existing buildings and infrastructure, especially EFMUTS
- 5 mitigation action (#13, 57, 58, 59, and 60) will help promote disaster-resistant development and disaster recovery
- 2 mitigation actions (#11, and 60) will help develop institutional support of hazard mitigation within Government of Guam agencies and the public
- 8 mitigation actions (#2, 3, 8, 9, 10, 16, 19, and 31) will help protect human health and safety
- 1 mitigation actions (#32) will help eliminate or reduce the damage to residential property and the disruption of life caused by repeated flooding

6.6 Administration of NFIP

This section demonstrates and provides a summary description of how the Government of Guam agencies work together in collaboration with federal, private, and NGO partners to administer the NFIP pre- and post-disaster.

6.6.1 Changes in Participation, Insurance Coverage, and Trends in Guam

From 2019 to 2021, the Government of Guam assessed the feasibility of implementing FEMA's Community Rating System (CRS) to improve flood insurance participation and floodplain management. However, interest among policyholders was limited due to the predominantly low-tier premiums of NFIP policies on the island. This led the Government of Guam to decide against pursuing the CRS program as the low participation did not justify the effort.

Despite the decision not to implement CRS, Guam has made strides in enhancing flood risk management. The upcoming Flood Insurance Rate Map (FIRM) layer update in 2025, initiated in 2020, is a significant development. This update involves comprehensive studies by the USACE, which are expected to provide more accurate floodplain data. This data will not only inform future flood mitigation projects but also has the potential to increase NFIP participation, demonstrating the long-term benefits of these initiatives.

Guam's active engagement with FEMA's Risk Mapping Assessment and Planning (Risk MAP) program clearly demonstrates the government's commitment to enhancing community resilience. By integrating flood risk mitigation into its planning and development processes, updating local data, and prioritizing risks, the Government of

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Guam is expected to positively influence insurance coverage trends. As accurate risk assessments and effective mitigation strategies are implemented, more property owners will probably be encouraged to secure flood insurance, strengthening the overall community resilience.

There has been a notable change in insurance coverage over recent years. In 2019, Guam had 96 NFIP policies in force, with insurance coverage amounting to \$21,434,000, as illustrated in Table 6-4. By 2024, the number of policies in force remained the same at 96, but the total premiums collected increased to \$135,025, with insurance coverage also increasing to \$21,434,000, as shown in **Table 51**. The number of closed paid losses rose from 163 in 2019 to 172 in 2024, with the dollar amount of closed paid losses increasing from \$2,085,060.69 to \$2,134,157.29.

Table 51. Insurance Overview

Total By Community	
Total Number of Policies:	96
Total Premiums:	\$135,025
Insurance in Force:	\$21,434,000
Total Number of Closed Paid Losses:	172
\$ of Closed Paid Losses:	\$2,134,157
Group Flood Insurance	
Total Number of Policies:	0
Total Premiums:	\$0
Insurance in Force:	\$0
Total Number of Closed Paid Losses:	24
\$ of Closed Paid Losses:	\$164,697
Post Firm Minus Rated Policies	
Total Number of Minus Rated Policies:	4
A Zone Minus Rated Policies:	3
V Zone Minus Rated Policies:	1
Manufactured Homes	
Total Number of Policies:	0
Total Number of Closed Paid Losses:	0
\$ of Closed Paid Losses:	\$0
ICC	
Total Number of ICC Closed Paid Losses:	0
\$ of ICC Closed Paid Losses:	\$0
1316	
Number of Properties by Community:	0
Substantial Damage Losses	
Number of Substantial Damage Closed Paid Losses:	12

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Table 52. Insurance Occupancy

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	Amount of Closed Paid Losses	Adjustment Expense
Single Family	77	\$97,576	\$14,919,000	142	\$1,684,385.63	\$134,508.83
2-4 Family	9	\$22,497	\$1,878,000	12	\$153,803.76	\$11,117.68
All Other Residential	4	\$6,539	\$2,000,000	3	\$27,646.96	\$1,150.00
Non Residential	6	\$8,413	\$2,637,000	15	\$268,320.94	\$11,746.88
Total	96	\$135,025	\$21,434,000	172	\$2,134,157.29	\$158,523.39
	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	Amount of Closed Paid Losses	Adjustment Expense
Condo	2	\$3,155	\$500,000	9	\$49,096.60	\$3,115.00
Non Condo	94	\$131,870	\$20,934,000	163	\$2,085,060.69	\$155,408.39
Total	96	\$135,025	\$21,434,000	172	\$2,134,157.29	\$158,523.39

Table 53. Insurance Zone

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	Amount of Closed Paid Losses	Adjustment Expense
A01-30 & AE Zones	43	\$58,460	\$10,842,000	61	\$714,735.73	\$52,019.12
A Zones	27	\$48,083	\$4,870,000	31	\$431,169.04	\$24,598.54
AO Zones	0	\$0	\$0	3	\$0.00	\$375.00
AH Zones	0	\$0	\$0	0	\$0.00	\$0.00
AR Zones	0	\$0	\$0	0	\$0.00	\$0.00
A99 Zones	0	\$0	\$0	0	\$0.00	\$0.00
V01-30 & VE Zones	10	\$16,724	\$1,377,000	12	\$116,411.64	\$5,465.00
V Zones	0	\$0	\$0	0	\$0.00	\$0.00
D Zones	0	\$0	\$0	0	\$0.00	\$0.00
B, C & X Zone	-	-	-	-	-	-
Standard	15	\$11,319	\$4,129,000	32	\$608,184.06	\$64,551.33
Preferred	0	\$0	\$0	3	\$87,467.64	\$3,529.40
Total	95	\$134,586	\$21,218,000	142	\$1,957,968.11	\$150,538.39

These changes reflect the continuous efforts to improve flood risk management and insurance participation on the island. The updated FIRM layer and the integration of Risk MAP data are crucial steps and long-term investments in ensuring that Guam

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remains resilient to natural hazards. These initiatives are expected to encourage more residents to participate in the NFIP, thereby enhancing overall community resilience in the future.

6.6.2 Substantial Damage Administration

After a disaster, rebuilding in Guam, especially in flood-prone areas, requires compliance with local floodplain ordinances. “Substantial damage” is described by Guam law as damage where the restoration cost equals or exceeds 50% of the structure’s market value before the damage. Before issuing a permit, the Building Official must approve a tentative plan detailing information such as property boundaries, existing structures, street rights-of-way, topography, and flood proofing measures. Additional requirements include an environmental impact analysis and securing a performance bond. The Floodplain Administrator is responsible for reviewing permits, ensuring compliance with flood safety standards, maintaining documentation, and notifying relevant agencies about alterations or relocations of watercourses.

6.6.3 Community Rating System Participation

Between 2019 and 2021, the Government of Guam evaluated the viability of joining FEMA’s Community Rating System but found limited interest among policyholders, mainly due to the low-tier premiums of most National Flood Insurance Program (NFIP) policies on the island. The low participation rates led the government to determine that implementing a CRS was not justifiable. Although the CRS was proposed as a Silver Jackets project, it is unlikely to rank among the top projects selected for the current year. Efforts to set up the CRS with assistance from the USACE Silver Jackets continue, but substantial progress remains uncertain. The direction has shifted towards other flood risk mitigation strategies and projects that may benefit the island community more immediately. The ongoing assessment of community interest and feasibility will determine future CRS participation initiatives.

6.6.4 Risk Mapping, Assessment, and Planning

Risk MAP, in a collaborative effort, Guam’s Flood Insurance Rate Map (FIRM) layer, is set to be updated for the first time since 2007, following FEMA’s initiative that commenced with a discovery meeting in September 2020. Local agencies, including the BSP, GHS-OCD, and DPW, have come together to prioritize risks and provide updated data for the Risk MAP. The updated maps, based on recent comprehensive flood studies by the USACE, will include new floodplain extents for areas like Umatac, Santa Rita, Agat, and Merizo. These studies have informed continued flood risk mitigation projects, currently in the feasibility assessment phase, with implementation expected in 2025. The updated flood risk maps will play a crucial role in supporting permitting, planning, and development regulations; thereby, enhancing Guam’s resilience to natural hazards. Integrating local data with FEMA’s flood hazard mapping, this comprehensive approach highlights the collective commitment to better protect Guam’s communities.

SECTION 7 – PLAN MAINTENANCE

7.1 PURPOSE

This section describes the formal process to ensure the 2024 Guam HMP remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Guam HMP and the mitigation measures annually and revising and updating the Guam HMP every five years.

7.2 MONITORING, EVALUATING, AND UPDATING THE HMP

The State Mitigation Planning Policy Guide requirements for consideration by FEMA for the plan maintenance process are:

S17. Is there a description of the method and schedule for keeping the plan current? [44 CFR §§ 201.4(c)(5)(i) and 201.4(d)]

The plan must describe the process to monitor, evaluate and update the plan. The description must include:

- The agency/office responsible for monitoring, evaluating, and updating.
- The schedule for monitoring, evaluating, and updating.
 - o *Monitoring* means tracking the plan's implementation over time.
 - o *Evaluating* means assessing the effectiveness of the plan at achieving its stated purpose and goals.
 - o *Updating* means reviewing and revising the plan at least once every five years.

7.2.1 HMP Monitoring

The GHS-OCD has established a structured and dynamic process to monitor and update the 2024 Guam HMP. This process ensures continuous improvement and responsiveness to evolving risks and mitigation needs.

The GHS-OCD HM Section will continue to be responsible for the overall monitoring of the plan, including:

- Monitoring the implementation of the plan
- Confirming and clarifying the responsibilities assigned to the various agencies for implementing the mitigation actions listed in the implementation strategy
- Identifying financial resources for the mitigation actions
- Monitoring and documenting the implementation of the mitigation actions
- Facilitating the plan revision process
- Notifying the public when specific key milestones are achieved
- Maintaining current membership list of Hazard Mitigation Working Group

7.2.2 HMP Evaluation

The GHS-OCD HM Section will evaluate the 2024 Guam HMP annually. Annually, the GHS-OCD HM Section also convenes the Hazard Mitigation Working Group. This meeting strategically aligns with the Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO)

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releases. These sessions may span one or two days and provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities.

7.2.3 Post-Disaster Mitigation Action Evaluation

If a major disaster occurs, the GHS-OCD HM Section will convene approximately 6 months post-disaster to evaluate the Guam 2024 HMP to determine if risk assessments or mitigation actions need to be adjusted or additional mitigation actions added. The GHS-OCD HM Section will seek out any disaster damage assessment teams and reports to obtain information about the disaster to update the Guam 2024 HMP.

7.2.4 HMP Update

The GHS-OCD HM Section is responsible for updates to the 2024 Guam HMP. **Table 54** Plan Maintenance Strategy outlines the schedule for monitoring, evaluating, and updating the Guam 2024 HMP. Further description of these activities is in Section 7.3.

Table 54. Plan Maintenance Strategy

Date – Month, Year	Implementation Milestone	Responsible Entity
2024 (Year 1)		
July 2024	FEMA approval and Guam adoption of the 2024 Guam HMP	
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO

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	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email with questionnaire to RAC/ESF attendees (same agencies as Hazard Mitigation Working Group) · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information. · Updates will be incorporated into HMP Mitigation Strategy.	GHS-OCD HM Section Team overseen by SHMO

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Late Summer/Early Fall	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list. · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released. · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO
2025 (Year 2)		
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO

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	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email to RAC/ESF attendees · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information · Updates will be incorporated into HMP Mitigation Strategy	GHS-OCD HM Section Team overseen by SHMO
	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO

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July 2025	Submit application for HMP Update (if it is determined that the plan update will not be carried out solely in house and a contractor will be used)	GHS-OCD HM Section Team overseen by SHMO
2026 (Year 3)		
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO
	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email to RAC/ESF attendees · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information · Updates will be incorporated into HMP Mitigation Strategy	GHS-OCD HM Section Team overseen by SHMO

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	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO
2027 (Year 4)		
January 2027	Develop Stakeholder Engagement Plan for Guam HMP Update · With specific focus on how to include vulnerable, at-risk populations and climate-related agencies e.g., Micronesian climate change society.	GHS-OCD HM Section Team overseen by SHMO

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February/March 2027	Public Outreach · Example: University of Guam Charter Day · Leverage Mayor's Councils, nonprofits · Reach underserved populations through Palau Association, Red Cross, cultural associations, etc. · Distribute questionnaire (i.e., which village do you live in? Which hazard risk are you most concerned about? Etc.)	GHS-OCD HM Section Team overseen by SHMO
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO
	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email to RAC/ESF attendees · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information · Updates will be incorporated into HMP Mitigation Strategy	GHS-OCD HM Section Team overseen by SHMO

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	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released. · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO
July 2027	Start Guam HMP Update Process · HMP Kick Off meeting. · Initiate the Stakeholder Engagement Plan	GHS-OCD HM Section Team overseen by SHMO
2028 (Year 5)		
	Continue preparation of the Guam HMP 2029 Update	GHS-OCD HM Section Team overseen by SHMO

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February/March 2028	Public Outreach · Example: University of Guam Charter Day · Leverage Mayor's Councils, nonprofits · Reach underserved populations through Palau Association, Red Cross, cultural associations, etc. · Distribute questionnaire (i.e., which village do you live in? Which hazard risk are you most concerned about? Etc.)	GHS-OCD HM Section Team overseen by SHMO
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO
	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email to RAC/ESF attendees · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information · Updates will be incorporated into HMP Mitigation Strategy	GHS-OCD HM Section Team overseen by SHMO

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	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO
2029		
	Continue preparation of the Guam HMP 2029 Update	GHS-OCD HM Section Team overseen by SHMO
July, October, January, April	Quarterly · Use quarterly reports on FEMA funded mitigation projects to update Mitigation Strategy (i.e., indicate project completion, cost increases, etc.)	GHS-OCD HM Section Team overseen by SHMO

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	Quarterly RAC/ESF Meetings · 1-2 weeks before meeting, GHS HM Section Team sends email to RAC/ESF attendees · During the meeting, GHS Mitigation Section will explain what information they are looking for (e.g., progress status updates on mitigation actions) and plug what Hazard Mitigation is and what Hazard Mitigation Planning is. · Approximately 1 week after RAC/ESF workshop, GHS Mitigation Section will send another email to follow up and ask for the information · Updates will be incorporated into HMP Mitigation Strategy	GHS-OCD HM Section Team overseen by SHMO
	Annual Meeting · GHS HM Section works with SHMO to create an agenda and confirm stakeholder attendee list · Meeting spans 1-2 days, ideally just after BRIC/FMA NOFO released · Convenes the Hazard Mitigation Working Group. · Present Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Notice of Funding Opportunity (NOFO) releases. · Provide a dedicated time for stakeholders to discuss their mitigation actions in depth, ensuring that the HMP remains aligned with current mitigation efforts and funding opportunities. · Potential to provide technical assistance to stakeholders that requested it during quarterly updates.	GHS-OCD HM Section Team overseen by SHMO

2029 July	2029 Guam HMP Update is adopted	

7.2.5 Monitoring Progress Of Mitigation Activities

The State Mitigation Planning Policy Guide requirements for consideration by FEMA for monitoring the progress of mitigation activities are:

S18. Does the plan describe the systems for monitoring implementation and reviewing progress? [44 CFR §§201.4(c)(5)(ii) and 201.4(c)(5)(iii)]

- The plan must describe the system for tracking the implementation of the mitigation activities and projects identified in the mitigation strategy. This includes all mitigation activities, not just those funded by FEMA.
- The system must include the following:
 - o A schedule.
 - o The agency or office responsible for coordination.
 - o The role of the agencies/offices identified in the mitigation strategy as responsible for implementation of actions.
 - The plan must describe a system for reviewing progress on achieving the mitigation strategy's goals that includes the criteria and process for evaluating progress.

7.2.6 Review of Progress on Implementing Mitigation Goals and Mitigation Actions

The 2024 Guam HMP includes mitigation activities which comprise the mitigation strategy; it includes projects potentially funded by FEMA as well as other federal and state funding mechanisms.

The GHS-OCD HM Section will monitor through quarterly reports any open FEMA-funded mitigation projects (e.g., BRIC, HMGP) and making updates to the Mitigation Strategy based on any noted changes to mitigation actions such as estimated cost, timeline, and project status.

The quarterly Response Activity Coordination (RAC) and Emergency Support Function (ESF) meetings are vital to this monitoring process. Prior to each meeting, stakeholders receive a questionnaire (see Appendix _) from the GHS Mitigation Section, prompting them to prepare a status update on the mitigation actions for which their agency is responsible. This proactive approach facilitates a structured review of continuous mitigation strategies and actions, enabling stakeholders to report progress and identify any emerging challenges or opportunities.

To encapsulate the updates and feedback gathered through stakeholder engagements, the GHS Mitigation Section creates and maintains an appendix of documents titled "Mitigation Activities." This appendix is updated quarterly with amended versions of the Mitigation Strategy based on stakeholder feedback. Also, it includes stakeholder and community outreach activity records, providing all changes and developments are documented and incorporated into the HMP. Coordination with the GHS Public Information Officer helps document and disseminate information about these outreach

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activities, capturing details on announcements and attendance and integrating new information into the HMP. Hence, through this systematic and inclusive approach, the GHMO ensures the HMP is up-to-date and reflective of the collective input and efforts of all stakeholders involved in disaster mitigation across Guam.

The GHS-OCD HM Section will have a digital working version of the 2024 HMP that will be used as updates occur. This digital working version will include an amendment sheet at the start of each Section where the adjustment will be recorded, and reader can be informed of the updates or changes and direct where it is located. Amendment sheet will include a date, brief description, and section location.

Continued Public Involvement

The Government of Guam is dedicated to direct public involvement in continually reshaping and updating the Guam HMP. In compliance with the State Mitigation Planning Policy Guide, the 2024 Guam HMP and the various revision processes will be made accessible to the public. Copies of the 2024 Guam HMP will be available for review on the GHS-OCD's website. All copies of the 2024 Guam HMP will list the address and phone number of the GHS-OCD HM Section, which is responsible for monitoring public comments and accepting suggestions regarding plan revisions. Also, the GHS-OCD HM Section will identify and seize opportunities to raise community awareness of the 2024 Guam HMP, priority hazards, and potential mitigation projects in the public, private, and NGO sectors. GHS-OCD HM Section will look for public engagement opportunities that will reach underserved communities and organizations with climate change and climate adaptation expertise.

Plan Integration

The GHS-OCD HM Section will monitor new plan development or updates to current plans to enhance, align and update the risk, hazard, and strategies of the 2024 HMP. Related plans include the Guam Comprehensive Economic Development Strategy, Guam Comprehensive Emergency Management Plan, Port of Guam Modernization Plan, GWA Capital Improvement Plan, GPA Capital Improvement Plan, DPW Capital Improvement, Guam Integrated Preparedness Plan, Typhoon Mawar Resilience Report conducted by FEMA, THIRA/SPPR, Emergency Plan from critical infrastructure Agencies, Climate Change Committee Comprehensive Plan, DOD Hazard Mitigation Plan, and the CNMI Hazard Mitigation Plan for regional consistency.

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APPENDIX A – ADOPTION RESOLUTION

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APPENDIX B – MA CROSSWALK

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Standard State Hazard Mitigation Plan Checklist

The *State Hazard Mitigation Plan Review Tool* demonstrates how the State Hazard Mitigation Plan meets the regulation in 44 CFR §201.4, for standard state plans, and 44 CFR §201.5, for enhanced state plans.

Standard State Hazard Mitigation Plan		Yes	No
Does the plan meet the standard state hazard mitigation plan requirements?		X	
Repetitive Loss Strategy		Yes	No
Does the plan include a Repetitive Loss Strategy? [S6/RL1; S8/RL2; S9/RL3; S10/RL4; S13/RL5; and S15/RL6]		X	
Enhanced State Hazard Mitigation Plan		Yes	No
Does the plan meet the enhanced state hazard mitigation plan requirements?		N/A	

State/Territory: Guam	Title of Plan: 2019 Guam Hazard Mitigation Plan	Date of Plan: July 2019
Point of Contact: Leo Espia	Address: 221-B Chalan Palasyo Tutuhan, 96910, Guam	
Title: Deputy Administrator		
Agency: Government of Guam Homeland Security Planning		
Phone Number: 671-475-9600	E-Mail: leo.espia@ghs.guam.gov	

Date Received at FEMA: 1 st submission: July 2, 2019 2 nd submission: July 18, 2019		Date Results Sent from FEMA: 1 st submission: July 4, 2019 2 nd submission: July 19, 2019	
FEMA Reviewer Name: JoAnn Scordino, Jesse Carpentier, Xing Liu	FEMA Reviewer Title: Community Planner(s)	Date: July 2, 2019 July 18, 2019	
FEMA Reviewer Name: Asia King	FEMA Reviewer Title: Risk Analyst	Date: July 1, 2019	
FEMA Approver Name: Juliette Hayes	FEMA Approver Title: Mitigation Division Director	Date: July 26, 2019	

Standard State Hazard Mitigation Plan Checklist

Standard Plan Regulation Checklist		Location in Plan	Yes	No
Planning Process				
S1. Does the plan describe the planning process used to develop the plan? [44 CFR §§201.4(b) and (c)(1)]	a. Does the plan describe the current update process, including: how the plan was prepared, schedule or timeframe, specific milestones and activities, and agencies and stakeholders who were involved.	Section 3 3.1 3.2.5 – 3.4	X	
	b. Was the mitigation planning process integrated to the extent possible with other state planning efforts?	Section 3.2.5 3.4	X	
S2. Does the plan describe how the state coordinated with other agencies and stakeholders? [44 CFR §§201.4(b) and (c)(1)]	a. Does the plan describe how other state and Federal agencies and other stakeholders were involved in the process?	Section 3.2, 3.3	X	
	b. Does the plan describe how the state coordinated with other agencies and stakeholders responsible for: - Emergency management - Economic development - Land use/development - Housing - Health/social services - Infrastructure - Natural/cultural resources	Section 3.2, 3.3	X	
	a. Does the plan describe limitations in sectors where coordination with agencies and stakeholders is not practicable?	Section 3.2.1 – 3.2.5	X	
Planning Process - Required Revisions: None				
Hazard Identification and Risk Assessment				
Standard Plan Regulation Checklist		Location in Plan	Yes	No

S3. Does the risk assessment include an overview of the type and location of all natural hazards that can affect the state? [44 CFR §201.4(c)(2)(i)]	a. Does the plan include a current summary of the natural hazards that can affect the state, including information on: - Location - Extent - Previous occurrences	Section 5.3 Appendix D	X	
	b. Does the plan provide an explanation for any commonly recognized natural hazards that were omitted?	Section 5.2	X	
S4. Does the risk assessment provide an overview of the probabilities of future hazard events? [44 CFR §201.4(c)(2)(i)]	a. Does the risk assessment provide a summary of the probability of future hazard events, including projected changes in occurrences for each natural hazard in terms of: - Location - Extent - Intensity - Frequency and/or duration?	Section 5.3	X	
	b. Do the probabilities include considerations of changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards?	Section 5.3.11 (Sea Level Rise/Climate Change) Section 5.3.16	X	
S5. Does the risk assessment address the vulnerability of state assets located in hazard areas and estimate the potential dollar losses to these assets? [44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]	a. Does the risk assessment include an analysis of the potential impacts of hazard events to state assets and a summary of the assets most vulnerable to the identified hazards or probably future hazard events?	Section 5.3 Appendix E Appendix F	X	
	b. Does the risk assessment estimate potential dollar losses to state assets located in identified hazard areas?	Section 5.3 Appendix E Appendix F	X	

S6. Does the risk assessment include an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses to vulnerable structures? [44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]	a. Does the risk assessment provide a current summary of the most vulnerable jurisdictions based on the state, local, and tribal, as applicable, risk assessments in terms of: - Jurisdictions most threatened by identified the hazards - Jurisdictions most susceptible to damage and loss from hazard events related to populations and assets	Section 5.3, Appendix F	X	
	b. Does the risk assessment include a summary of potential losses to the identified vulnerable structures based on estimates in the local risk assessments, as well as the state risk assessment?	Section 5.3, Appendix F	X	
	c. Does the risk assessment address repetitive loss (RL) and severe repetitive loss (SRL) properties (see Element RL1)?	Section 5.5.5	X	
S7. Was the risk assessment revised to reflect changes in development? [44 CFR §201.4(d)]	a. Does the plan provide a summary of the changes in development that have occurred or are projected to occur in hazard prone areas based on the state, local, and tribal, as applicable, risk assessments? Including: - Changes to land use and the built environment - Changes in population demographics that may affect vulnerability to hazard events - Changes to the vulnerability of state-owned or operated buildings, infrastructure, and critical facilities	Section 5.5.5	X	
<u>Hazard Identification and Risk Assessment - Required Revisions:</u> None				

Mitigation Strategy and Priorities			
Standard Plan Regulation		Location in State	Yes No

S8. Does the mitigation strategy include goals to reduce / avoid long-term vulnerabilities from the identified hazards? [44 CFR §201.4(c)(3)(i)]	a. Does the plan identify hazard mitigation goals representing what the state seeks to accomplish through mitigation plan implementation?	Section 6.4	X	
	b. Are the goals consistent with the hazards and vulnerabilities identified in the risk assessment?	Section 6.4	X	
	c. Do the goals address reducing the vulnerability of jurisdictions within the state as well as the vulnerability of state- owned or operated buildings, infrastructure, and critical facilities?	Section 6.4	X	
	d. Does the plan include goals to address RL and SRL properties? (See Element RL2)	6.4, Goal 6	X	
S9. Does the plan prioritize mitigation actions to reduce vulnerabilities identified in the risk assessment? [44 CFR §§201.4(c)(3)(iii) and (iv)]	a. Does the plan identify actions based on the current risk assessment to reduce the vulnerability of jurisdictions within the state as well as the vulnerability of state-owned or operated buildings, infrastructure, and critical facilities?	Section 6.5	X	
	b. Does the plan describe the process used by the state to evaluate and prioritize actions that are cost effective, environmentally sound, and technically sound?	Section 7.2.1, and Section 7.2.2	X	
	c. Does the plan describe how each action contributes to the hazard mitigation goals?	Section 6.5.3	X	
	d. Does the plan describe how the local and tribal, as applicable, mitigation strategies are linked within the state mitigation strategy?	N/A	X	
	e. Does the plan address RL and SRL properties in the mitigation strategy? (See Element RL 3)	Section 6.5.1 2, Action No. 33	X	

S10. Does the plan identify current and potential sources of funding to implement mitigation actions and activities? [44 CFR §201.4(c)(3)(iv)]	a. Does each mitigation action or project include the identification of current and/or potential sources of Federal, state, local, tribal, as applicable, or private funding for implementation?	Section 6.3	X	
	b. At a minimum, does the plan identify FEMA mitigation funding sources, including, if applicable, but not limited to HMGP, PDM, FMA and PA C-G?	Section 6.3	X	
	c. Does the plan identify current and potential sources of funding with respect to RL and SRL properties? (See Element RL4)	Section 6.3	X	
S11. Was the plan updated to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities? [44 CFR §201.4(d)]	a. Does the plan describe the status of hazard mitigation actions in the previous plan by identifying those that have been completed or not completed? For actions not completed, does the plan narrate the status?	Section 6.5.1, and Table 50	X	
	b. Is the prioritization of mitigation actions and activities updated based on the updated analysis of risks, capabilities, and progress?	Section 6.5	X	
Mitigation Strategy and Priorities - Required Revisions: None				
State Mitigation Capabilities				
Standard Plan Regulation Checklist		Location in Plan	Yes	No
S12. Does the plan discuss the evaluation of the state's hazard management policies, programs, capabilities, and funding sources to mitigate the	a. Does the plan describe existing state pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the state?	Section 6.2	X	

hazards identified in the risk assessment? [44 CFR §201.4(c)(3)(ii)]	b. Does the plan include an evaluation of state laws, regulations, policies, and programs related to hazard mitigation, as well as to development in hazard-prone areas, to include the state's administration of the NFIP and CRS; and Risk MAP program?	Section 6.2	X	

	c. Does the plan include a discussion of state funding capabilities for hazard mitigation projects, including a general description of the state's use of funds for hazard mitigation projects and a general discussion on the state's use of FEMA mitigation programs and funding sources, including but not limited to HMGP, PDM, and FMA; and PA C-G?	Section 6.3	X	
	d. Does the plan include a general summary of obstacles and challenges; and changes since the previous plan approval?	3.2.5 (Second to the last paragraph) 6.5.1 7.3.3	X	

State Mitigation Capabilities - Required Revisions: None

Local Coordination and Mitigation Capabilities

Standard Plan Regulation Checklist		Location in Plan	Yes	No
S13. Does the plan generally describe and analyze the effectiveness of local and tribal, as applicable, mitigation policies, programs, and capabilities? [44 CFR §201.4(c)(3)(ii)]	a. Does the plan provide a general summary of current local and tribal, as applicable, policies, programs, and capabilities of jurisdiction to accomplish hazard mitigation?	N/A	X	
	b. Does the plan describe the effectiveness of local and tribal, as applicable, mitigation policies, programs, and capabilities? Including, challenges and opportunities for implementing local and tribal mitigation policies, programs, and capabilities?	N/A	X	
	c. Does the plan include RL and SRL properties in the analysis of effectiveness? (See Element RL5)	N/A	X	

S14. Does the plan describe the process to support the development of approvable local and tribal, as applicable, mitigation plans? [44 CFR §§201.3(c)(5) and 201.4(c)(4)(i)]	a. Does the plan describe how the state supports developing or updating FEMA-approvable local and tribal, as applicable, mitigation plans, including the process used to provide training; technical assistance; and funding?	N/A – no local mitigation plans in Guam	X	
	b. Does the plan provide a summary of the FEMA-approved local and tribal, as applicable, mitigation plan coverage; barriers to developing or updating, adopting, and implementing FEMA-approved local and tribal, as applicable, mitigation plans; and an approach to remove barriers to advance mitigation planning?	N/A – no local mitigation plans in Guam	X	
S15. Does the plan describe the criteria for prioritizing funding? [44 CFR §201.4(c)(4)(iii)]	a. Does the plan describe criteria for prioritizing jurisdictions to receive planning and project grants under available Federal and non-Federal programs?	N/A – no sub-applicants in Guam	X	
	b. Does the plan address RL and SRL properties when prioritizing funding? (See Element RL6)	N/A – no sub-applicants in Guam	X	
S16. Does the plan describe the process and timeframe to review, coordinate, and link local and tribal, as applicable, mitigation plans with the state mitigation plan?	a. Does the plan describe the process and timeframe used by the state to review and submit approvable local and tribal, as applicable, mitigation plans to FEMA?	N/A – no local mitigation plans in Guam	X	
	b. Does the plan describe the process and timeframe used by the state to coordinate and link risk assessments and mitigation strategy information from local and tribal, as applicable, mitigation plans into the state mitigation plan?	N/A – no local mitigation plans in Guam	X	
<u>Local Coordination and Mitigation Capabilities - Required Revisions:</u> None				
Plan Review, Evaluation, and Implementation				

Standard Plan Checklist	Location No Regulation in Plan	Yes

S17. Is there a description of the method and schedule for keeping the plan current? [44 CFR §§201.4(c)(5)(i) and 201.4(d)]	a. Does the plan describe the process to monitor, evaluate, and update the plan?	Section 7	X	
	b. Does the plan specifically identify the agency/office responsible for monitoring, evaluating, and updating?	Section 7	X	
	c. Does the plan specifically identify the schedule for monitoring, evaluating, and updating?	Section 7	X	
S18. Does the plan describe the systems for monitoring implementation and reviewing progress? [44 CFR §§201.4(c)(5)(ii) and 201.4(c)(5)(iii)]	a. Does the plan describe the system for tracking the implementation of the mitigation activities and projects identified in the mitigation strategy? Including all mitigation strategies, not just those funded by FEMA.	Section 7	X	
	b. Does the system include a schedule; agency/office responsible for coordination; and role of the agencies/offices identified in the mitigation strategy as responsible for implementation of actions?	Section 7.3.3 7.2.3	X	
	c. Does the plan describe a system for reviewing progress on achieving the goals of the mitigation strategy that includes the criteria and process for evaluating progress?	Section 7.3.2	X	

Plan Review, Evaluation, and Implementation - Required Revisions: None

Adoption and Assurances

Standard Plan Regulation Checklist	Location in Plan	Yes	No
S19. Did the state provide documentation that the plan has been formally adopted? [44 CFR §201.4(c)(6)]	The Governor of Guam will issue an Executive Order to formally adopt the plan.	X	

S20. Did the state provide assurances? [44 CFR §201.4(c)(7)]	a. Does the plan include assurances that the state will manage and administer FEMA funding in accordance with applicable Federal statutes and regulations?	Section 1	X	
	b. Does the plan include assurances that the state will amend its plan whenever necessary to reflect changes in state or Federal laws and statutes?	Section 1	X	
<u>Adoption and Assurances - Required Revisions:</u> None				
Repetitive Loss (RL) Strategy				
Standard Plan Regulation Checklist		Locati on in Plan	Ye s	N o
RL1. Did Element S6 (risk assessment) address RL and SRL properties? [44 CFR §§201.4(c)(2)(ii), 201.4(c)(2)(iii), and 201.4(c)(3)(v)]		See Element S6	X	
RL2. Did Element S8 (mitigation goals) address RL and SRL properties? [44 CFR §§201.4(c)(3)(i) and 201.4(c)(3)(v)]		See Element S8 6.4, Goal 6	X	
RL3. Did Element S9 (mitigation actions) address RL and SRL properties? [44 CFR §§201.4(c)(3)(iii) and 201.4(c)(3)(v)]		See Element S9 6.5.1, Action No. 33	X	
RL4. Did Element S10 (funding sources) address RL and SRL properties? [44 CFR §§201.4(c)(3)(iv) and 201.4(c)(3)(v)]		See Element S10	X	
RL5. Did Element S13 (local and tribal, as applicable, capabilities) address RL and SRL properties? [44 CFR §§201.4(c)(3)(ii) and 201.4(c)(3)(v)]		N/A - See Element S13	X	
RL6. Did Element S15 (prioritizing funding) address RL and SRL properties? [44 CFR §§201.4(c)(4)(iii) and 201.4(c)(3)(v)]		N/A - See Element S15	X	
<u>Repetitive Loss Strategy - Required Revisions:</u> None				

Guam is not applying for enhanced status at this time, so the Enhanced Checklist has been removed from this review tool.

Strengths and Opportunities for Improvement

This section allows FEMA's plan reviewers to provide feedback on the strengths and opportunities for improvement of the State of Nevada's Hazard Mitigation Plan and their mitigation program.

Strengths:

- 1) Conducting the Hazard Mitigation Strategies workshop and engaging your wider stakeholder community is an excellent example of public outreach and the planning process.
- 2) Your list of hazard types is quite comprehensive and not limited to the traditional hazards that are captured by Hazard Mitigation Plans. Instead they reflect all hazards that pose true risk to the population and physical assets of the island. Please continue to work with this mindset in future plan updates and build good mitigation strategies around these identified hazards and risks.
- 3) The mitigation actions clearly address most of the risks and vulnerabilities identified in the previous sections. Furthermore, specific funding sources have been identified for all of the proposed mitigation actions. Given the level of specificity of the actions, it seems that Guam is ready to implement its mitigation strategy as funding sources become available. I look forward to seeing what progress is made in the next update.
- 4) The capabilities assessment is thorough and cleanly organized in a table that indicates several details of each capability, including whether it affects development in hazard-prone areas, is pre- and/or post- disaster, and how it can be improved. It is very useful for the reviewers, as well as the users/implementors of this plan, to see existing capabilities assessed in this way.
- 5) There is a very comprehensive, detailed discussion of internal and external funding sources, which will help implementors know the funding alternatives for the proposed or future mitigation actions.

Opportunities for Improvement:

- 1) In the Planning Process element, it is not necessary to include all the past plan update summaries or they could be condensed into an appendix so as to not bulk up the plan and confuse current activities. Also, though documentation of meetings is not required in the plan, it is helpful to include as an appendix or make sure to note where documents are stored for the

planning team to maintain.

- 2) It is important for the Risk Assessment to be based on the latest demographics as well as knowledge gleaned from natural hazard events that have occurred since the previous plan update. The next plan update should ideally document events and or disasters that have happened and use the impacts from these events to inform the assessment of vulnerability in terms of population and physical assets.
- 3) Climate change studies that have been done for Guam should be incorporated and should inform the discussion about the probability of future events.
- 4) While the current plan contains a fairly robust section on Vulnerability Analysis by village, the quantitative analysis was only done for a subset of the hazard identified. Future plan updates would ideally expand the quantitative analysis of vulnerability to additional hazards.
- 5) As only one mitigation action from the 2014 HMP was implemented, it would be helpful to see a deeper evaluation of the barriers to implementing the mitigation strategy over the last five years. If recent disasters were the primary barrier, what changes or resources are needed to ensure that mitigation is still a priority post-disaster?
- 6) For the Plan implementation section, the info was very generic and from the 2014 plan. Though it technically passes, it has no real actionable strength for an implementable 2019 – 2024 plan. For the next update, we would highly recommend making this section very specific to your current team and plan.

End.

APPENDIX C – DEFINITIONS

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100-hundred year floodplain. Also referred to as the Base Flood Elevation (BFE) and Special Flood Hazard Area. An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year.

Acquisition of hazard-prone structures. Local governments can acquire lands in high hazard areas through conservation easements, purchase of development rights, or outright purchase of property.

Actions. Specific actions that help achieve goals and objectives. Multiple mitigation actions may be defined to feed into an evaluation of the alternative actions.

Arson. The act of willfully and maliciously burning of property, especially with criminal or fraudulent intent.

Asset. Any natural or human-made feature that has value, including, but not limited to people; buildings; infrastructure like bridges, roads, and sewer and water systems; lifelines like electricity and communication resources; or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.

Base Flood Elevation (BFE). Elevation of the base flood in relation to a specified datum, such as the National Geodetic Vertical Datum of 1929. The BFE is used as a standard for the National Flood Insurance Program (NFIP).

Benefit-cost analysis. Benefit-cost analysis is a systematic, quantitative method of comparing the projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.

Best Management Practices. Appropriate, site-specific management techniques that maximize the benefits of land and natural resource management actions, while minimizing impacts.

Biological hazards. A hazard caused by the presence of any microorganism, virus, infectious substance, or biological product that may be engineered as a result of biotechnology or any naturally occurring microorganism, virus, infectious substance, or biological product, capable of causing death, disease, or other biological malfunction.

Bond. A debt obligation issued by states, cities, counties, and other governmental entities to raise money to pay for public projects, such as government facilities and infrastructure.

Building. A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Building codes. Regulations that set forth standards and requirements for the construction, maintenance, operation, occupancy, use, or appearance of buildings, premises, and dwelling units. Building codes can include standards for structures to withstand natural hazards.

Building/structure collapse. The failure and downfall of a structure. The collapse may result from a variety of natural causes such as hurricanes/typhoons, earthquakes, tornadoes, floods, or from manmade circumstances such as construction deficiencies, neglect, aging infrastructure, or acts of terrorism.

Capability assessment. An assessment that provides an inventory and analysis of a community or state's current capacity to address the threats associated with hazards. The capability assessment attempts to identify and evaluate existing policies, regulations, programs, and practices that positively or negatively affect the community or state's vulnerability to hazards or specific threats.

Channel maintenance. Ensuring that flood channels, storm sewers, retaining ponds, etc. do not become blocked by debris, sedimentation, overgrowth, or structural failure. **Coastal zone.** The area along the shore where the ocean meets the land as the surface of the land rises above the ocean. This land/water interface includes barrier islands, estuaries, beaches, coastal wetlands, and land areas with direct drainage to the ocean.

Civil disobedience. The refusal to obey civil laws or decrees, usually taking the form of passive resistance. People practicing civil disobedience break a law because they consider the law unjust, want to call attention to its justice, and hope to bring about its repeal or amendment. They are also willing to accept a penalty for breaking the law.

Civil disturbance. When individuals or segments of the population create a situation, often a result of civil unrest, requiring a response from the emergency response community to protect lives and property. The disturbance may be small and isolated to a small area or be of a larger scale and exceeding the response capabilities of a jurisdiction. Activities are normally active (demonstrations, looting, riots) rather than passive (public speeches, sit-downs, marches).

Civil unrest. When a segment of the civil population indicates its discontent or dissatisfaction with existing political, social, or religious issues. The unrest may materialize as a civil disturbance or civil disobedience. Activities may be passive (public speeches, sit-downs, marches) or active (demonstrations, looting, riots).

Coastal erosion. The process of erosion of coastal areas via wave action, particularly due to high surf and storm surge caused by tropical storms (i.e., hurricanes, typhoons). May include damage to barrier islands, estuaries, beaches, coastal wetlands, and land areas with direct drainage to the ocean.

Coastal zone management regulations. Regulations enacted to control growth and protect natural resources along coastlines. Under the federal Coastal Zone Management Act enacted in 1972, states and local governments adopt coastal zone management regulations designed to preserve, protect, and, where possible, restore or enhance valuable natural coastal resources

such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the wildlife dependent on those habitats.

Comprehensive plan. A document, also known as a “general plan,” covering the entire geographic area of a community and expressing community goals and objectives. The plan lays out the vision, policies, and strategies for the future of the community, including all of the physical elements that will determine the community’s future development. This plan can discuss the community’s desired physical development, desired rate and quantity of growth, community character, transportation services, location of growth, and siting of public facilities and transportation. In most states, the comprehensive plan has no authority in and of itself, but serves as a guide for community decision-making.

Consequences. The damage (full or partial), injuries, and losses of life, property, environment, and business that can be quantified by some unit of measure, often in economic or financial terms.

Construction of barriers around structures. Protective structures, such as berms and retaining walls, created by grading or filling areas with soil meant to keep flood waters from reaching buildings.

Cost-effectiveness. Cost-effectiveness is a key evaluation criterion for federal grant programs. Cost- effectiveness has several possible definitions, although for grant-making purposes the Federal Emergency Management Agency (FEMA) defines a cost-effective project as one whose long-term benefits exceed its costs. That is, a project should prevent more expected damage than it costs initially to fund the effort, which is done to ensure that limited public funds are used in the most efficient manner possible. Benefit-cost analysis is one way to illustrate that a project is cost-effective.

Essential Facilities, Major Utilities, and Transportation Systems. Buildings, facilities and infrastructure vital to the health, safety, and welfare of the population and the functioning of the community. For the purpose of this plan the following are considered EFMUTSs.

Essential Facilities are essential to the health and welfare of the whole population and are especially important following hazard events. Essential facilities include hospitals and other medical facilities, police and fire stations, emergency operations centers and evacuation shelters, and schools.

Major Utilities such as potable water, wastewater, and electric power systems.

Transportation Systems include airports, port facilities, bridges, traffic signals, and major roads.

FEMA’s HAZUS program includes two additional categories that are not included in this plan:

High Potential Loss Facilities are facilities that would have a high loss associated with them, such as nuclear power plants, dams, and military

installations. Not included due to control of these facilities by the U.S. military.

Hazardous Material Facilities include facilities housing industrial/HAZMAT, such as corrosives, explosives, flammable materials, radioactive materials, and toxins. Not considered due to the control of most of these by the U.S. military or by private entities.

Dam/levee failure. Dam/levee failure can be caused by natural occurrences such as floods, rock slides, earthquakes, or the deterioration of the foundation or the materials used in construction. Usually the changes are slow and not readily discovered by visual examination. Such a failure presents a significant potential for a disaster in that significant loss of life and property would be expected in addition to the possible loss of power and water resources.

Dams. Dams are artificial barriers that impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water. For a more detailed definition, see the National Dam Safety Program Act (as amended through Public Law 106-580, December 29, 2000).

Debris. The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can cause additional damage to other assets.

Density controls. Regulations that manage growth by limiting the density of development, often expressed in terms of the number of dwelling units per acre. Density controls allow the community to plan in an orderly way for infrastructure.

U.S. Department of Homeland Security (DHS). Following the September 11, 2001, terrorist attacks, President George W. Bush created a new federal government department to bring 22 previously separate domestic agencies together. The new department's first priority is protecting the nation against further terrorist attacks. Component agencies analyze threats and intelligence, guard borders and airports, protect critical infrastructure, and coordinate the response for future emergencies. The new department is organized into five major directorates: Border and Transportation Security; Emergency Preparedness and Response (EPR); Science and Technology; and Information Analysis and Infrastructure Protection; Management. In addition, several other critical agencies have been folded into the new department or are newly created. FEMA is the foundation of the EPR Directorate.

Design review standards. Guidelines enacted by local governments requiring new development to meet certain appearance and aesthetic standards and establishing a process by which local officials can examine site plans or structure blueprints to assess compliance with those standards. Design review standards can help ensure new development blends with existing buildings and the landscape or meet other priorities, including hazard loss reduction.

Design standards. A set of guidelines pertaining to the appearance and aesthetics of buildings or improvements that governs construction, alteration, demolition, or relocation of a building or improvement of land.

Disaster Mitigation Act of 2000 (DMA 2000). DMA 2000 (Public Law 106-390) is the latest legislation to improve the planning process. It was signed into law on October 30, 2000. This new legislation reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur.

Drought. A drought occurs when water supplies cannot meet established demands. "Severe" to "extreme" drought conditions endanger livestock and crops, significantly reduce surface and ground water supplies, increase the potential risk for wildland fires, increase the potential for dust storms, and cause significant economic loss. Humid areas are more vulnerable than arid areas. Drought may not be constant or predictable and does not begin or end on any schedule.

Dune and beach restoration. Actions taken to reestablish dunes and beaches that serve as natural protection against coastal flooding and storm surge. Dune and beach restoration activities consist of replenishing sand, replanting protective vegetation, controlling or restricting foot and vehicle traffic, and constructing sand traps or wind barriers.

Earthquake. An earthquake is a naturally induced shaking of the ground, caused by the fracture and sliding of rock within the Earth's crust. The magnitude is determined by the dimensions of the rupturing fracture (fault) and the amount of displacement that takes place. The larger the fault surface and displacement, the greater the energy. In addition to deforming the rock near the fault, this energy produces the shaking and a variety of seismic waves that radiate throughout the Earth. Earthquake magnitude is measured using the Richter Scale and earthquake intensity is measured using the Modified Mercalli Intensity Scale.

Easements. Grant a right to use property, or restrict the landowner's right to use the property in a certain way.

Elevation of structures. Raising structures above the base flood elevation to protect structures

Emergency Preparedness and Response (EPR) Directorate. One of five major DHS Directorates that builds upon formerly independent FEMA. EPR is responsible for preparing for natural and man-made disasters through a comprehensive, risk-based emergency management program of preparedness, prevention, response, and recovery. This work incorporates the concept of disaster-resistant communities, including providing federal support for local governments that promote structures and communities that reduce the chances of being hit by disasters.

Emergency Response Plan. A document that contains information on the actions that may be taken by a governmental jurisdiction to protect people and property before, during, and after a disaster.

Emergency response services. The actions of first responders such as firefighters, police, and other emergency services personnel at the scene of a hazard event. The first responders take appropriate action to contain the hazard, protect property, conduct search and rescue operations, provide mass care, and ensure public safety.

Eminent domain. The right of a government to appropriate private property for public use, with adequate compensation to the owner.

Enemy attack. The use of aggressive action against an opponent in pursuit of an objective. An “enemy attack” is considered an attack of one sovereign government against another as either a declared or undeclared act of war.

Environmental review standards. Guidelines established to ensure new development adheres to certain construction and site design standards to minimize the impact on the environment.

Erosion. Wearing away of the land surface by detachment and movement of soil and rock fragments during a flood or storm over a period of years, through the action of wind, water, or other geologic processes.

Explosion/Fire. An explosion is the sudden loud release of energy and a rapidly expanding volume of gas that occurs when a gas explodes or a bomb detonates. Explosions result from the ignition of volatile products such as petroleum products, natural and other flammable gases, HAZMAT/chemicals, dust, and bombs. While an explosion surely may cause death, injury and property damage, a fire routinely follows, which may cause further damage and inhibit emergency response.

Exposure. The number, types, qualities, or monetary values of various types of property or infrastructure and life that may be subject to an undesirable or injurious hazard event.

Extreme air pollution. Pollution is the contamination of the earth's environment with materials that interfere with human health, the quality of life, or the natural functioning of ecosystems. Air pollution is the addition of harmful substances to the atmosphere. It makes people sick, causing breathing problems and sometimes cancer, and it harms plants, animals, and the ecosystems in which they live. Some pollutants return to earth in the form of acid rain and snow that corrodes structures, damage vegetation, and makes streams and lakes unsuitable for life. “Extreme air pollution” exceeds established thresholds resulting in the need to take corrective actions and cause the public to take precautions.

Extreme heat. Extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Humid conditions may also add to the discomfort of high temperatures.

Federal Emergency Management Agency (FEMA). Formerly independent agency created in 1978 to provide a single point of accountability for all federal activities related to disaster mitigation and emergency preparedness, response and recovery. As of March 2003, FEMA is a part of the DHS' EPR Directorate.

Fire-proofing. Actions taken on and around buildings to prevent the spread of fires.

Flood Hazard Area. The area on a map shown to be inundated by a flood of a given magnitude.

Flood Insurance Rate Map (FIRM) or Digital Flood Insurance Rate Map (DFIRM). Map of a community, prepared by FEMA that shows the special flood hazard areas and the risk premium zones applicable to the community.

Flood Mitigation Assistance (FMA) Program. A program created as part of the National Flood Insurance Reform Act of 1994. FMA provides funding to assist communities and states in implementing actions that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other NFIP insurable structures, with a focus on repetitive loss properties.

Flood zone. A geographical area shown on a FIRM that reflects the severity or type of flooding in the area.

Floodplain development regulations. Regulations requiring flood insurance and mandating certain design aspects of new or substantially improved structures that lie within regulated flood-prone areas. Current federal regulations through the NFIP require that, at a minimum, new residential buildings in the Special Flood Hazard Area have their lowest floor at or above the base flood elevation.

Floodplain zoning. Zoning regulations that prescribe special uses for and serve to minimize development in floodplain areas.

Flood-proofing. Actions that prevent or minimize future flood damage. Making the areas below the anticipated flood level watertight or intentionally allowing floodwaters to enter the interior to equalize flood pressures are examples of flood proofing.

Floods. A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any sources, or (3) mudflows or the sudden collapse of shoreline land.

Forest and vegetation management. The management of forests and vegetation so they are resilient to landslides, high-winds, and other storm-related hazards.

Forest fire fuel reduction. Minimizing fuel loads in forested areas by clearing excess ground cover and thinning diseased or damaged woodland to create healthier forests and to decrease the vulnerability to the devastation of forest fire.

Frequency. A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered. Probability is a related term.

Fuel/Resource shortage. A fuel/resource shortage is defined as an actual or potential shortage of natural gas, crude and refined petroleum, petroleum-derived fuels, or other critical commodities that significantly impacts the ability to: render essential government and emergency services (medical, fire, safety); and threatens the health and safety of the public.

Fujita scale of tornado intensity. Rates tornadoes with numeric values from F0 to F5 based on tornado winds speed and damage sustained. An F0 indicates minimal damage such as broken tree limbs or signs, while an F5 indicates severe damage sustained.

General obligation bond. A bond secured by the taxing and borrowing power of the municipality issuing it.

Geographic Information System (GIS). A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.

Goals. General guidelines that explain what you want to achieve. Goals are usually broad statements with long-term perspective.

Hazard event. A specific occurrence of a particular type of hazard.

Hazard identification. The process of identifying hazards that threaten an area.

Hazard information center. Information booths, publication kiosks, exhibits, etc. that display information to educate the public about hazards that affect the jurisdiction and hazard mitigation activities people can undertake.

Hazard mitigation. Cost-effective measures taken to reduce or eliminate long-term risk from hazards and their effects.

Hazard Mitigation Grant Program (HMGP). Authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to natural disasters and to enable mitigation activities to be implemented as a community recovers from a disaster.

Hazard profile. A description of the physical characteristics of hazards and a determination of various descriptors, including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are recorded and displayed as maps.

Hazard threat recognition. The process of identifying possible hazards and estimating potential consequences.

Hazard warning systems. Systems or equipment such as community sirens and National Oceanic Atmospheric Administration weather radios designed to provide advanced warning of an impending hazard. Warning systems allow communities to take protective actions before a hazard event occurs, including taking cover, finding shelter, or moving furniture, cars, and people out of harm's way.

Hazard. A source of potential danger or adverse condition. Hazards include both natural and man-made events. A natural event is a hazard when it has the potential to harm people or property and may include events such as floods, earthquakes, tsunamis, typhoons, and wildland fires that strike populated areas. Man-made hazard events originate from human activity and may include technological hazards and terrorism. Technological hazards arise from human activities and are assumed to be accidental and/or have unintended consequences (i.e., manufacture, storage and use of HAZMAT). While no single definition of terrorism exists, the Code of Federal Regulations defines terrorism as "...unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives."

Hazardous materials incidents. A spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment of a HAZMAT, but excludes: (1) any release that results in exposure to poisons solely within the workplace, with respect to claims that such persons may assert against the employer of such persons; (2) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; (3) release of source, byproduct, or special nuclear material from a nuclear incident; and (4) the normal application of fertilizer.

Hazardous surf. Coastal or lake surf that is unusually high that overpower persons and small watercraft near or in the water. Often associated with rip currents. Typically the result of regional weather systems, such as high winds or tropical storms.

HAZUS, HAZUS-MH. A GIS-based, nationally standardized, loss estimation tool developed by FEMA. HAZUS-MH is the new multihazard version that includes earthquake, wind, hurricane, and flood loss estimate components.

Health and safety maintenance. Sections of emergency response/operations plans that provide for the security of affected areas, including clean up and special precautions for each type of hazard (i.e., draining standing water after a flood, cautioning about aftershocks after an earthquake or successive tsunami waves, etc.).

Hillside development regulations. Site design and engineering techniques prescribed through regulations such as selective grading, drainage

improvements, and vegetation clearance to eliminate, minimize, or control development on hillsides, thereby protecting the natural features of hillsides and reducing the likelihood of property damage from landslides.

Hostage situation. A situation in which people are held hostage and negotiations take place for their release. The situation may range from a simple domestic or isolated criminal act to an attempt to impose will on a national or international scale to intimidate or coerce a government to further a political, social, or religious objective.

Hurricane. An intense tropical cyclone, formed in the atmosphere over warm ocean areas, in which wind speeds reach 74 miles per hour or more and blow in a large spiral around a relatively calm center or “eye.” Hurricanes develop over the north Atlantic Ocean, northeast Pacific Ocean, or the southern Pacific Ocean east of 160°E longitude. Hurricane circulation is counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. See typhoon.

Hysteria (Mass). Also known as “mass psychogenic illness” and “hysterical contagion,” mass hysteria is a situation in which a symptom or set of symptoms with no physical explanation spreads quickly among a group. It may occur as a reaction to an incident of domestic terrorism.

Implementation strategy. A comprehensive strategy that describes how the mitigation actions will be implemented.

Infestations. An infestation consists of an invasion or spreading of a living organism (plant, animal, etc.) that has an adverse (unwanted) effect on the population or the environment. The effect may range from a simple nuisance to an infectious disease or destructive parasite or insect. Infestations may result from nonindigenous plants, rodents, weeds, parasites, insects, and fungi, and may adversely affect people, animals, agriculture, economy (i.e., tourism), and property.

Infrastructure. Refers to the public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology, such as phone lines or Internet access; vital services, such as public water supplies and sewer treatment facilities; and an area's transportation system. airports, heliports, highways, bridges, tunnels, roadbeds, overpasses, railways, bridges, rail yards, depots; and waterways, canals, locks, seaports, ferries, harbors, dry docks, piers, and regional dams.

Landslides/mudslides/debris flows. Landslides, like avalanches are massive downward and outward movements of slope-forming materials. The term landslide is restricted to movement of rock and soil and includes a broad range of velocities. Slow movements, although rarely a threat to life, can destroy buildings or break buried utility lines. A landslide occurs when a portion of a hill slope becomes too weak to support its own weight. The weakness is generally initiated when rainfall or some other source of water increases the water content of the slope, reducing the shear strength of the

materials. A mud slide is a type of landslide referred to as a flow. Flows are landslides that behave like fluids: mud flows involve wet mud and debris.

Levees and floodwalls. Flood barriers constructed of compacted soil or reinforced concrete walls.

Liquefaction. The phenomenon that occurs when ground shaking (earthquake) causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength.

located in areas prone to flooding.

Loss estimation. Forecasts of human and economic impacts and property damage from future hazard events, based on current scientific and engineering knowledge.

Memorandum of Agreement. A nonbinding statement that defines the duties, responsibilities, and commitment of the different parties or individuals; provides a clear statement of values, principles, and goals; and establishes an organizational structure to assist in measuring and evaluating progress.

Mitigate. To cause to become less harsh or hostile; to make less severe or painful. Mitigation activities are actions taken to eliminate or reduce the probability of the event, or reduce its severity of consequences, either prior to or following a disaster/emergency.

Mitigation actions. Activities, measures, or projects that help achieve the goals and objectives of a mitigation plan.

Mitigation plan. A systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards typically present in a defined geographic area, including a description of actions to minimize future vulnerability to hazards.

Modified Mercalli Intensity Scale. The Modified Mercalli Intensity Scale is commonly used in the United States by seismologists seeking information on the severity of earthquake effects.

Intensity ratings are expressed as Roman numerals between I at the low end and XII at the high end. The Intensity Scale differs from the Richter Magnitude Scale in that the effects of any one earthquake vary greatly from place to place, so many Intensity values (i.e., IV, VII) may be measured from one earthquake. Each earthquake, on the other hand, should have just one Magnitude, although the several methods of estimating it will yield slightly different values (i.e., 6.1, 6.3).

National Flood Insurance Program. Federal program created by Congress in 1968 that makes flood insurance available in communities that enact minimum floodplain management regulations as indicated in 44 CFR §60.3.

Objectives. Objectives define strategies or implementation steps to attain the identified goals. Unlike goals, objectives are specific and measurable.

Open space preservation. Preserving undeveloped areas from development through any number of methods, including low-density zoning, open space zoning, easements, or public or private acquisition. Open space preservation is a technique that can be used to prevent flood damage in flood-prone areas, land failures on steep slopes or liquefaction-prone soils, and can enhance the natural and beneficial functions of floodplains.

Ordinance. A term for a law or regulation adopted by a local government.

Performance standards. Standards setting the allowable effects or levels of impact of development. Often used in conjunction with traditional zoning, the standards typically address specific environmental conditions, traffic, or stormwater runoff. Can also be imposed on structures in hazard areas to ensure they withstand the effect of hazards.

Planning. The act or process of making or carrying out plans; the establishment of goals, policies, and procedures for a social or economic unit.

Planning team. A group composed of government, private sector, and individuals with a variety of skills and areas of expertise, usually appointed by a city or town manager, or chief elected official. The group finds solutions to community mitigation needs and seeks community acceptance of those solutions.

Policy. A course of action or specific rule of conduct to be followed in achieving goals and objectives.

Post-disaster mitigation. Mitigation actions taken after a disaster has occurred, usually during recovery and reconstruction.

Post-disaster recovery ordinance. An ordinance authorizing certain governmental actions to be taken during the immediate aftermath of a hazard event to expedite implementation of recovery and reconstruction actions identified in a pre-event plan.

Post-disaster recovery planning. The process of planning those steps the jurisdiction will take to implement long-term reconstruction with a primary goal of mitigating its exposure to future hazards. The post-disaster recovery planning process can also involve coordination with other types of plans and agencies, but it is distinct from planning for emergency operations.

Power/utility failure. A power/utility failure is defined as an actual or potential shortage of electric power or the interruption of electrical power that significantly threatens health and safety. Many communities are vulnerable to many localized, short and long-term energy emergencies. Power shortages or failures do occur and may be brought on by severe weather conditions, such as blizzards, ice storms, extreme heat, thunderstorms, or events such as war, or civil disturbance.

Private activity bond. A bond whose interest may or may not be federally taxable. Under the Internal Revenue Code, private activity bonds are described generally as any bond. (1) of which more than 10 percent of the

proceeds is to be used in a trade or business of any person or persons other than a governmental unit, and which is to be directly or indirectly repaid, or secured by revenues from, a private trade or business; and (2) in which an amount exceeding the lesser of 5 percent or \$5 million of the proceeds is to be used for loans to any person or persons other than a governmental unit. Certain private activity bonds are tax exempt when used to finance private water, wastewater, and multifamily housing projects.

Probability. A measure of how often events of a particular magnitude are expected to occur. Probability describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered. May also be measured in terms of the chance that an event will be exceeded (or not exceeded) over a specified period of time. Frequency is a related term.

Public education and outreach programs. Any campaign to make the public more aware of hazard mitigation and mitigation programs, including hazard information centers, mailings, public meetings, etc.

Q3 data. The Q3 Flood Data product is a digital representation of certain features of FEMA's FIRM product, intended for use with desktop mapping and GIS technology. The digital Q3 Flood Data are created by scanning the effective FIRM paper maps and digitizing selected features and lines. The digital Q3 Flood Data are designed to serve FEMA's needs for disaster response activities, NFIP activities, risk assessment, and floodplain management.

Radiological accident. A radiological accident is a release of radioactive materials. It can occur where radioactive materials are used, stored, or transported. Potentially nuclear power plants (fixed nuclear facilities), hospitals, universities, research laboratories, industries, major highways, railroads, or shipping yards could be the site of a radiological accident.

Radon. Radon is a naturally occurring radioactive gas that is odorless and tasteless. It is formed from the radioactive decay of uranium. Uranium is found in small amounts in most rocks and soil. It slowly breaks down to other products such as radium, which breaks down to radon.

Radon also undergoes radioactive decay. Radon enters the environment from the soil, from uranium and phosphate mines, and from coal combustion.

Radon has a radioactive half-life and about 4 days, meaning that one-half of a given amount of radon will decay to other products every 4 days. Some of the radon produced in the soil will move to the surface and enter the air. Radon also moves from the soil and enters the groundwater.

Real estate disclosure. Laws requiring the buyer and lender to be notified if a property is located in a hazard-prone area.

. **Regulation.** Most states have granted local jurisdictions broad regulatory powers to enable the enactment and enforcement of ordinances that deal with public health, safety, and welfare. These include building codes, building inspections, zoning, floodplain and subdivision ordinances, and growth management initiatives.

Relocation out of hazard areas. A mitigation technique that features the process of demolishing or moving a building to a new location outside the hazard area.

Repetitive loss property. A property that is currently insured for which two or more NFIP losses (occurring more than 10 days apart) of at least \$1000 each have been paid within any 10- year period since 1978.

Reservoirs. Large water storage facilities that can be used to hold water during peak runoff periods for controlled release during off-peak periods.

Resolutions. Expressions of a governing body's opinion, will, or intention that can be executive or administrative in nature. Most planning documents must undergo a council resolution, which must be supported in an official vote by a majority of representatives to be adopted. Other methods of making a statement or announcement about a particular issue or topic include proclamations and declarations.

Resources. Resources include the people, materials, technologies, money, etc., required to implement strategies or processes. The costs of these resources are often included in a budget. See definition for structural retrofitting.

Richter Magnitude Scale. A logarithmic scale devised by seismologist C. F. Richter in 1935 to express the total amount of energy released by an earthquake. While the scale has no upper limit, values are typically between 1 and 9, and each increase of 1 represents a 32-fold increase in released energy.

Rip current. A rip current is a shallow river or channel of water on the surface of the ocean. Special weather conditions can cause rip currents to form, particularly strong winds blowing toward the shore, which causes water pressure to build up on sandbars, reefs, or rocks.

Risk. The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk assessment. A process or method for evaluating risk associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure, and consequences.

Sabotage. Sabotage is the deliberate destruction of property, dismantling of technology or other interference or obstruction of normal operations.

"Sabotage" is normally considered an act related to war; similar acts during "nonwar" conditions would be considered a terrorist act.

Safe room/shelter. A small interior room constructed above grade and used to provide protection from tornadoes and other severe storm events. Bathrooms and large closets often double as safe rooms.

Seawalls/bulkheads. Vertical coastal walls that are built and designed to protect buildings against shoreline erosion. May also protect against storm surge.

Sediment and erosion control regulations. Regulations that stipulate the amount of sediment and erosion that is acceptable for land undergoing development.

Shoreline setback regulations. Regulations that establish a minimum distance between the existing shoreline and buildable areas.

Special events. An event of such a magnitude, media visibility, or importance that may require extraordinary preparations by government and possible response by emergency response agencies. Such events may be considered an opportunity or target for activist or terrorist activities.

Special tax bond. A bond secured by the pledge of a specific special tax.

Special use permits. Permits granted by local governments for land uses that have the potential for creating conflicts with uses on adjacent properties.

Stafford Act. The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100- 107 was signed into law November 23, 1988, and amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially as they pertain to FEMA and its programs.

Stakeholder. Individual or group that will be affected in any way by an action or policy. Stakeholders include businesses, private organizations, and citizens.

State Hazard Mitigation Officer. The representative of state government who is the primary point of contact with FEMA, other state and federal agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities.

Storm surge. Rise in the water surface above normal water level on the open coast due to the action of wind stress and atmospheric pressure on the water surface.

Stormwater management regulations. Regulations governing the maintenance and improvement of urban stormwater systems and the implementation of land treatment actions to minimize the effects of surface water runoff. Land treatment actions include maintenance of vegetative cover, terracing, and slope stabilization.

Strategy. Collection of actions to achieve goals and objectives.

Stream corridor restoration. The restoration of the areas bordering creeks, including the stream bank and vegetation.

Stream dumping regulations. Regulations prohibiting dumping in the community's drainage system, thereby maintaining stream carrying capacities and reducing the possibility of localized flooding.

Strike. A strike is an organized work stoppage carried out by a group of employees for the purpose either of enforcing demands relating to employment conditions on their employer or of protesting unfair labor practices. A strike may be engaged to obtain improvement in work conditions, higher wages or shorter hours, to forestall an adverse change in conditions of employment, or to prevent the employer from carrying out actions viewed by workers as detrimental to their interests.

Structural retrofitting. Modifying existing buildings and infrastructure to protect them from hazards.

Subdivision and development regulations. Regulations and standards governing the division of land for development or sale. Subdivision regulations can control the configuration of parcels, set standards for developer-built infrastructure, and set standards for minimizing runoff, impervious surfaces, and sediment during development. They can be used to minimize exposure of buildings and infrastructure to hazards.

Subdivision. The division of a tract of land into two or more lots for sale or development.

Subsidence. Land subsidence occurs when large amounts of ground water have been withdrawn from certain types of rocks, such as fine-grained sediments. The rock compacts because the water is partly responsible for holding the ground up. When the water is withdrawn, the rocks fall in on itself.

Substantial damage. Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceeds 50 percent of the market value of the structure before the damage.

Taxation. Taxes and special assessments can be an important source of revenue for governments to help pay for mitigation activities. The power of taxation can also have a profound impact on the pattern of development in local communities. Special tax districts, for example, can be used to discourage intensive development in hazard-prone areas.

Terrorism (economic, cyber, nuclear, biological, and chemical). "Terrorism is the unlawful use of force or violence, or threatened use of force or violence, against persons and places for the purpose of intimidation and/or coercing a government, its citizens, or any segment thereof for political or social goals." (Department of Justice, Federal Bureau of Investigation). Terrorism can include computer-based (cyber) attacks and the use of weapons of mass destruction to include chemical, biological, radiological, nuclear, or explosive agents.

Thunderstorms/high winds. Thunderstorms are characterized as violent storms that typically are associated with high winds, dust storms, heavy rainfall, hail, lightning strikes, and/or tornadoes. The unpredictability of thunderstorms, particularly their formation and the rapid movement to new locations heightens the possibility of floods.

Tornadoes/dust devils. A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds in excess of 250 mph. Damage paths can exceed a mile wide and 50 miles long. Tornadoes are one of nature's most violent storms. In an average year, 800 tornadoes are reported across the United States, resulting in 80 deaths and over 1,500 injuries. The damage from tornadoes is due to high winds. The Fujita Scale of Tornado Intensity measures tornado/high wind intensity and damage. A dust devil is a small but rapidly rotating column of wind made visible by the dust, sand, and debris it picks up from the surface. They typically develop best on clear, dry, hot afternoons.

Transfer of development rights. A growth management technique through which development rights are transferred from a designated "sending" area to a designated "receiving" area. The sending area is generally prohibited from development and the receiving area is a targeted development area that can be built at a higher density.

Transportation accident. A transportation accident is an incident related to a mode of transportation (highway, air, waterway, port, and harbor) where an emergency response is necessary to protect life and property.

Tropical storm. A tropical system in which the maximum sustained surface wind ranges from 34 to 63 knots (39 to 73 mph). Tropical storms are associated with heavy rain, high wind, and thunderstorms. High intensity rainfall in short periods is typical. A tropical storm is classified as a hurricane/typhoon when its sustained winds reach or exceed 74 mph (64 knots). These storms are medium to large in size and are capable of producing dangerous winds, torrential rains, and flooding, all of which may result in tremendous property damage and loss of life, primarily in coastal populated areas. The effects are typically most dangerous before a hurricane/typhoon makes landfall, when most damage occurs.

Tsunami. Great sea wave produced by submarine earth movement or volcanic eruption.

Typhoon A special category of tropical cyclone peculiar to the North Pacific Basin, frequently affecting areas in the vicinity of Guam and the North Mariana Islands. Typhoons whose maximum sustained winds attain or exceed 150 mph are called super typhoons.

Urban forestry and landscape management. Forestry management techniques that promote the conservation of forests and related natural resources in urbanized areas, with a focus on obtaining the highest social, environmental, and economic benefits.

Volcanoes. A volcano is a vent in the Earth from which molten rock (magma) and gas erupt. The molten rock that erupts from the volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Volcanic eruptions can

be placed into two general categories: those that are explosive and those that are effusive resulting in gently flowing lava flows, spatter cones, and lava fountains. Many eruptions are highly explosive in nature. They produce fragmental rocks from erupting lava and surrounding area rock and may produce fine volcanic ash that rises many kilometers into the atmosphere in enormous eruption columns. Explosive activity can also cause widespread ash fall, pyroclastic flows, debris avalanches, landslides, pyroclastic surges, and lahars.

Vulnerability. Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damage, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power—if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

Vulnerability assessment/analysis. The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability analysis should address impacts of hazard events on the existing and future built environment.

Vulnerable populations. Any segment of the population that is more vulnerable to the effects of hazards because of things such as lack of mobility, sensitivity to environmental factors, or physical abilities. These populations can include, but are not limited to, senior citizens and school children.

Wave run-up. The height that the wave extends up to on steep shorelines, measured above a reference level (the normal height of the sea, corrected to the state of the tide at the time of wave arrival).

Wetlands development regulations. Regulations designed to preserve and/or minimize the impact of development on wetlands.

Wildland fires. Wildland fire is a rapid, persistent chemical reaction that releases heat and light, especially the exothermic combination of a combustible substance with oxygen. Combine severe burning conditions with people or lightning and the stage is set for the occurrence of large, destructive wildland fires.

Wind-proofing. Modification of design and construction of buildings to withstand wind damage.

Zoning. The division of land within a local jurisdiction by local legislative regulation into zones of allowable types and intensities of land uses.

Zoning or land use map. A map that identifies the various zoning district boundaries and the uses permitted by a zoning ordinance within those boundaries.

. **Zoning ordinance.** Designation of allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

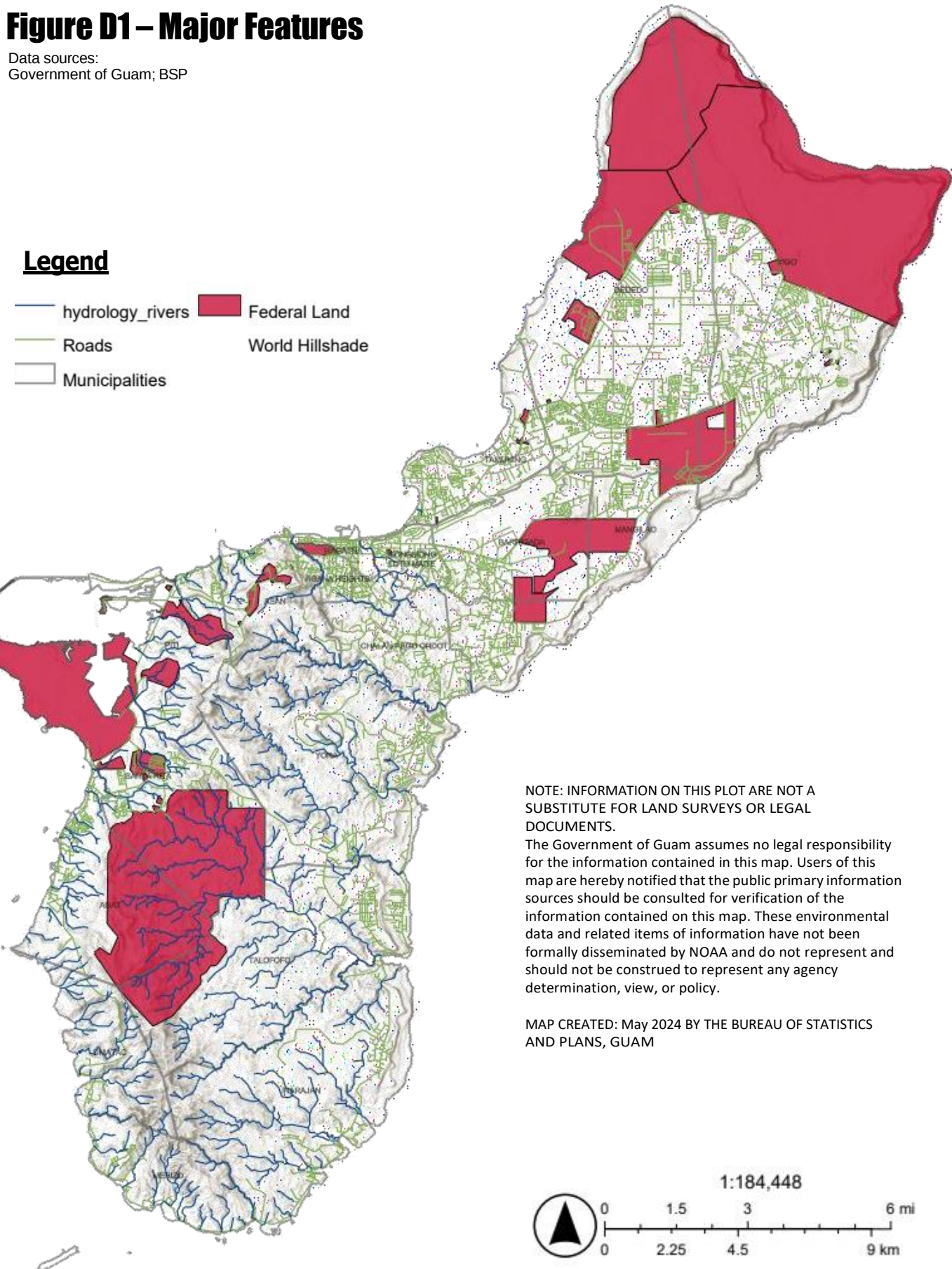
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Data sources:
Government of Guam; BSP

Legend



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AND PLANS, GUAM

Figure D2- Soils

Data sources:

Government of Guam; USDA Soil Conservation Service (now NRCS)

Legend

 Municipalities

USA Soils Map Units 2D

 Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustalfs, Alfisols

 Very-fine, kaolinitic, isohyperthermic Typic Tropaqualfs, Alfisols

 Very-fine, kaolinitic, isohyperthermic Oxyc Haplustalfs, Alfisols

 Very-fine, mixed, isohyperthermic Ultic Paleustalfs, Alfisols

 Very-fine, montmorillonitic, isohyperthermic Vertic Haplustalfs, Alfisols

 Carbonatic, isohyperthermic Typic Ustipsamments, Entisols

 Clayey, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents, Entisols

 Clayey-skeletal, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents, Entisols

 Fine, mixed, acid, isohyperthermic Aquic Ustifluvents, Entisols

 Very-fine, mixed, nonacid, isohyperthermic Aerit Tropic Fluvaquents, Entisols

 Very-fine, mixed, nonacid, isohyperthermic Tropic Fluvaquents, Entisols

 Isohyperthermic Troposaprists, Histosols

 Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustolls, Mollisols

 Very-fine, kaolinitic, isohyperthermic Inceptic Haplustox, Oxisols

 Rock Outcrop and Urban Unclassed

World Hillshade

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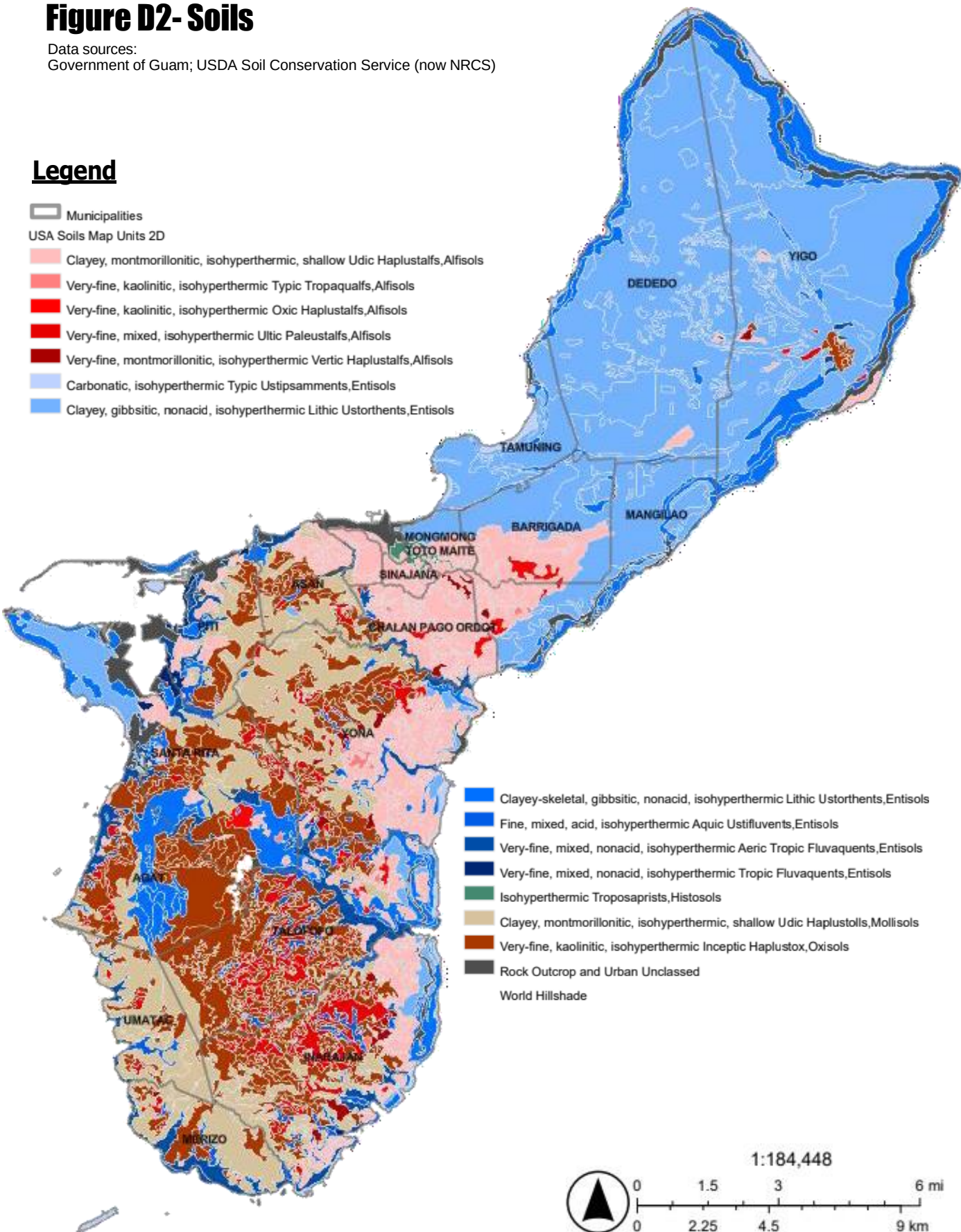
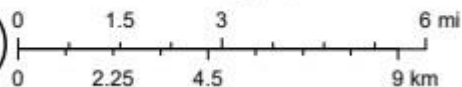
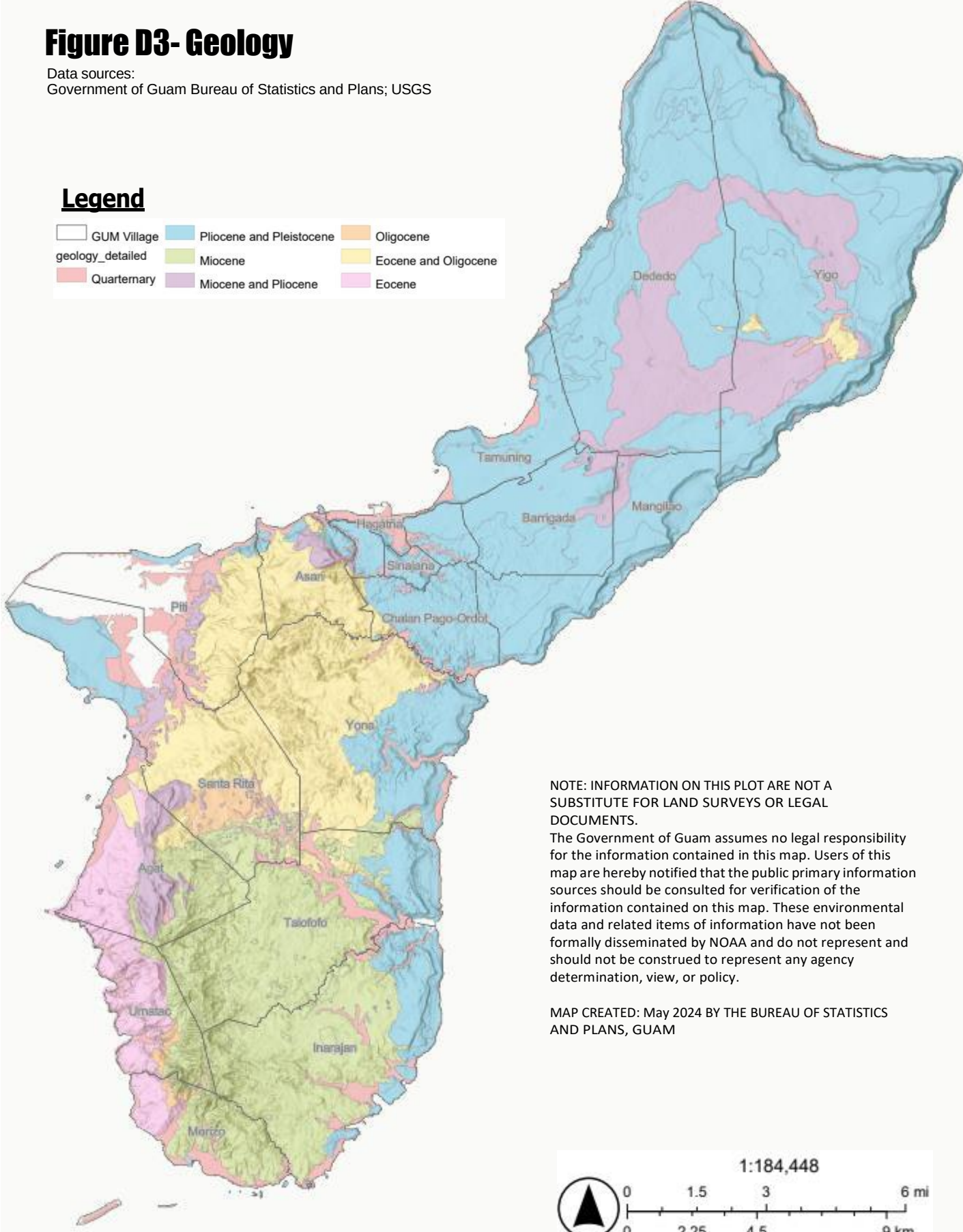


Figure D3- Geology

Data sources:
Government of Guam Bureau of Statistics and Plans; USGS

Legend

	GUM Village		Pliocene and Pleistocene		Oligocene
	geology_detailed		Miocene		Eocene and Oligocene
	Quaternary		Miocene and Pliocene		Eocene



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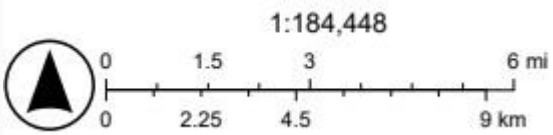
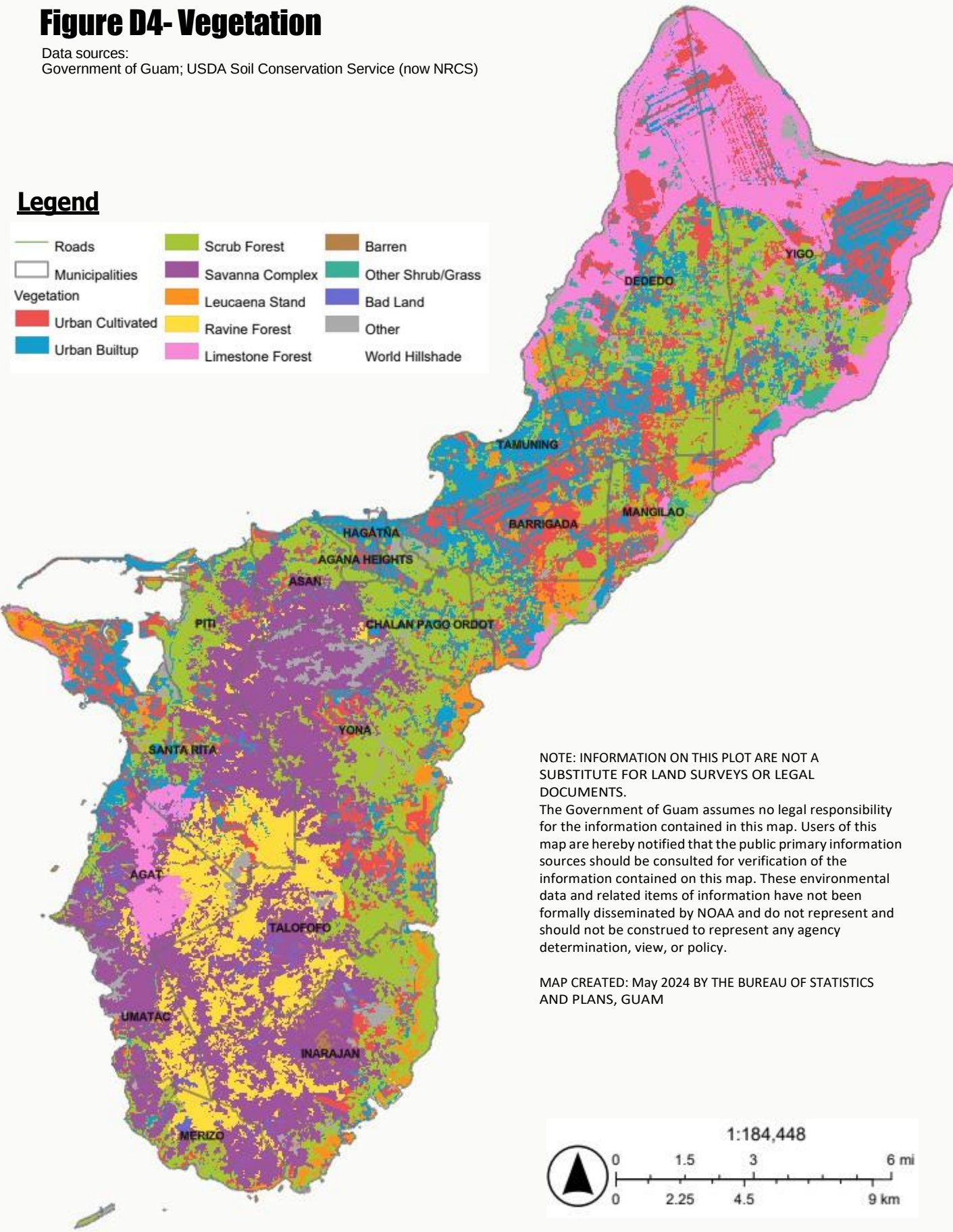


Figure D4- Vegetation

Data sources:
Government of Guam; USDA Soil Conservation Service (now NRCS)

Legend

 Roads	 Scrub Forest	 Barren
 Municipalities	 Savanna Complex	 Other Shrub/Grass
 Vegetation	 Leucaena Stand	 Bad Land
 Urban Cultivated	 Ravine Forest	 Other
 Urban Builtup	 Limestone Forest	 World Hillshade



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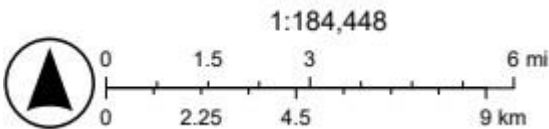
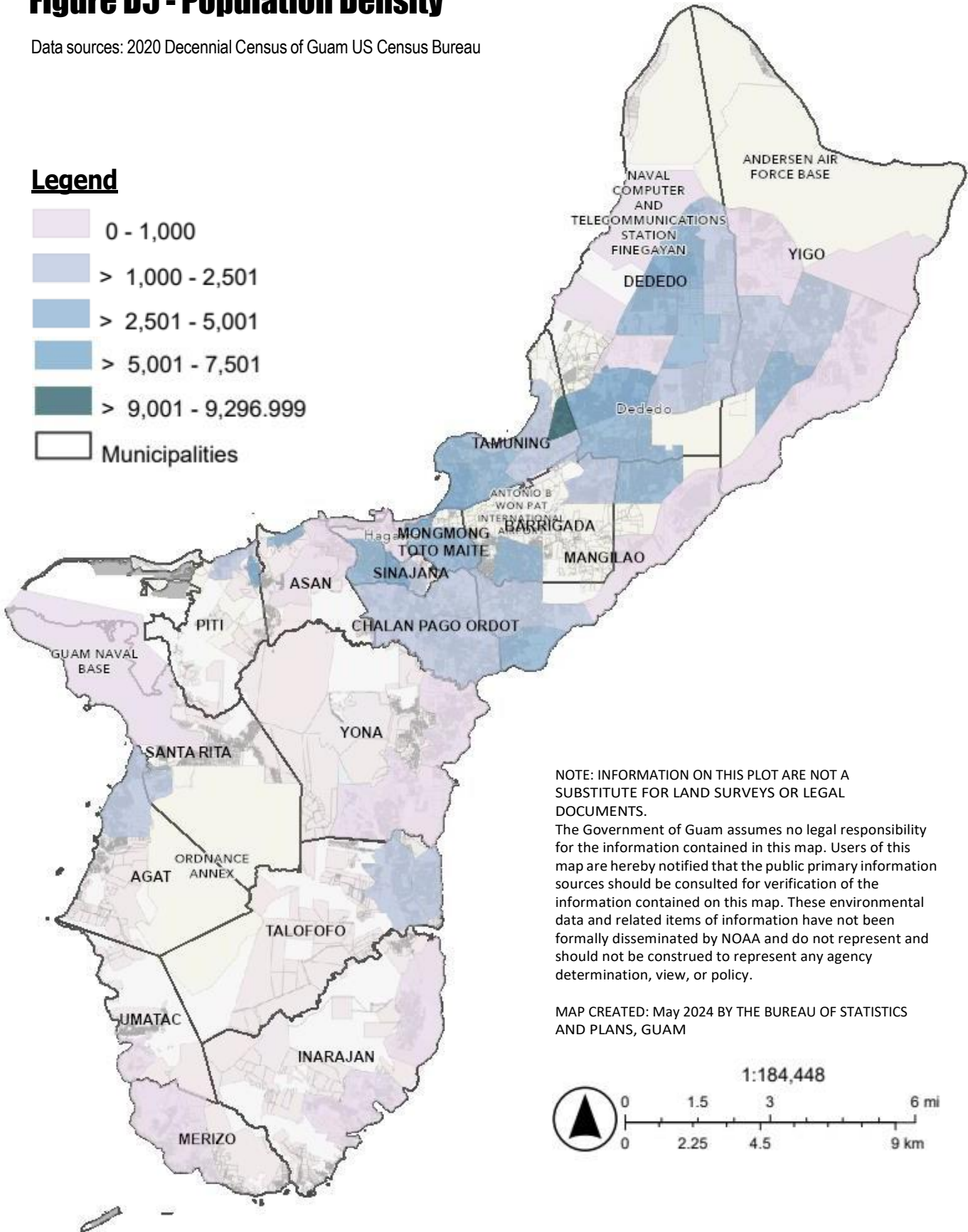
MAP CREATED: May 2024 BY THE BUREAU OF STATISTICS AND PLANS, GUAM

Figure D5 - Population Density

Data sources: 2020 Decennial Census of Guam US Census Bureau

Legend

- 0 - 1,000
- > 1,000 - 2,501
- > 2,501 - 5,001
- > 5,001 - 7,501
- > 9,001 - 9,296.999
- Municipalities

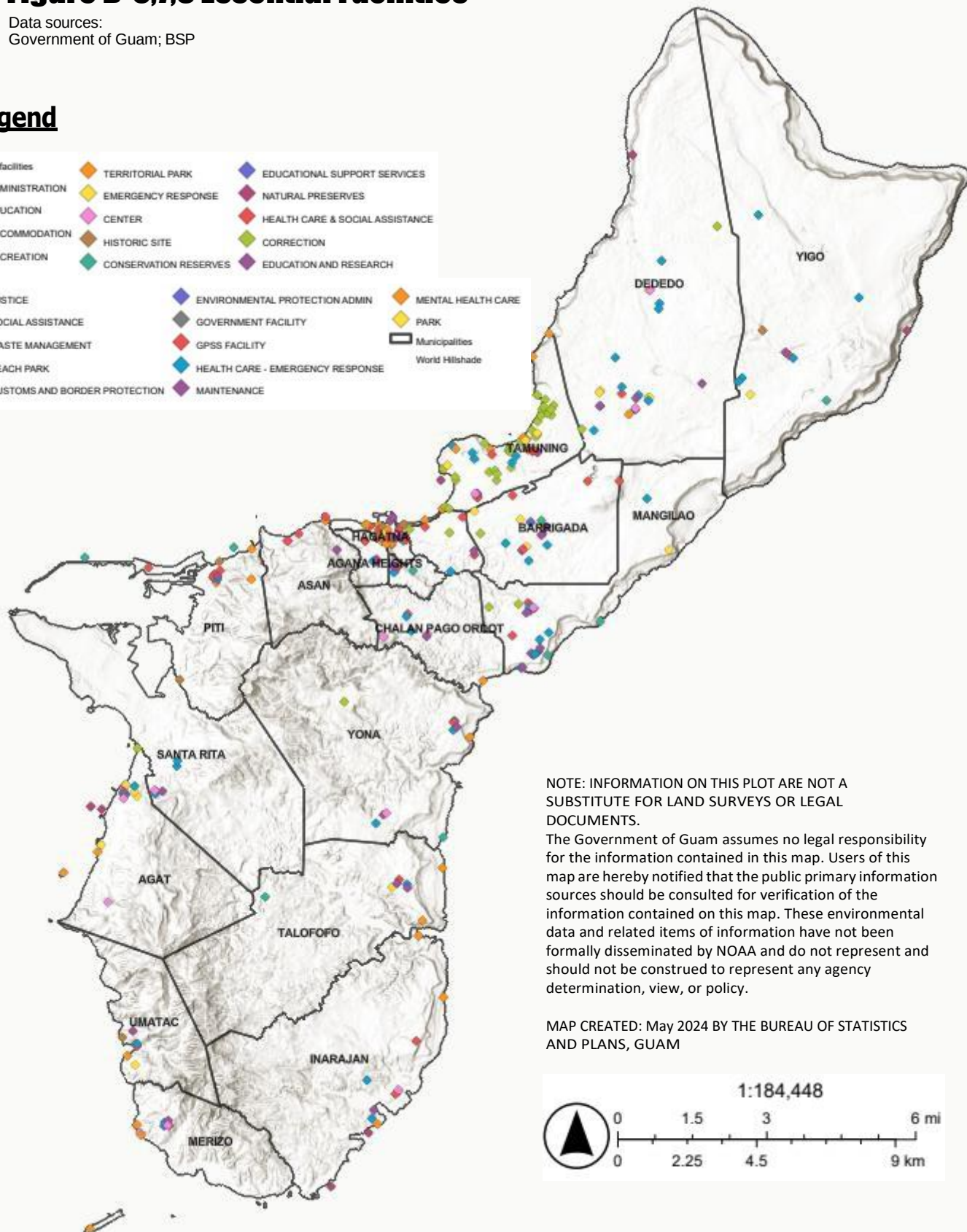


Data sources:
Government of Guam; BSP

Essential facilities

ADMINISTRATION	TERRITORIAL PARK	EDUCATIONAL SUPPORT SERVICES
EDUCATION	EMERGENCY RESPONSE	NATURAL PRESERVES
ACCOMMODATION	CENTER	HEALTH CARE & SOCIAL ASSISTANCE
RECREATION	HISTORIC SITE	CORRECTION
	CONSERVATION RESERVES	EDUCATION AND RESEARCH

JUSTICE	ENVIRONMENTAL PROTECTION ADMIN	MENTAL HEALTH CARE
SOCIAL ASSISTANCE	GOVERNMENT FACILITY	PARK
WASTE MANAGEMENT	GPSS FACILITY	Municipalities
BEACH PARK	HEALTH CARE - EMERGENCY RESPONSE	World Hiltshade
CUSTOMS AND BORDER PROTECTION	MAINTENANCE	



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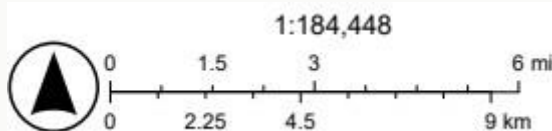


Figure D-9 – Major utilities: Electric Power Facilities

Source: Guam Power Authority

Legend

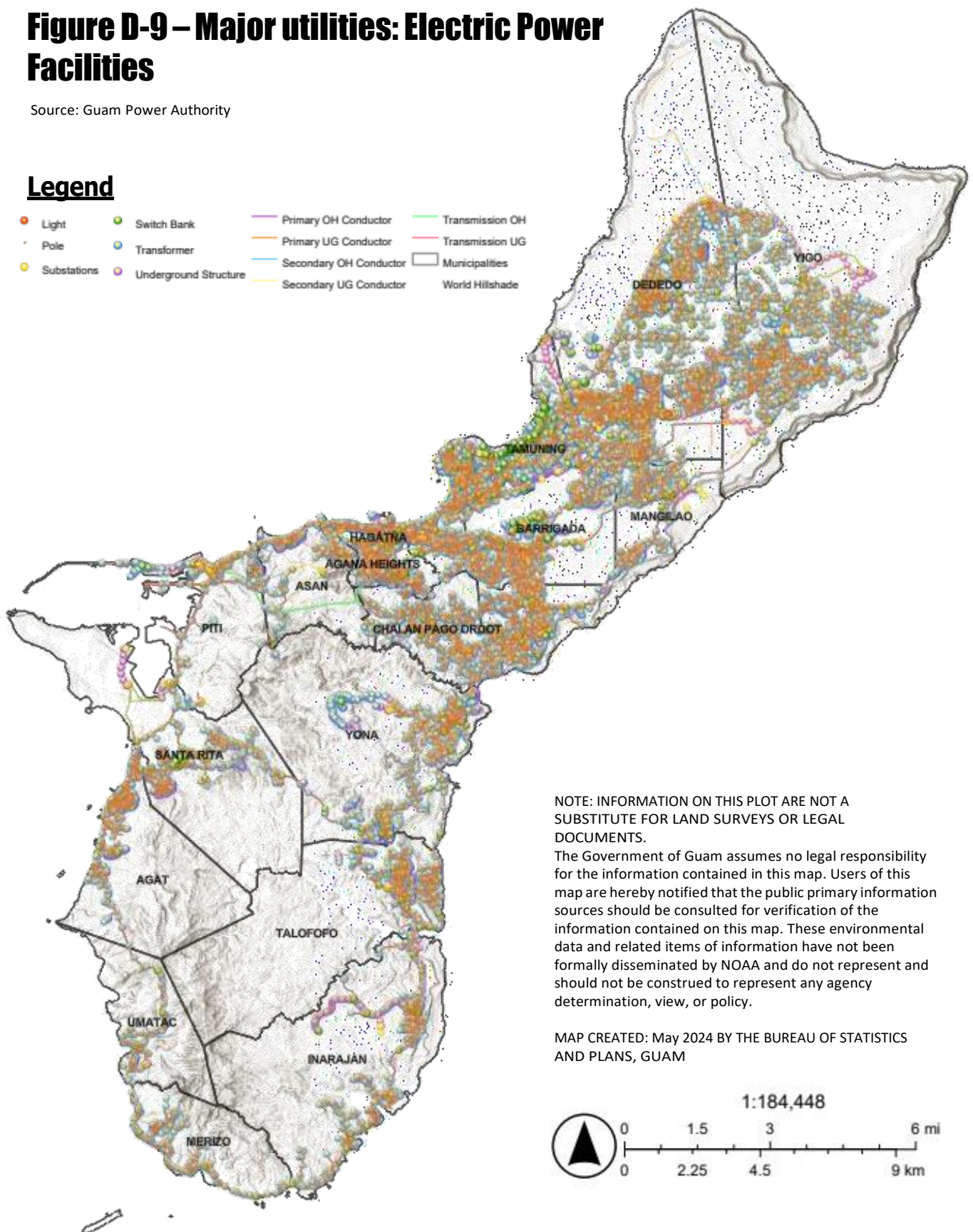
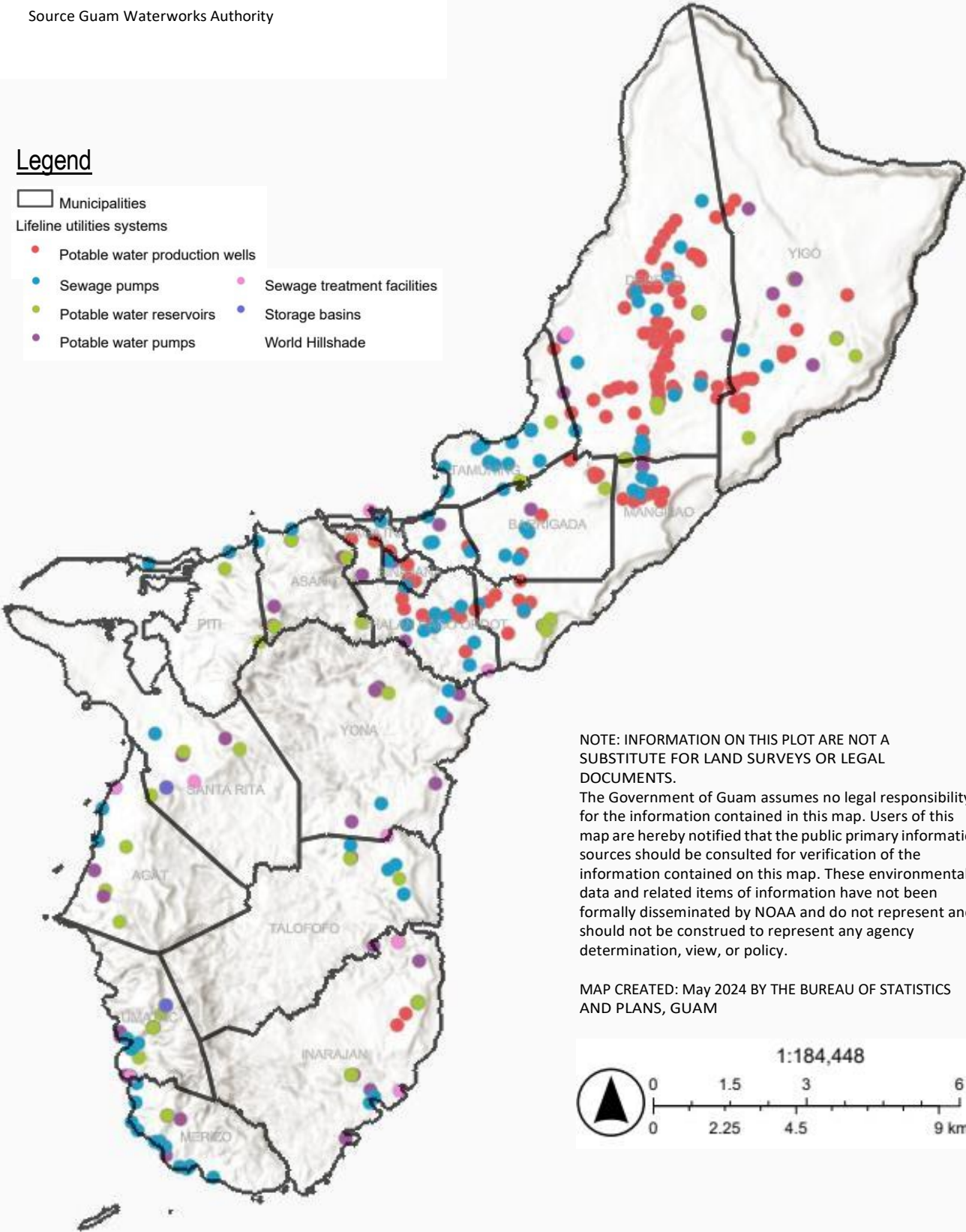


Figure D-10 – Major utilities: Potable Water and Wastewater Facilities

Source Guam Waterworks Authority

Legend

- Municipalities
- Lifeline utilities systems
- Potable water production wells
- Sewage pumps
- Potable water reservoirs
- Potable water pumps
- Sewage treatment facilities
- Storage basins
- World Hillshade



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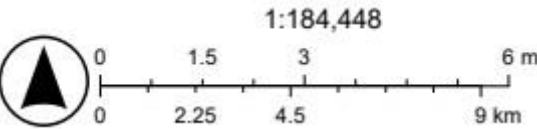


Figure D- 11 Transportation Systems

Data sources:
Government of Guam; BSP

Legend

- Transportation systems
-  Port Facilities

 Roads

 Municipal Airport

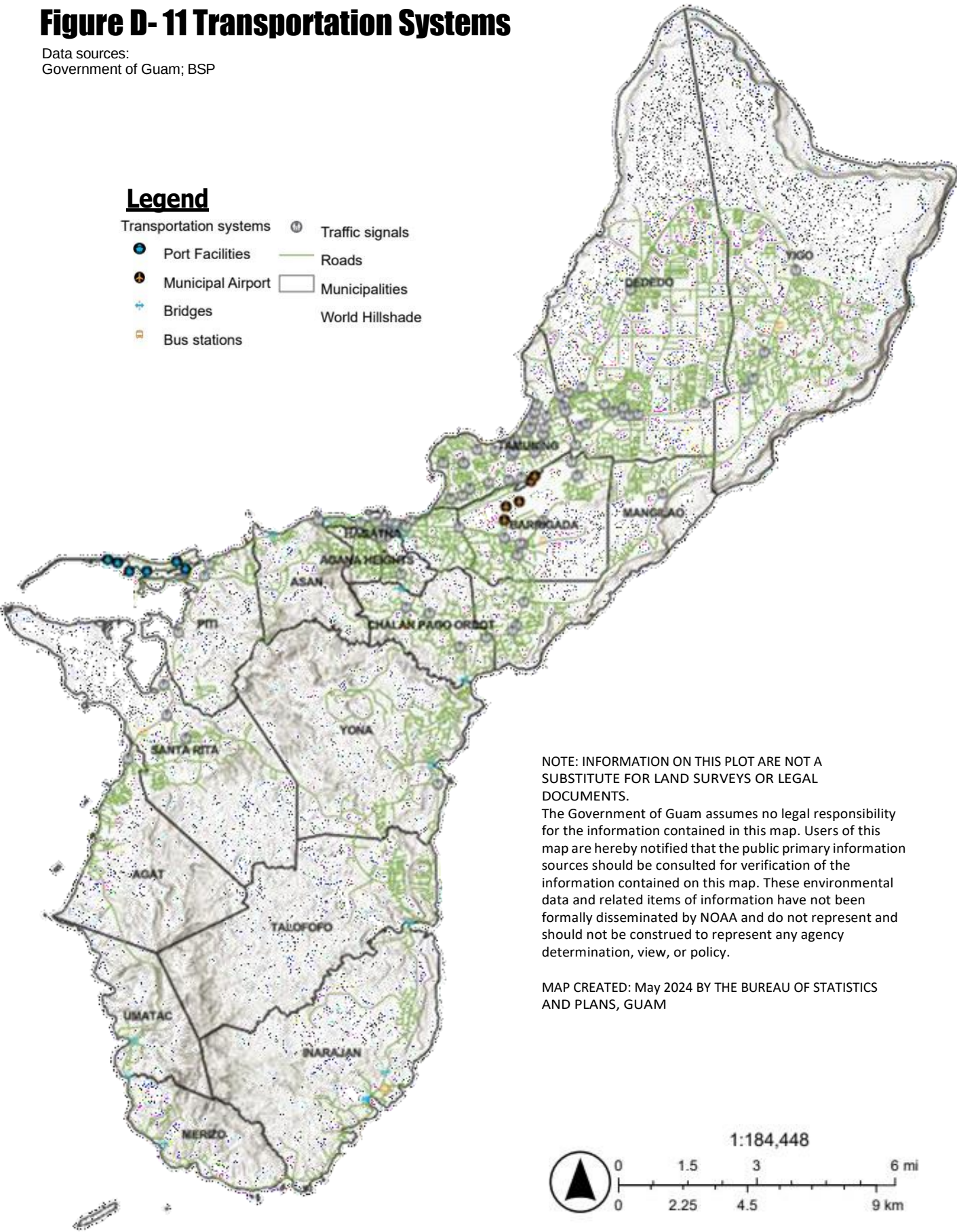
 Municipalities

 Bridges

 Bus stations

 Traffic signals

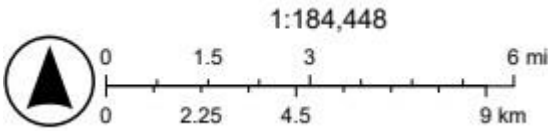
 World Hillshade



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Data sources: NOAA 2020 High Resolution Lidar, BSP Building Footprint Extraction

Legend

7

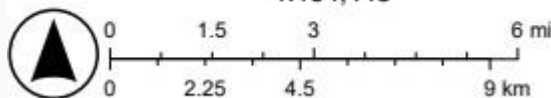


Figure D-13 – Fault Susceptibility

Data sources: Government of Guam; USGS; NOAA; USDA Forest Service; University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

Note:

To account for the uncertainty in the location of surface fault traces and the width of the deformation zone, the zones that are considered to have a potentially high surface faulting hazard encompass a 0.18-mile radial buffer (984.25 feet.) surrounding the faults

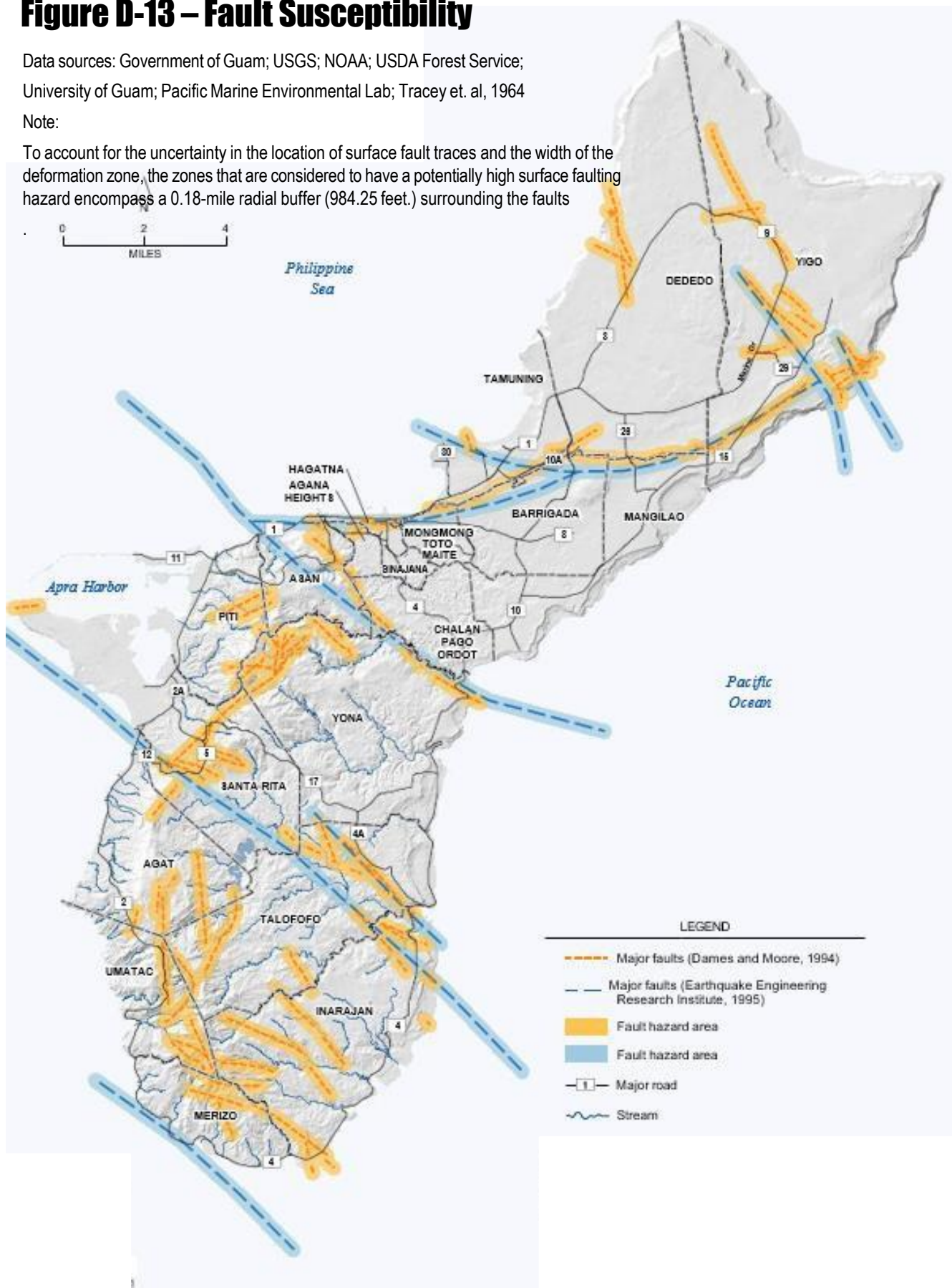


Figure D-14 Liquefaction hazard area

Data sources: Data sources: Government of Guam; USGS; NOAA; USDA Forest Service; University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

Legend

 Liquefication Hazard

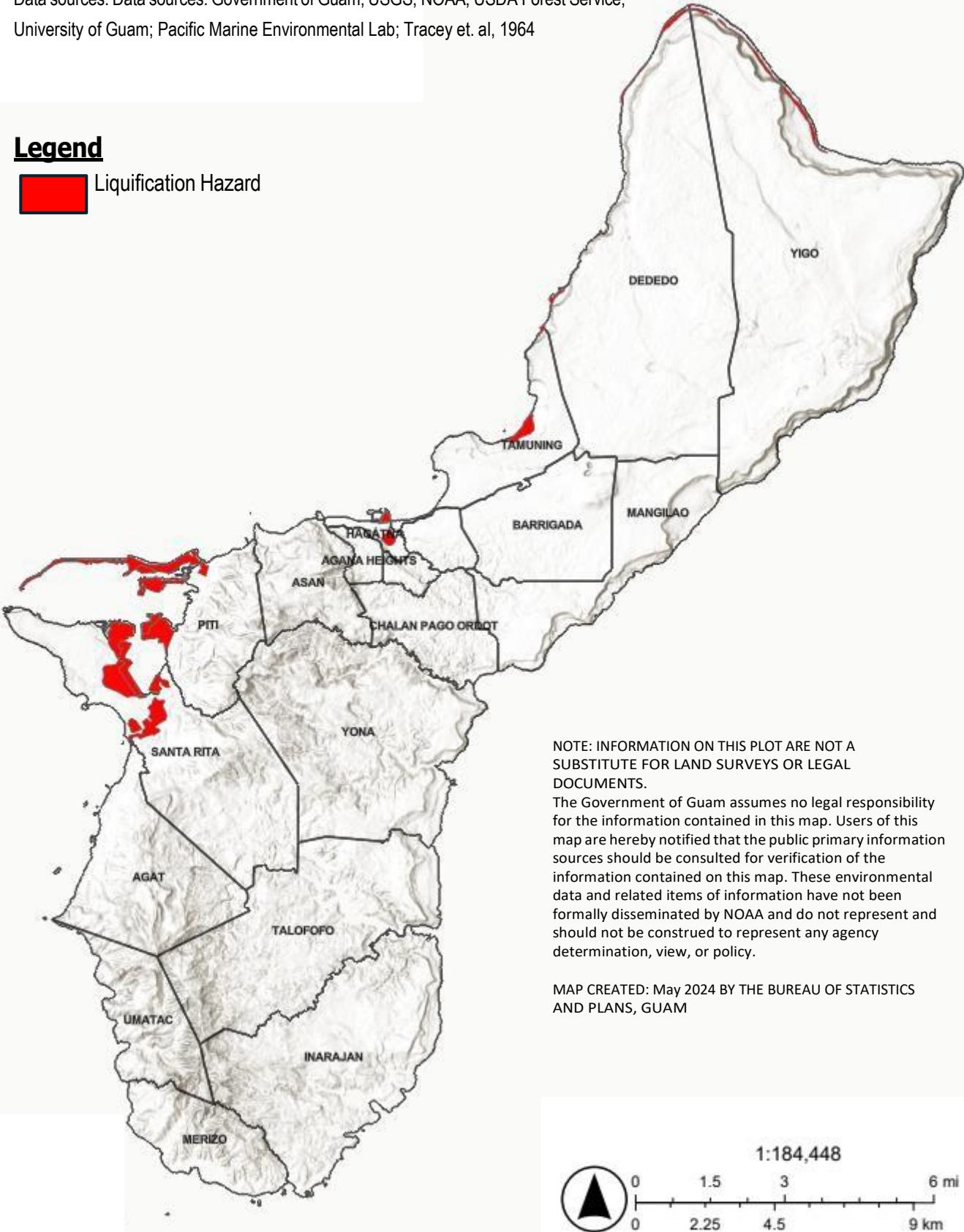


Figure D-15—Local Historical Seismicity, 1900-2024

Source: USGS earthquake.usgs.gov

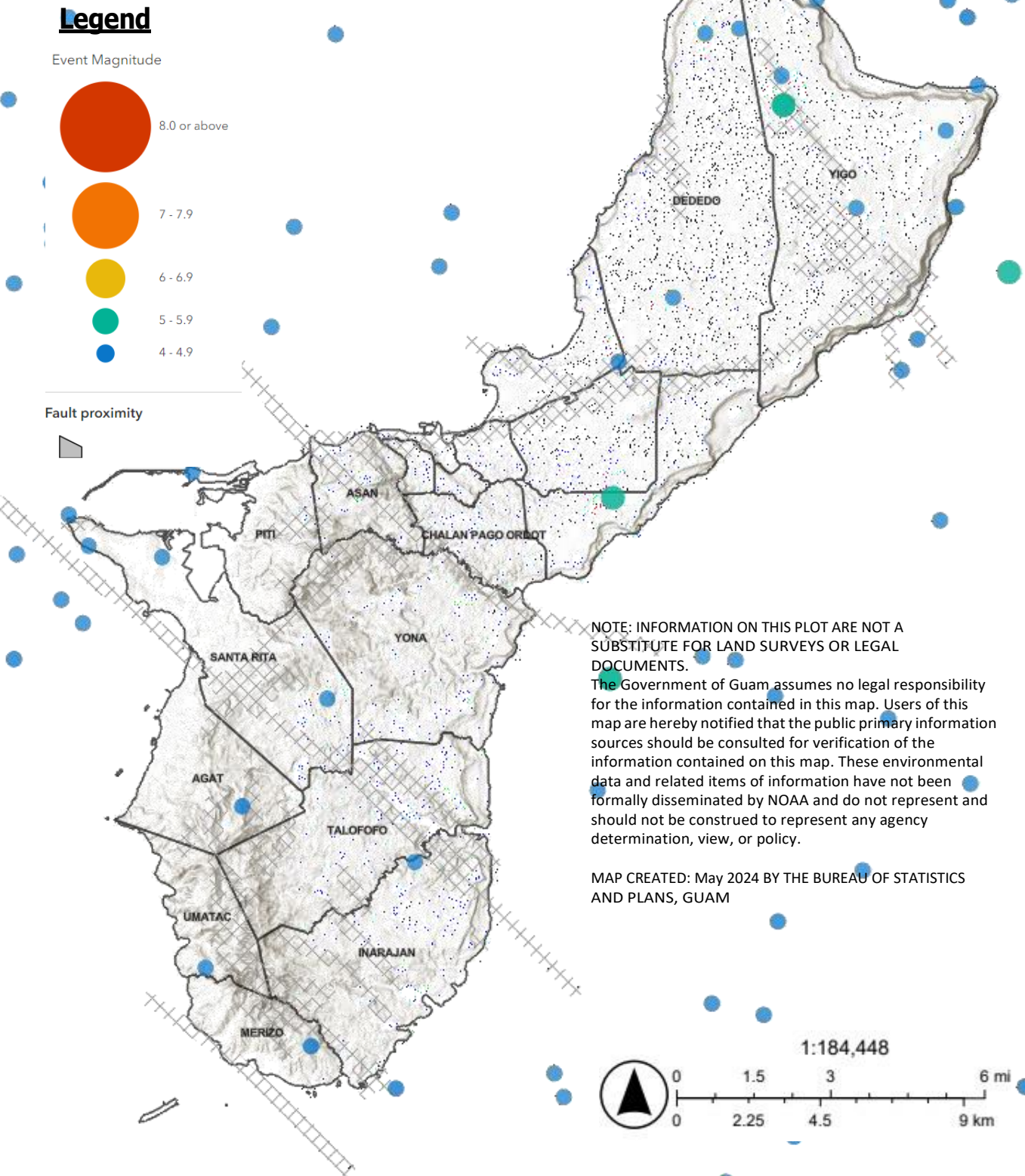


Figure D-16—Regional Historical Seismicity, 1900-2024

Source: USGS earthquake.usgs.gov

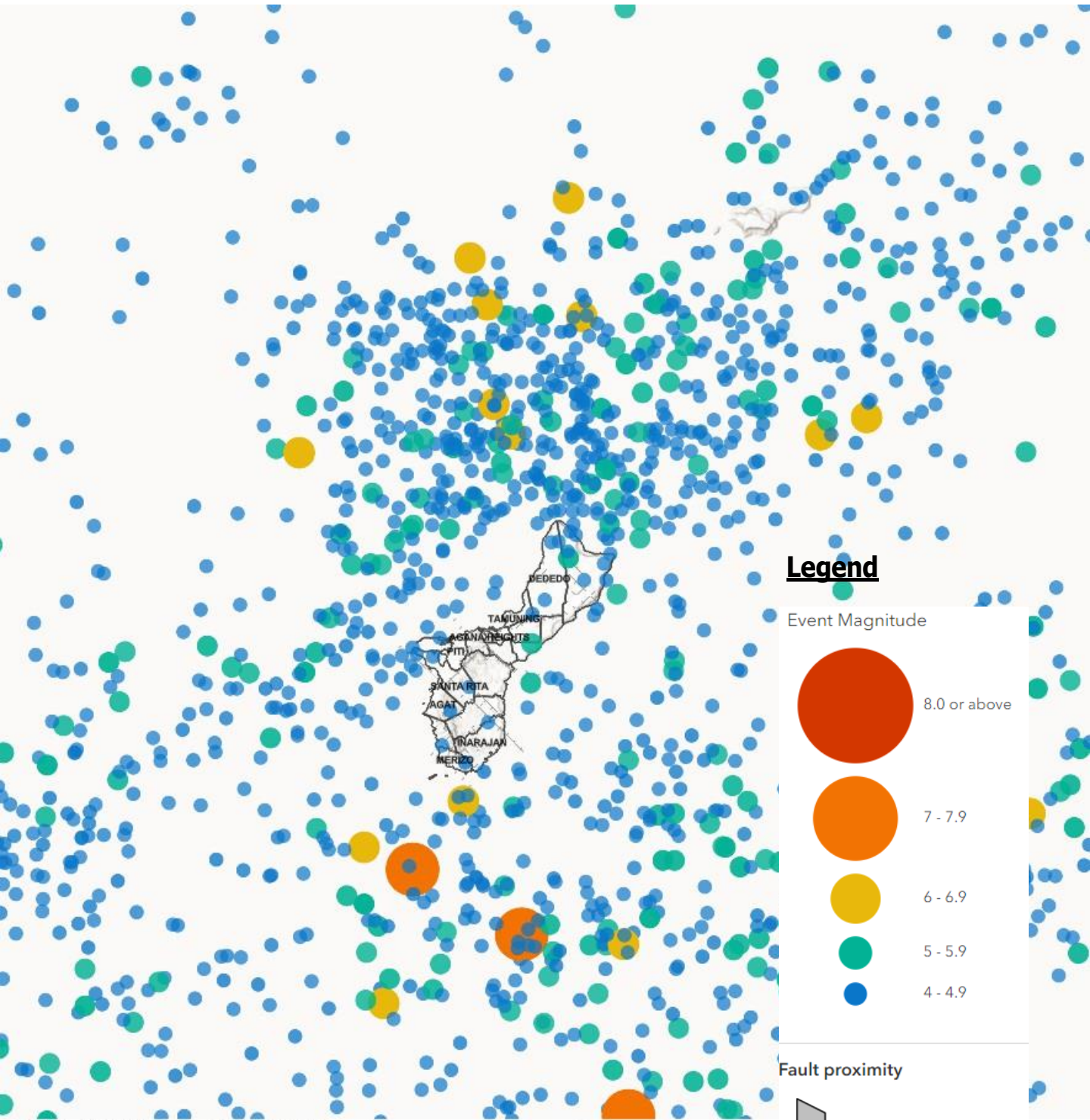
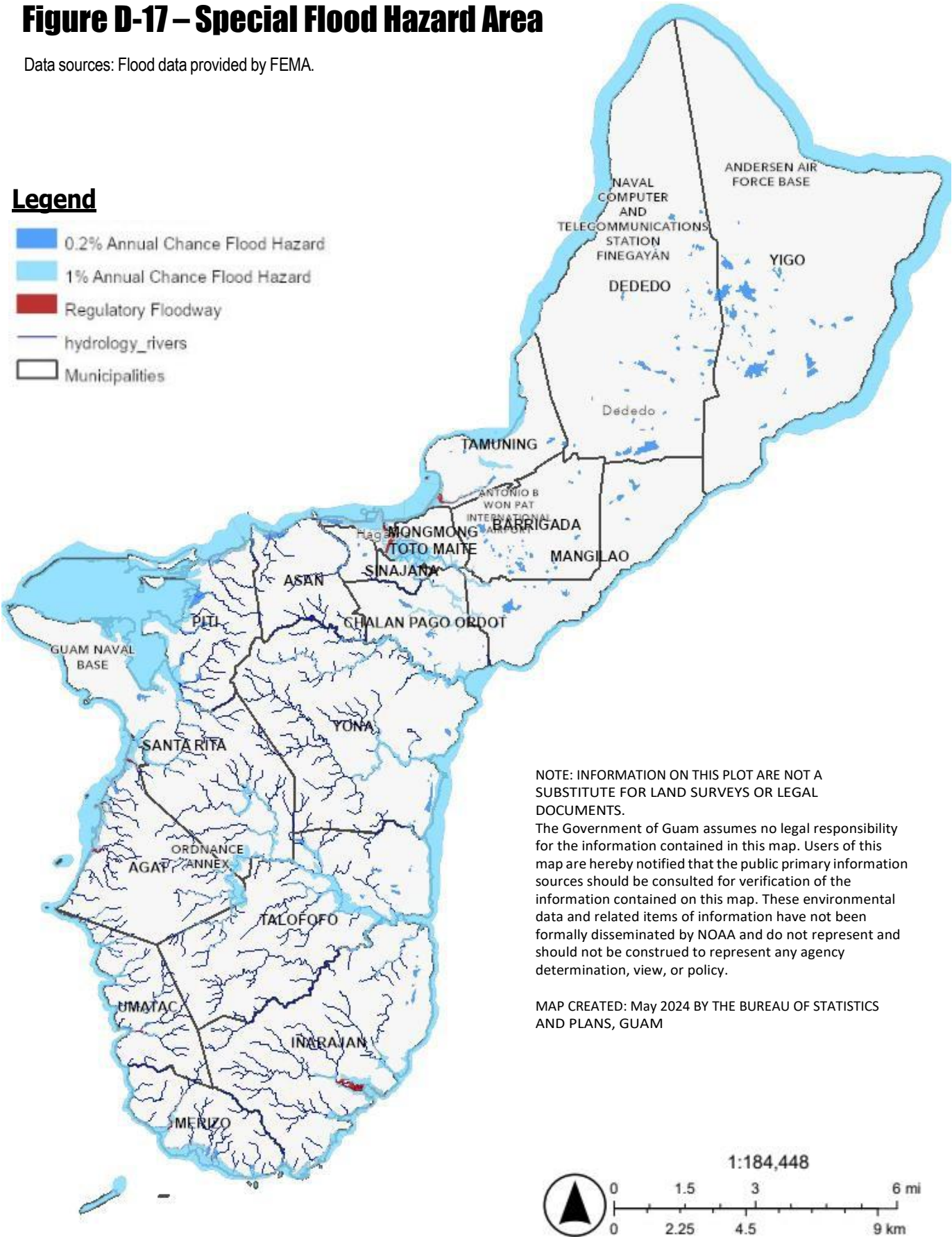


Figure D-17 – Special Flood Hazard Area

Data sources: Flood data provided by FEMA.

Legend

- 0.2% Annual Chance Flood Hazard
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- hydrology_rivers
- Municipalities



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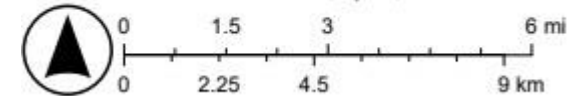
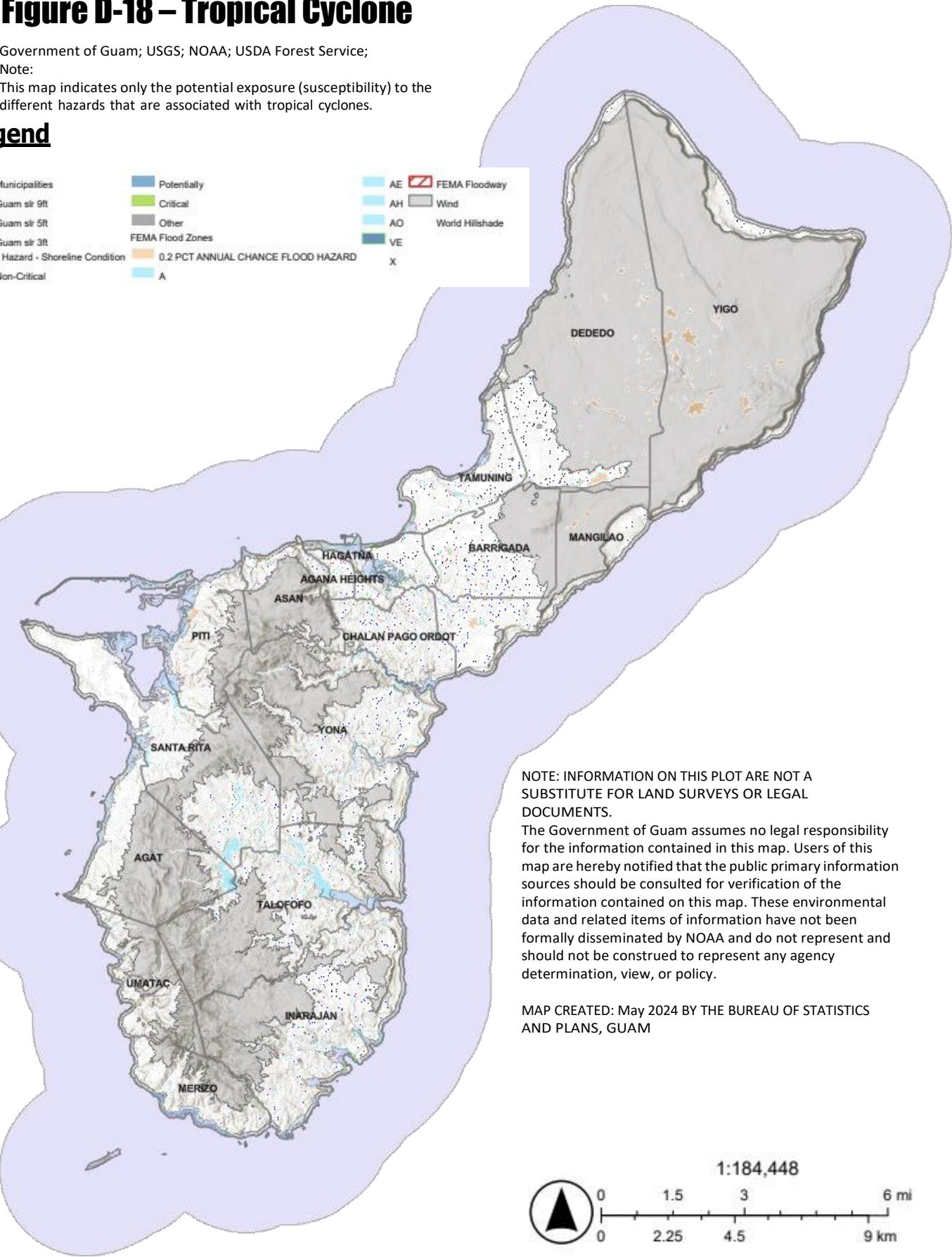


Figure D-18 – Tropical Cyclone

Government of Guam; USGS; NOAA; USDA Forest Service;
Note:
This map indicates only the potential exposure (susceptibility) to the different hazards that are associated with tropical cyclones.

Legend



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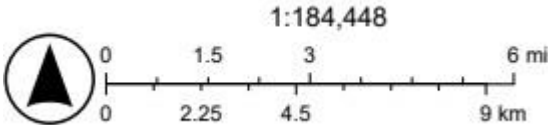


Figure D19 – Social Vulnerability

Data sources: 2020 Decennial Census of Guam US Census Bureau
University of Guam “Calculating the Social Vulnerability Index for Guam” pub: 2021

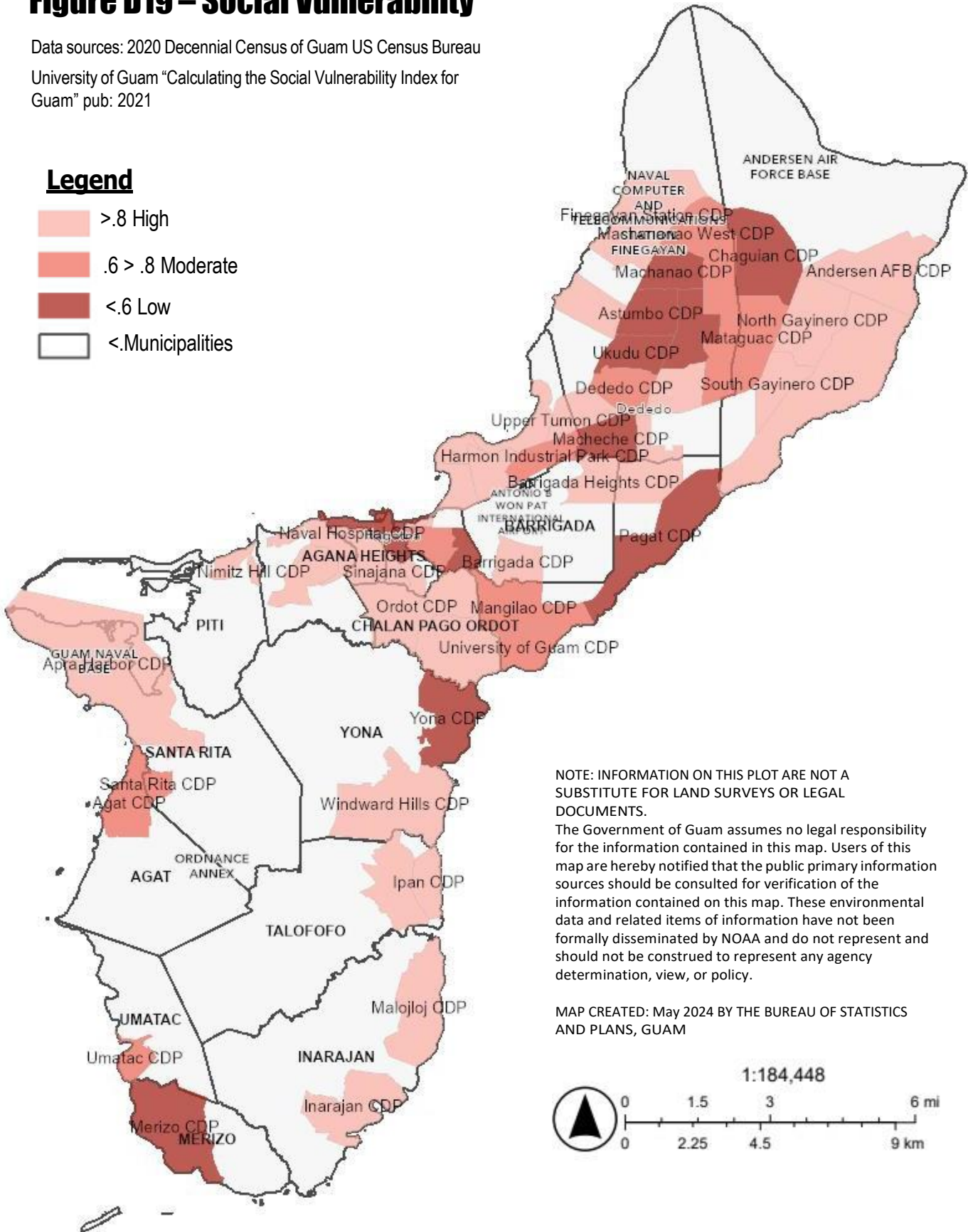


Figure D20 – Coral Reefs

Data sources: NOAA, Government of Guam BSP

Legend

- Marine protected areas

Benthic habitat (detailed)

Aggregate Reef, Coral 10%<50%

Aggregate Reef, Coral 50%<90%

Pavement, Coral 50%<90%

Rubble, Coral 10%<50%

Scattered Coral/Rock, Coral 10%<50%

Spur and Groove, Coral 10%<50%
- Aggregated Patch Reef, Coral 50%<90%

Individual Patch Reef, Coral 10%<50%

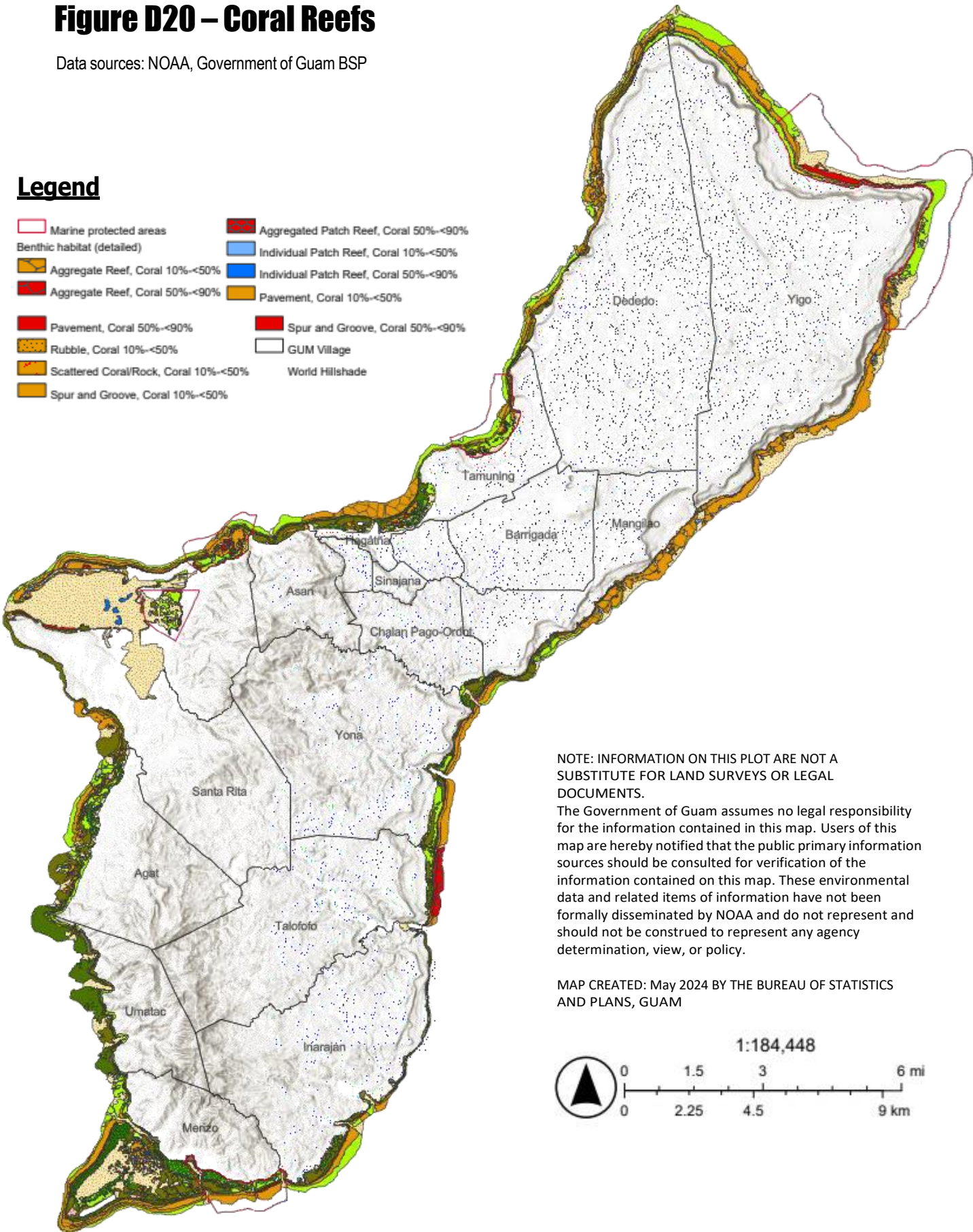
Individual Patch Reef, Coral 50%<90%

Pavement, Coral 10%<50%

Spur and Groove, Coral 50%<90%

GUM Village

World Hillshade



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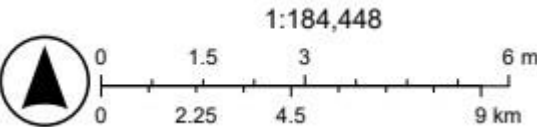


Figure D-22 – Severe Wind

Government of Guam; USGS; NOAA; USDA Forest Service;
University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964
Note:

This map indicates only the potential exposure (susceptibility) to the hazard, but does not indicate the probability or magnitude of specific hazard events. This is a generalized description for areas that are naturally more susceptible to severe winds.

Legend



Potential high wind susceptibility:
100-foot buffer inland from shoreline
and all areas with ground elevations
greater than 300 feet.

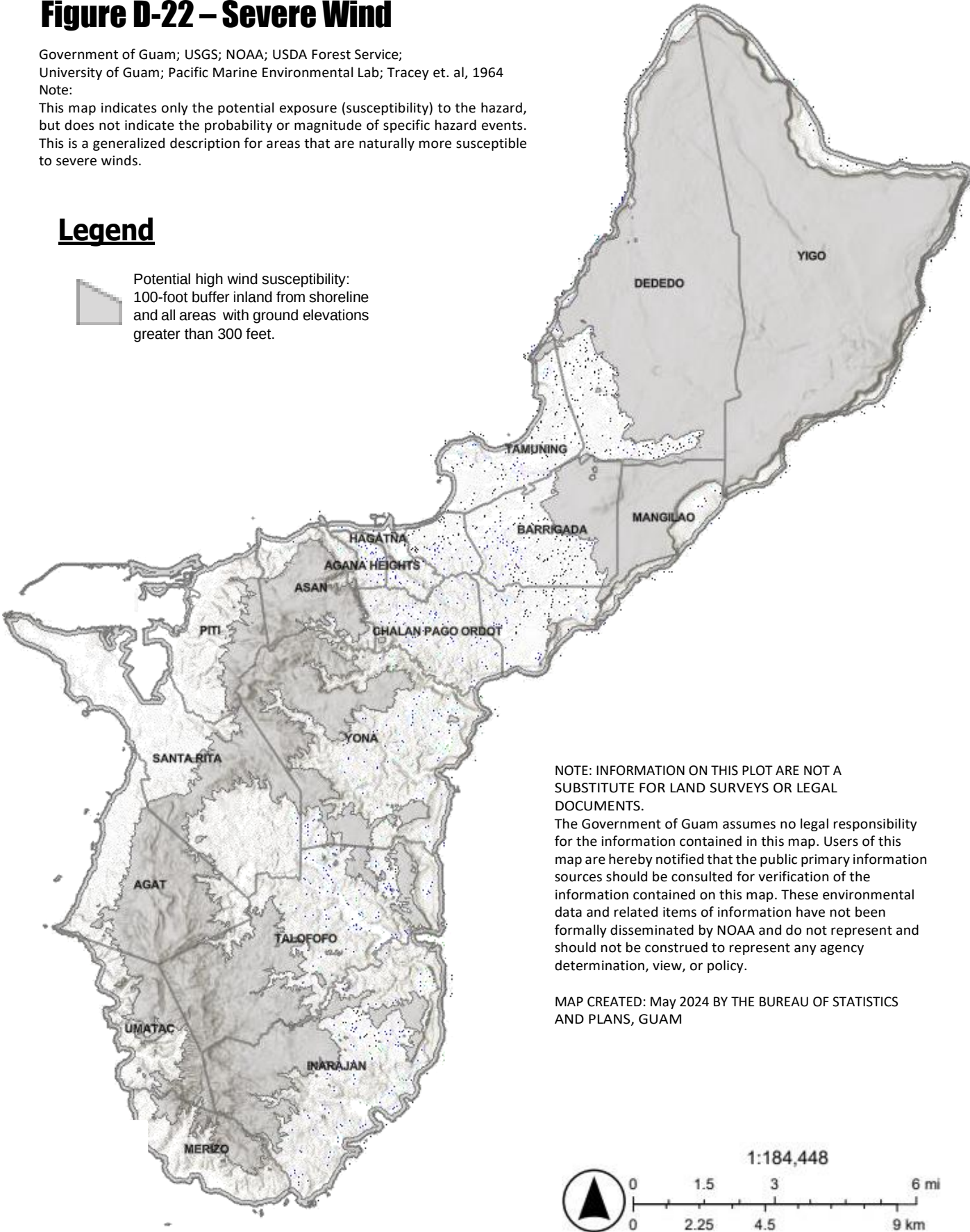


Figure D-23 – Landslide / Slope Failure

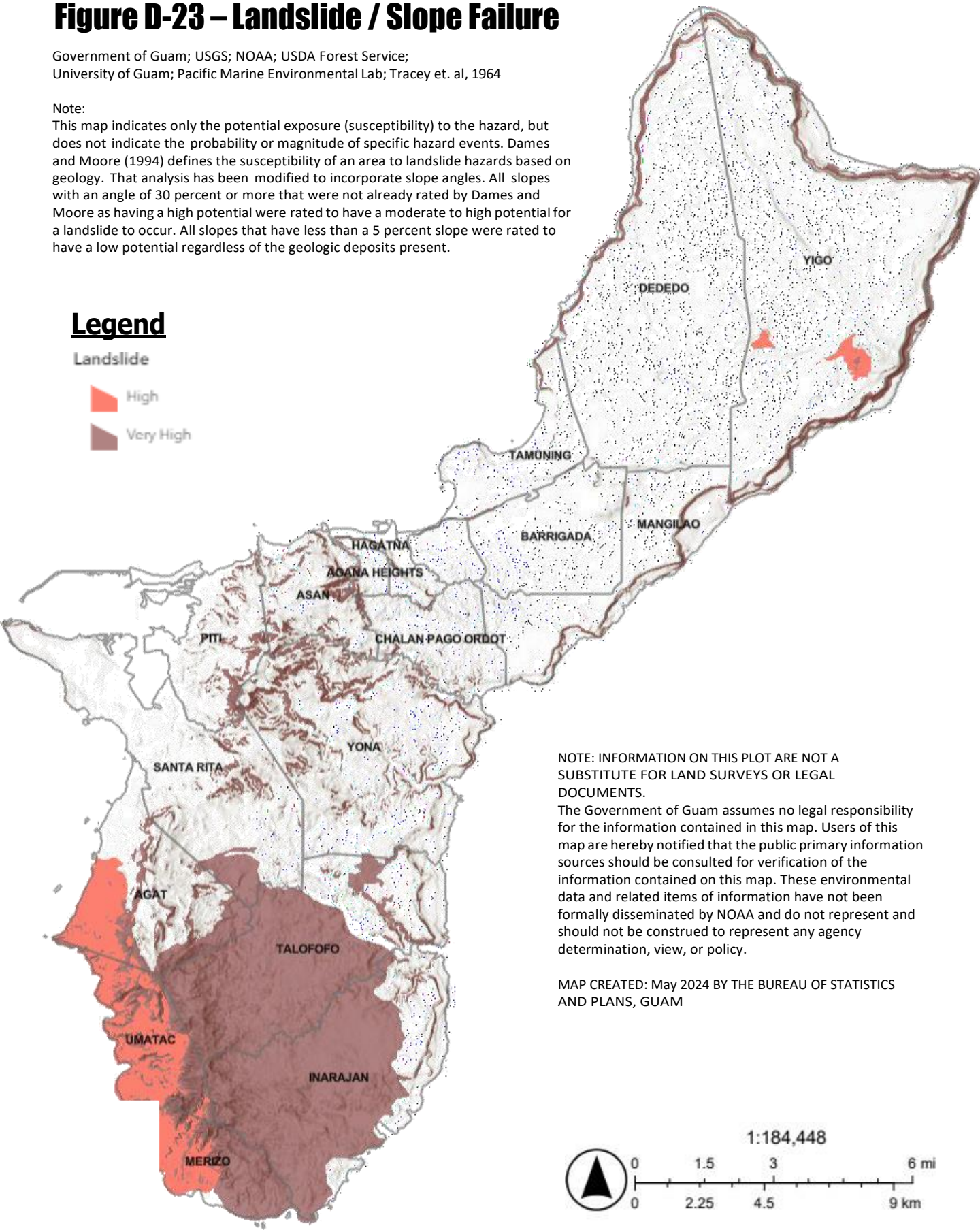
Government of Guam; USGS; NOAA; USDA Forest Service;
University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

Note:
This map indicates only the potential exposure (susceptibility) to the hazard, but does not indicate the probability or magnitude of specific hazard events. Dames and Moore (1994) defines the susceptibility of an area to landslide hazards based on geology. That analysis has been modified to incorporate slope angles. All slopes with an angle of 30 percent or more that were not already rated by Dames and Moore as having a high potential were rated to have a moderate to high potential for a landslide to occur. All slopes that have less than a 5 percent slope were rated to have a low potential regardless of the geologic deposits present.

Legend

Landslide

- High
- Very High



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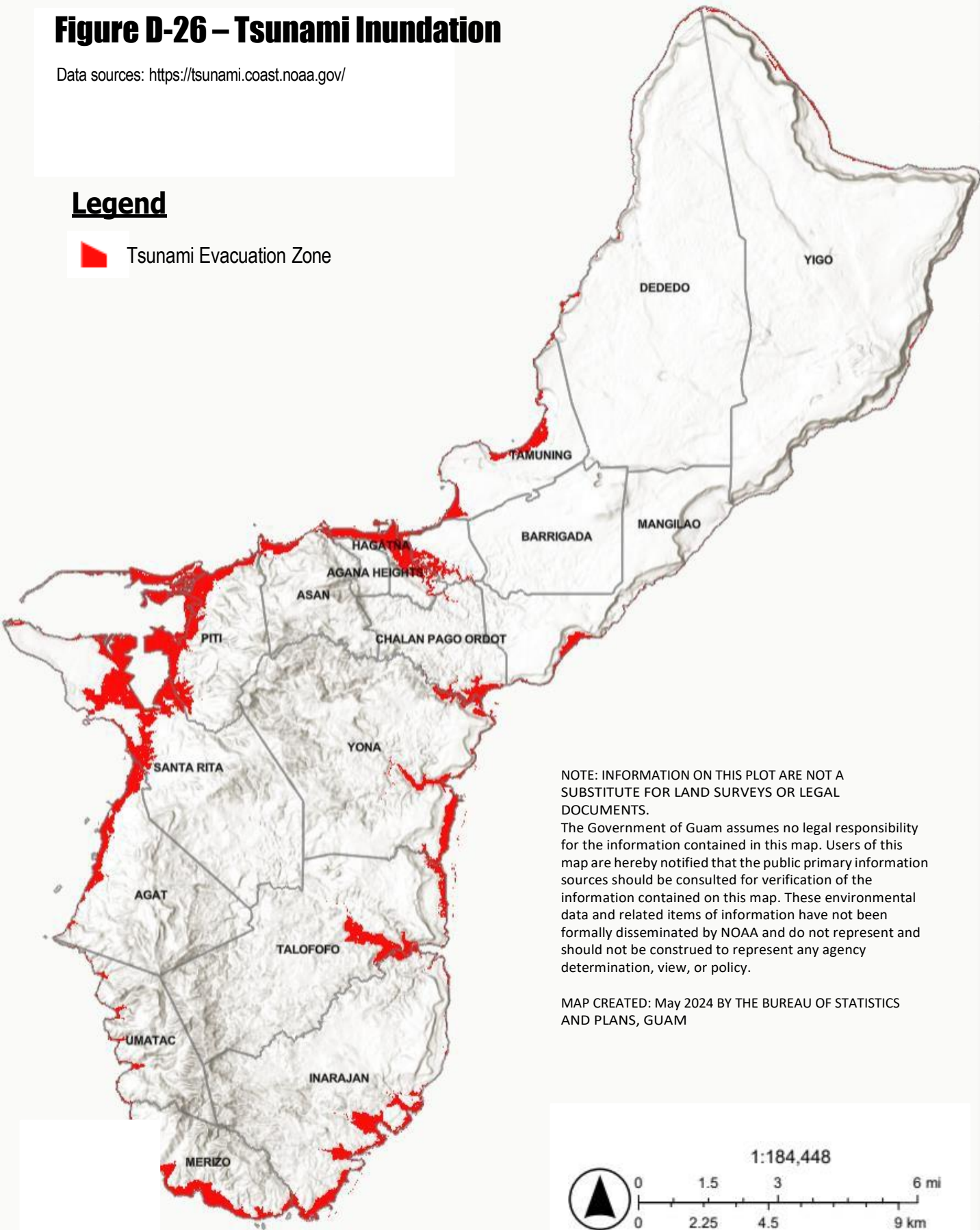
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Figure D-26 – Tsunami Inundation

Data sources: <https://tsunami.coast.noaa.gov/>

Legend

 Tsunami Evacuation Zone



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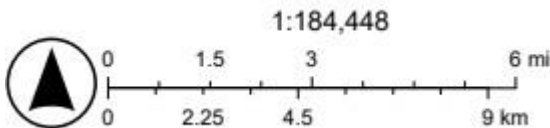


Figure D-27 – Wildland fire hazard area

Data Source: Government of Guam; USGS; NOAA; USDA Forest Service; University of Guam; Pacific Marine Environmental Lab; Tracey et. al, 1964

Note:

This map indicates only the potential exposure (susceptibility) to the hazard, but does not indicate the probability or magnitude of specific hazard events. Wildland fire severity is based on three combined considerations:

- 1) Critical fire-weather frequency (2 to 7 days/yr for the island of Guam)
- 2) Slope % (<40, 41-60, or >61)
- 3) Fuel classification

Legend



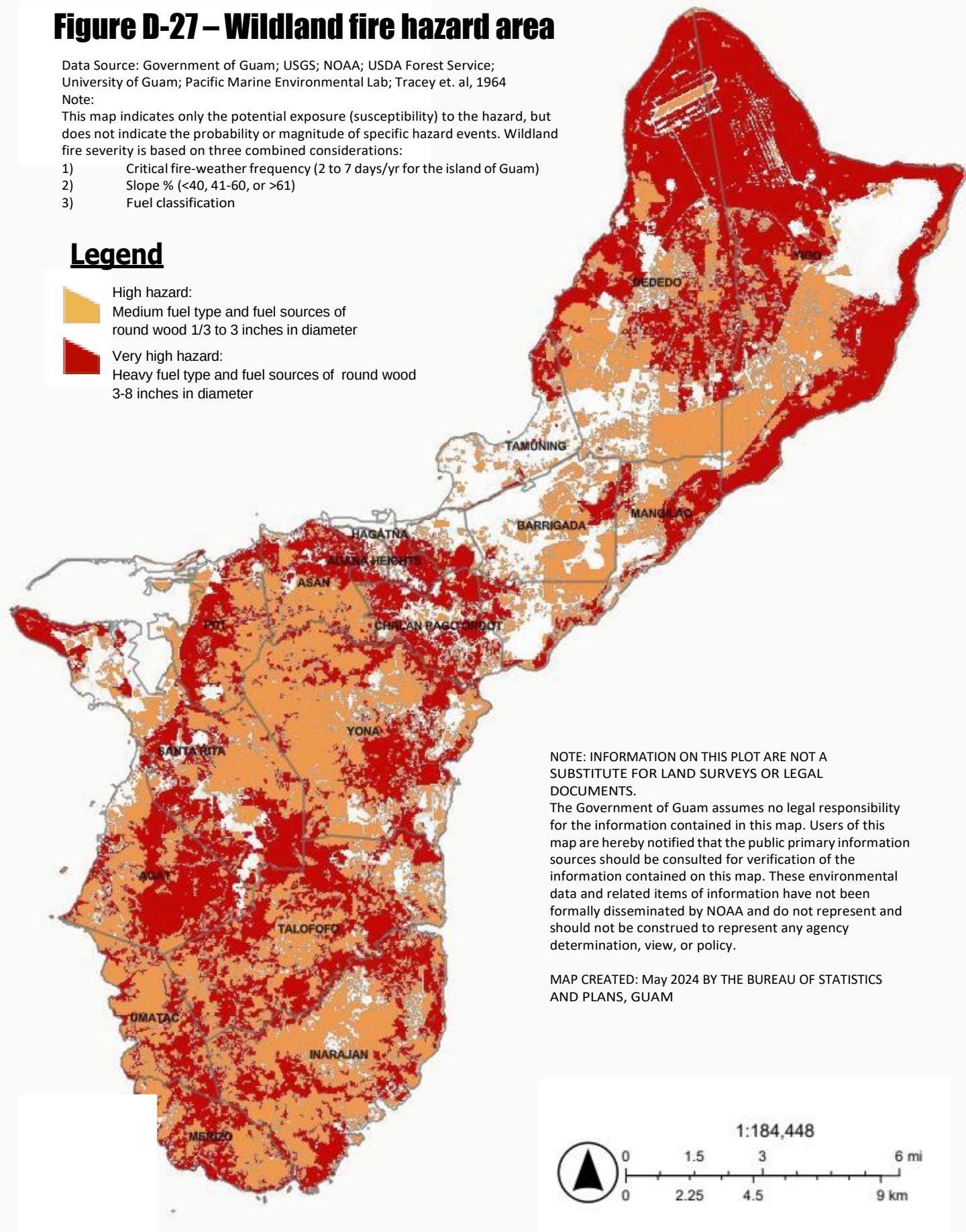
High hazard:

Medium fuel type and fuel sources of round wood 1/3 to 3 inches in diameter



Very high hazard:

Heavy fuel type and fuel sources of round wood 3-8 inches in diameter



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Figure D-27 – Wildland Fires 2015-2023

Data Source: Institute of Pacific Islands Forestry (IPIF), USDA Forest Service.

Legend

- GUM Village

Guam_Fires_2020

Guam_Fires_2017

Guam_Fires_2022

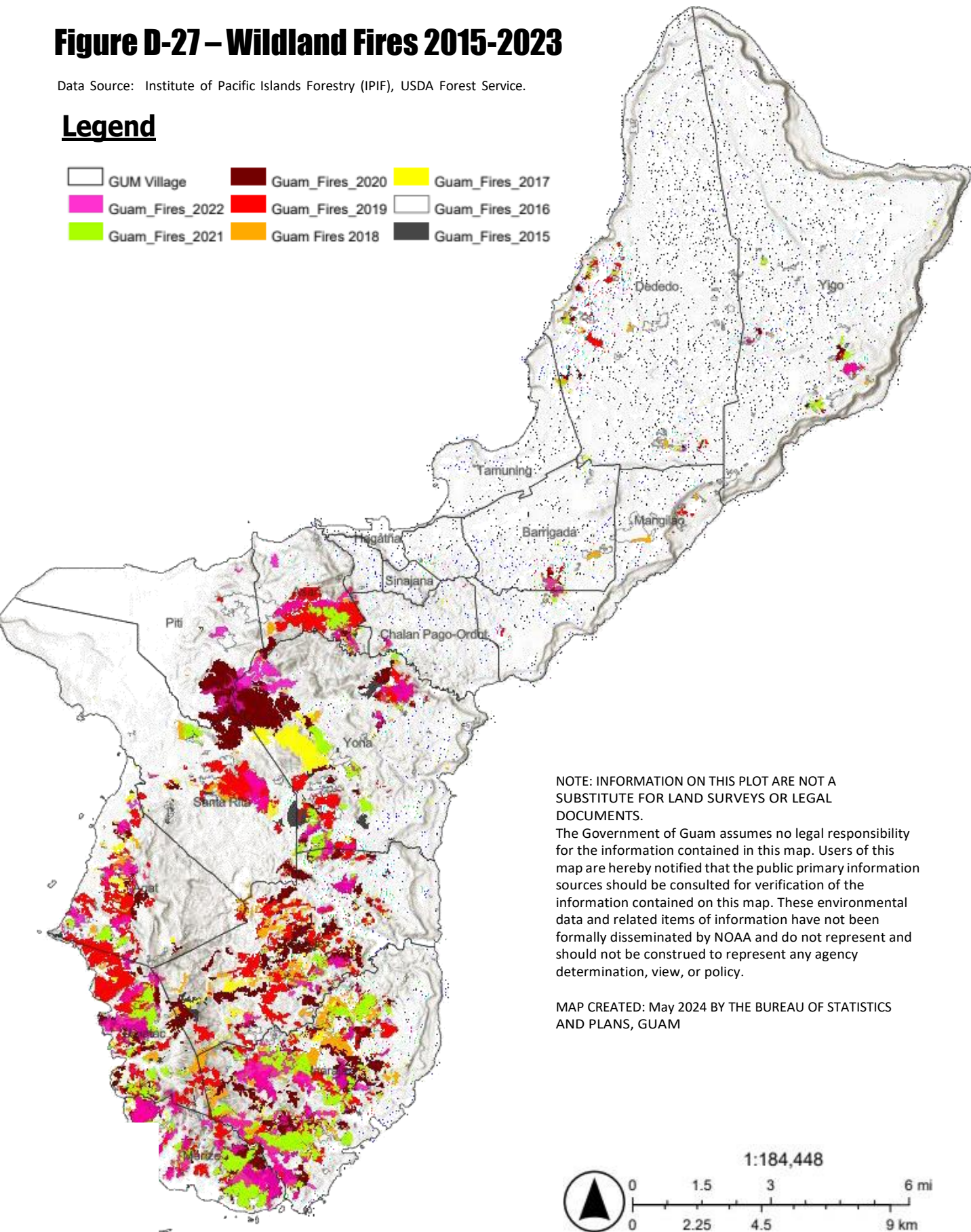
Guam_Fires_2019

Guam_Fires_2016

Guam_Fires_2021

Guam_Fires_2018

Guam_Fires_2015



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**APPENDIX E – ESSENTIAL FACILITIES, MAJOR UTILITIES,
AND TRANSPORTATION SYSTEMS**

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Table E-1. Essential Facilities

Category	Facility Name	Village
Fire Stations	Agat New Fire Rescue Station	Agat
	Agat Fire Station #5	Agat
	Agat Harbor Fire Rescue	Agat
	Barrigada Fire Station #3	Barrigada
	911 Fire Dispatch	Barrigada
	Fire Rescue Base #1	Barrigada
	Guam International Airport, Aircraft Fire Rescue Station	Barrigada
	Astumbo Fire Station #12	Dededo
	Dededo Fire Station #4	Dededo
	Inarajan Fire Station #6	Inarajan
	Piti Fire Station #7	Piti
	Sinajana Fire #2	Sinajana
	Talofofo Fire Station #11	Talofofo
	Tamuning/Tumon Fire Station #1	Tamuning/Tumon
	Umatac Fire Station #8	Umatac
	Yigo Fire Station #10	Yigo
	Yona Fire Station #9	Yona
Police Stations	Agat Police Precinct Command	Agat
	Southern Police Precinct Command	Agat
	Agat Senior Citizen Center	Agat
	Dededo Police Precinct Command	Dededo
	Dededo Senior Citizen Center	Dededo
	Astumbo Senior Citizen Center	Dededo
	Hagatna Police Precinct Command	Hagatna

Table E-1. Essential Facilities

Category	Facility Name	Village
Police Stations (cont'd.)	Tamuning/Tumon Police Koban	Tamuning/Tumon
	Tumon Police Koban	Tamuning/Tumon
	Tumon/Tamuning/Tumon Precinct Command	Tamuning/Tumon
	Guam Police Department Headquarters	Mongmong-Toto-Maite
Senior Centers	Agana Heights Senior Citizens Center*	Agana Heights
	Agat Senior Citizens Center*	Astumbo, Dededo
	Astumbo Senior Citizens Center*	Agat
	Dededo Senior Citizens Center*	Dededo
	The Adult Day Care*	Dededo
	Inarajan Senior Citizens Center	Inarajan
	Mangilao Senior Citizens Center	Mangilao
	Merizo Senior Citizens Center	Merizo
	Santa Rita Senior Citizens Center	Santa Rita
	Sinajana Senior Citizens Center*	Sinajana
	Tamuning/Tumon Senior Citizens Center	Tamuning/Tumon
	GUMA Trankilidat Senior Citizens Home	Tamuning/Tumon
	Yigo Senior Citizens Center*	Yigo
	Yona Senior Citizens Center	Yona
Community Centers	Agana Heights Community Center	Agana Heights
	Agat Community Center	Agat
	Asan Community Center	Asan
	Barrigada Community Center	Barrigada
	Chalan Pago Community Center	Chalan Pago
	Dededo Community Center	Dededo

Table E-1. Essential Facilities

Category	Facility Name	Village
	Lagu Resource Center (Youth Center)	Dededo
	Mangilao Community Center	Mangilao
	Merizo Community Center	Merizo
	Merizo Youth Center	Merizo
	Mongmong-Toto-Maite Community Center	Mongmong-Toto-Maite
Community Centers (cont'd.)	Santa Rita Community Center	Santa Rita
	Sinajana Community Center	Sinajana
	Tamuning/Tumon Community Center	Tamuning/Tumon
	Yona Community Center	Yona
Historic Sites	Padre Palomo Historic Site	Hagatna
	Plaza De Espana Historic Site	Hagatna
	San Antonio Historic Bridge	Hagatna
	Fort Santa Agueda Historic Site	Hagatna
	Government Hill	Hagatna
	Japanese Historic Cave	Hagatna
	Latte Stone Historic Park	Hagatna
	Atantano Historic Shrine	Piti
	Fort San Jose	Umatac
	Umatac Bay Historic Park	Umatac
	San Dionisio Historic Church Ruins	Umatac
	South Pacific Memorial Park	Yigo
Cemeteries and Burial Grounds	Naval Memorial Cemetery Park	Hagatna
	Inarajan Public Burial Ground	Inarajan
	Merizo Public Burial Ground	Merizo

Table E-1. Essential Facilities

Category	Facility Name	Village
	Guam Veterans Burial Ground	Piti
	Vicente A. Limtiaco Public Burial Ground	Piti
Parks, Preserves, and Beaches	Anae Island Territorial Park	Agat
	Nimitz Territorial Beach Park	Agat
	Hill 40	Agat
	Alutom Natural Preserve Island	Agat
	Yona Natural Preserve Island	Agat
	Agat Marina*	Agat
	Nimitz House	Asan
	Barrigada War Memorial Park	Barrigada
	Francisco Perez Beach Park	Chalan Pago-Ordot
	Central Park	Dededo
	Falcona Natural Preserve Beach	Dededo
	Buffer Territorial Strip Park	Dededo
	Agana Wetlands Park	Hagatna
	East Agana Beach	Hagatna
	West Agana Territorial Beach Park	Hagatna
	Skinner Plaza Territorial Park	Hagatna
	San Roman Hill Hilltriangle Park	Hagatna
	Adelup Territorial Park	Hagatna
	Marine Drive Territorial Strip Park	Hagatna
	Paseo De Susana Territorial Park	Hagatna
	G.D. Perez Marina*	Hagatna
	Saluglula Territorial Pool Park	Inarajan

Table E-1. Essential Facilities

Category	Facility Name	Village
	Talofofo Territorial Beach Park	Inarajan
	Asgon Natural Preserve Island	Inarajan
Parks, Preserves, and Beaches (cont'd.)	Gef Pago Cultural Village	Inarajan
	Guijen Natural Preserve Island	Inarajan
	Asiga Territorial Beach Park	Inarajan
	Iates Conservation Reserve	Mangilao
	Fadian Point Conservation Reserve	Mangilao
	Taguan Conservation Reserve	Mangilao
	Merizo Seashore Pier Park	Merizo
	Dano Seashore Park	Merizo
	Hoover Park	Piti
	Tepungan Territorial Beach Park	Piti
	Piti Bay Conservation Reserve	Piti
	Pedro Santos Park	Piti
	Luminao Reef Conservation Reserve	Piti
	Agana Spring Conservation Reserve	Sinajana
	Ipan Territorial Beach Park	Talofofo
	Asquiroga Territorial Cave Park	Talofofo
	Tinechong Conservation Reserve	Talofofo
	Chinese Park	Tamuning/Tumon
	Matapang Territorial Beach Park	Tamuning/Tumon
	Aputguan Territorial Beach Park	Tamuning/Tumon
	Puntan Dos Amantes Territorial Park	Tamuning/Tumon
	Tanguisson Territorial Beach Park	Tamuning/Tumon

Table E-1. Essential Facilities

Category	Facility Name	Village
Parks, Preserves, and Beaches (cont'd.)	Governor Joseph Flores-Ypao Territorial Beach Park	Tamuning/Tumon
	Tamuning/Tumon Natural Preserve Lot	Tamuning/Tumon
	Alupat Natural Preserve Island	Tamuning/Tumon
	Fort Nuestra De La Soledad	Umatac
	Fort Santo Angel	Umatac
	Anao Natural Preserve Lot	Yigo
	Lujuna Conservation Reserve	Yigo
	Tagachang Territorial Beach Park	Yona
	Togcha Beach Conservation Reserve	Yona
Recreation Facilities	Agana Heights Baseball Field	Agana Heights
	Agat Baseball Field	Agat
	Agat Small Boat Marina	Agat
	Maina Basketball Courts	Asan
	Tiyan North Softball Field	Barrigada
	Tiyan South Softball Field	Barrigada
	Tiyan Tennis Courts	Barrigada
	Adam William Leahy Sports Complex	Barrigada
	Jose Atoigue Baseball Field	Chalan Pago Ordot
	Dededo Robbie Webber Soccer Field	Dededo
	Dededo Baseball Field – Liguan	Dededo
	Dededo Baseball Field – Village	Dededo
	Dededo Baseball Field – Paradise Estate	Dededo

Table E-1. Essential Facilities

Category	Facility Name	Village
Recreation Facilities (cont'd.)	Wettengel Football Field	Dededo
	Guam Major League Baseball Field	Hagatna
	Jose Guerrero Baseball Field	Hagatna
	Hagatna Swimming Pool	Hagatna
	Hagatna Tennis Court	Hagatna
	Gregorio Periz Marina	Hagatna
	Inarajan Baseball Field	Inarajan
	Old Mangilao Baseball Field	Mangilao
	Mangilao Mayors Baseball Field	Mangilao
	George Washington Football and Track Field	Mangilao
	University of Guam Tennis Courts	Mangilao
	Soccer and Baseball Field	Mangilao
	Merizo Baseball Field	Merizo
	Mongmong-Toto-Maite Baseball Field	Mongmong-Toto-Maite
	Piti Baseball Field	Piti
	Joe Guzman Baseball Field	Santa Rita
	Sinajana Baseball Field	Sinajana
	Talofofo Baseball Field – East	Talofofo
	Talofofo Baseball Field – West	Talofofo
	Tamuning/Tumon Tennis Court	Tamuning/Tumon
	Greyhound Race Track	Tamuning/Tumon
	Tamuning/Tumon Baseball Field and Tennis Courts	Tamuning/Tumon
	Tumon Golf Driving Range	Tamuning/Tumon
	Umatac Baseball Field	Umatac

Table E-1. Essential Facilities

Category	Facility Name	Village
Recreation Facilities (cont'd.)	Yigo Baseball Field	Yigo
	Yona Baseball Field	Yona
	Baza Gardens Baseball Field	Yona
Governor's Complex	Government House	Hagatna
Government of Guam Administration, Agencies, Departments, and Offices	Agat Waste Transfer Station	Agat
	Department of Parks and Recreation Office	Agana Heights
	Department of Revenue and Taxation Office	Barrigada
	Guam Customs and Border Protection Office	Barrigada
	Guam Environmental Protection Agency – Main Office	Barrigada
	Guam Environmental Protection Agency Office	Barrigada
	GEPA Laboratory Offices	Barrigada
	Department of Integrated Services for Individuals with Disabilities Office	Barrigada
	Department of Military Affairs - Guam National Guard	Barrigada
	Guam Public Library System Office	Chalan Pago-Ordot
	Ordot Landfill	Chalan Pago-Ordot
	Commission on Decolonization, Bureau of Budget and Management Research, Bureau of Statistics and Plans, Chamorro Land Trust Commission, and Governor's Community Outreach Federal Programs Offices	Dededo
	Ancestral Lands Commission and Chamorro Land Trust Commission Offices	Dededo
	Guam Housing and Urban Renewal Authority GUMA San Jose Residential Center	Dededo
	Dededo Solid Waste Transfer Station	Dededo
	Department of Public Works Quarry Site	Dededo
	Guam Water Works Laboratory	Dededo
	Emergency Operation Center and Guam Homeland Security/Office of Civil Defense	Hagatna

Table E-1. Essential Facilities

Category	Facility Name	Village
Government of Guam Administration, Agencies, Departments, and Offices (cont'd.)	Chamorro Village	Hagatna
	Public Defender's Office	Hagatna
	Governor Ricardo J. Bordallo Complex	Hagatna
	Guam Fire Department Headquarters	Hagatna
	Public Auditor's Office	Hagatna
	Guam Legislature	Hagatna
	Superior Court of Guam	Hagatna
	Guam Public School System Office	Hagatna
	Office of the Attorney General	Hagatna
	Department of Administration Office	Hagatna
	Department of Labor Office	Hagatna
	Department of Vocational Rehabilitation Office	Hagatna
	Guam Council on the Arts and Humanities Agency Office	Hagatna
	Guam Mass Transit Authority Office	Hagatna
	Adult Correctional Facility	Mangilao
	Youth Correctional Facility	Mangilao
	Department of Public Health and Social Services Office	Mangilao
	Department of Youth Affairs Office	Mangilao
	Department of Agriculture Office	Mangilao
	Guam Developmental Disabilities Council Office	Mangilao
	Government of Guam Retirement Fund Office	Mongmong-Toto-Maite
	General Services Administration Office and Warehouse	Piti
	Port Authority of Guam Office Building	Piti

Table E-1. Essential Facilities

Category	Facility Name	Village
Government of Guam Administration, Agencies, Departments, and Offices (cont'd.)	Port Authority of Guam Security Building	Piti
	Guam Contractors License Board and Department of Public Works Office	Piti
	Guam Energy Office	Piti
	Guam Waterworks Authority Office	Piti
	Guam Public School System Warehouse	Piti
	Guam Housing and Urban Renewal Authority Office	Sinajana
	Guam Economic Development and Commerce Authority Office	Tamuning/Tumon
	Department of Land Management Office	Tamuning/Tumon
	Department of Public Works Compound	Tamuning/Tumon
	Guam Waterworks Authority Office	Tamuning/Tumon
	Pacific Energy Resource Center	Tamuning/Tumon
	Guam Fire Department Fleet Maintenance	Tamuning/Tumon
	Guam Power Authority Office	Tamuning/Tumon
	Guam Board of Accountancy Office	Tamuning/Tumon
	Guam Visitors Bureau Office	Tamuning/Tumon
	Department of Mental Health and Substance Abuse Office	Tamuning/Tumon
	Civil Service Commission Office	Tamuning/Tumon
	Veteran's Affairs Office	Tamuning/Tumon
	Office of the Medical Examiner	Tamuning/Tumon
	Guam Housing Corporation Office	Tamuning/Tumon
	Guam Appeals Board Office	Tamuning/Tumon

Table E-1. Essential Facilities

Category	Facility Name	Village
Libraries	Agat Public Library	Agat
	Barrigada Public Library	Barrigada
	Dededo Public Library	Dededo
	Nieves M. Flores Memorial Public Library	Hagatna
	Guam Territorial Law Library	Hagatna
	University of Guam Robert F. Kennedy Library	Mangilao
	University of Guam Micronesia Area Research Center	Mangilao
	Merizo Public Library	Merizo
	Yona Public Library	Yona
Mayors' Council of Guam	Mayors' Council Office	Hagatna
	Agana Heights Mayor's Office	Agana Heights
	Agat Mayor's Office	Agat
	Asan-Maina Mayor's Office	Asan
	Barrigada Mayor's Office	Barrigada
	Chalan Pago-Ordot Mayor's Office	Chalan Pago-Ordot
	Dededo Mayor's Office	Dededo
	Hagatna Mayor's Office	Hagatna
	Inarajan Mayor's Office	Inarajan
	Mangilao Mayor's Office	Mangilao
	Merizo Mayor's Office	Merizo
	Mongmong-Toto-Maite Mayor's Office	Mongmong-Toto-Maite
	Piti Mayor's Office	Piti
	Santa Rita Mayor's Office	Santa Rita

Table E-1. Essential Facilities

Category	Facility Name	Village
Mayors' Council of Guam (cont'd.)	Sinajana Mayor's Office	Sinajana
	Talofofo Mayor's Office	Talofofo
	Tamuning/Tumon Mayor's Office	Tamuning/Tumon
	Umatac Mayor's Office	Umatac
	Yigo Mayor's Office	Yigo
	Yona Mayor's Office	Yona
Health Care and Clinics	DMHSA Guma Ifil Office	Asan
	GMHA Skill Nursing Unit	Barrigada
	Northern Region Health Center	Dededo
	Inarajan Public Health Center	Inarajan
	Department of Mental Health and Substance Abuse Office	Tamuning/Tumon
Health Care and Clinics	Guam Memorial Hospital	Tamuning/Tumon
Public Schools	Agana Heights Elementary School	Agana Heights
	Oceanview Middle School	Agat
	Marcial Sablan Elementary School	Agat
	P.C. Lujan Elementary School	Barrigada
	L.P. Untalan Middle School	Barrigada
	Carbullido Elementary School	Barrigada
	Agueda Johnston Middle School	Chalan Pago-Ordot
	Ordot Chalan Pago Elementary School	Chalan Pago-Ordot
	Astumbo Middle School	Dededo
	Juan M. Guerrero Elementary School	Dededo
	Finegayan Elementary School	Dededo
	Liguan Elementary School	Dededo

Table E-1. Essential Facilities

Category	Facility Name	Village
Public Schools (cont'd.)	Wettengel Elementary School	Dededo
	Vicente S.A. Benavente Middle School	Dededo
	Maria Ulloa Elementary School	Dededo
	Astumbo Elementary School	Dededo
	Ukudu High School	Dededo
	Inarajan Elementary School	Inarajan
	Inarajan Middle School	Inarajan
	University of Guam Agricultural Experiment Station	Inarajan
	Adacao Elementary School	Mangilao
	George Washington High School	Mangilao
	Price Elementary School	Mangilao
	University of Guam Fieldhouse	Mangilao
	Guam Community College Campus	Mangilao
	University of Guam Marine Lab	Mangilao
	University of Guam Campus	Mangilao
	University of Guam Water and Environmental Research Lab	Mangilao
	Merizo Elementary School	Merizo
	San Miguel Elementary School	Mongmong-Toto-Maite
	Jose L.G. Rios Middle School	Piti
	Harry S. Truman Elementary School	Santa Rita
	Southern High School	Santa Rita
	J.P. Torres Elementary School	Santa Rita

Table E-1. Essential Facilities

Category	Facility Name	Village
Public Schools (cont'd.)	C.L. Taitano Elementary School	Sinajana
	Talofofo Elementary School	Talofofo
	John F. Kennedy High School	Tamuning/Tumon
	Tamuning/Tumon Elementary School	Tamuning/Tumon
	Lyndon B. Johnson Elementary School	Tamuning/Tumon
	Chief James A. Brodie Memorial School	Tamuning/Tumon
	F.Q. Sanchez Elementary School	Umatac
	Simon Sanchez High School	Yigo
	F.B. Leon Guerrero Middle School	Yigo
	Daniel L. Perez Elementary School	Yigo
	Upi Elementary School	Yigo
	Machananao Elementary School	Yigo
	M.U. Lujan Elementary School	Yona
	Guam Mission Academy	Yona
Hotels and Motels	Cliff Hotel	Agana Heights
	Aston Inn On-The-Bay	Agat
	Days Inn	Barrigada
	Harmon Loop Hotel	Dededo
	Starts Guam Resort Hotel	Dededo
	New Marina Hotel	Hagatna
	Ladera Towers	Mangilao
	Plumeria Garden Hotel	Mongmong-Toto-Maite
	Alupang Beach Tower	Tamuning/Tumon
	Days Inn	Tamuning/Tumon

Table E-1. Essential Facilities

Category	Facility Name	Village
Hotels and Motels (cont'd.)	Onward Agana Beach Hotel	Tamuning/Tumon
	Palace Hotel	Tamuning/Tumon
	GITC Hotel	Tamuning/Tumon
	Hilton Hotel	Tamuning/Tumon
	Hotel Maiana	Tamuning/Tumon
	Pacific Islands Club	Tamuning/Tumon
	Fiesta Hotel	Tamuning/Tumon
	Holiday Resort Guam	Tamuning/Tumon
	Hyatt Hotel	Tamuning/Tumon
	Guam Plaza Hotel	Tamuning/Tumon
	Guam Reef Hotel	Tamuning/Tumon
	Tumon Capital Hill Hotel	Tamuning/Tumon
	Westin Hotel	Tamuning/Tumon
	Nikko Hotel	Tamuning/Tumon
	Guam Aurora Resort Villa and Spa	Tamuning/Tumon
	Airport Hotel	Tamuning/Tumon
	Santa Fe On-The-Bay Hotel	Tamuning/Tumon
	Pia Marine Hotel	Tamuning/Tumon
	Pia Resort Hotel	Tamuning/Tumon
	Grand Plaza Hotel	Tamuning/Tumon
	Pacific Bay Hotel	Tamuning/Tumon
	Hunters Inn	Tamuning/Tumon

Table E-1. Essential Facilities

Category	Facility Name	Village
Hotels and Motels (cont'd.)	Royal Orchid Guam Hotel	Tamuning/Tumon
	Outrigger Guam Resort	Tamuning/Tumon
	Ohana Ocean View	Tamuning/Tumon
	The Bayview Hotel	Tamuning/Tumon
	New Century Hotel	Tamuning/Tumon
	Hotel Ypao	Tamuning/Tumon
	Polynesian Hotel/Apartments	Tamuning/Tumon
	Ramada Hotel and Suites	Tamuning/Tumon
	Sheraton Laguna Guam Resort	Tamuning/Tumon
	Tamuning/Tumon Plaza Hotel	Tamuning/Tumon
	Guam Marriott Resort	Tamuning/Tumon
	Golden Motel	Tamuning/Tumon
	Hafa Adai Motel	Tamuning/Tumon
	Leo Palace Resort	Yona

*Sites identified in Table E-1 but not included in the 2014 Guam HMP vulnerability analysis.

Table E-2 Major Utilities

Subcategory	Village
Electric Power Facilities	Dededo
	Dededo
	Piti
	Piti
	Tamuning/Tumon
	Yona
Electric Power Substations	Hagatna
	Barrigada
	Barrigada
	Barrigada
	Dededo
	Mangilao
	Mongmong Toto Mait
	Piti
	Santa Rita
	Santa Rita
	Talofofo
	Tamuning/Tumon
	Tamuning/Tumon
	Tamuning/Tumon
	Tamuning/Tumon

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

Subcategory	Village
Potable Water Enclosed Storage Facilities and Storage Basins (cont'd.)	Mangilao
	Mangilao
	Mangilao
	Mangilao
	Merizo
	Piti
	Santa Rita
	Santa Rita
	Santa Rita
	Santa Rita
	Talofofo
	Talofofo
	Talofofo
	Tamuning/Tumon
	Tamuning/Tumon
	Umatac
	Umatac
	Umatac
	Umatac
	Umatac
	Umatac
	Yigo
	Yigo
	Yigo

Table E-2 Major Utilities

Subcategory	Village
Potable Water Enclosed Storage Facilities and Storage Basins (cont'd.)	Yigo
	Yigo
	Yigo
	Yona
	Yona
	Yona
	Yona
Potable Water Pump Stations	Agana Heights
	Agat
	Agat
	Asan
	Asan
	Asan
	Asan
	Barrigada
	Chalan Pago-Ordot
	Dededo
	Dededo
	Dededo
	Dededo
	Dededo
	Dededo
	Inarajan
	Inarajan

Table E-2 Major Utilities

Subcategory	Village
Potable Water Pump Stations (cont'd.)	Inarajan
	Inarajan
	Inarajan
	Inarajan
	Mangilao
	Mangilao
	Merizo
	Merizo
	Merizo
	Mongmong Toto Maite
	Santa Rita
	Santa Rita
	Santa Rita
	Sinajana
	Talofoyo
	Umatac
	Umatac
	Umatac
	Umatac
	Umatac
	Umatac
	Yigo
	Yigo
	Yigo

Table E-2 Major Utilities

Subcategory	Village
Potable Water Pump Stations (cont'd.)	Yigo
	Yigo
	Yigo
	Yona
	Yona
	Yona
	Yona
	Yona
	Yona
Potable Water Treatment Plants (including Chlorination Buildings)	Dededo
	Dededo
	Inarajan
	Santa Rita
	Santa Rita
Wastewater Pump Stations	Agat
	Agat
	Agat
	Asan
	Asan
	Barrigada
	Barrigada
	Barrigada

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

Subcategory	Village
Wastewater Pump Stations	Inarajan
	Inarajan
	Mangilao
	Mangilao
	Mangilao
	Mangilao
	Mangilao
	Mangilao
	Mangilao
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Merizo
	Mongmong Toto Mait
	Mongmong Toto Mait
	Mongmong Toto Mait

Table E-2 Major Utilities

[illegible]

Table E-2 Major Utilities

Subcategory	Village
Wastewater Pump Stations (cont'd.)	Tamuning/Tumon
	Tamuning/Tumon
	Tamuning/Tumon
	Tamuning/Tumon
	Umatac
	Umatac
	Umatac
	Umatac
	Umatac
	Yigo
	Yigo
	Yona
	Yona
	Yona
Wastewater Treatment Plants	Agat
	Chalan Pago Ordot
	Dededo
	Hagatna
	Inarajan
	Umatac
	Yona

Table E-3 Transportation Systems

Category	Name	Village
Municipal Airport	Guam Airport Authority – Runway (two)	Barrigada
	Guam Airport Authority - Terminal	Barrigada
	Guam Airport Authority – Terminal and Offices	Barrigada
	Guam Airport Authority – Service Hangar	Barrigada
Port Facilities	Fuel Pier F-1	Piti
	Golf Pier	Piti
	Harbor Of Refuge Warehouse	Piti
	Hazmat Station*	Piti
	Hotel Wharf	Piti
	Wharfs F-2 Through F-6	Piti
	Port Container Yard and associated buildings and facilities**	Piti
Traffic Signals	Rt. 2 and Rt. 12	Agat
	Rt. 1 and Rt. 6 (Adelup)	Asan
	Rt. 8 and Tiyan Gate	Barrigada
	Rt. 10 and Mangilao (Pedestrian Crossing)	Barrigada
	Rt. 16 and Revenue and Taxation Building	Barrigada
	Rt. 16 and Rt. 8A (Radio Barrigada)	Barrigada
	Rt. 16 and Guam Main Post Office	Barrigada
	Rt. 16 and Rt. 10A/Rt.25 Overpass	Barrigada
	Rt. 8 and Rt. 10	Barrigada
	Rt. 8 and Rt. 33	Barrigada
	Rt. 10 and Sabanan Ma'agas Rd.	Chalan Pago-Ordot
	Rt. 4 and Rt. 15 (Maimai Rd.)	Chalan Pago-Ordot
	Rt. 4 and Rt. 10	Chalan Pago-Ordot

Table E-3 Transportation Systems

Category	Name	Village
Traffic Signals (cont'd.)	Rt. 4 and Rt. 19, Dero Rd.	Chalan Pago-Ordot
	Rt. 1 and Rt. 27a, Fatima St.	Dededo
	Rt. 16 and Rt. 27 (Harmon Loop)	Dededo
	Rt. 16 and Iglesia Ni Cristo (Pedestrian Crossing)	Dededo
	Rt. 16 and Rt. 27A, Fatima St.	Dededo
	Rt. 1 and Chalan Henry Kaiswer	Dededo
	Rt. 1 and Iglesia Circle (Skate Park)	Dededo
	Rt. 1 and Micronesia Mall (north exit)	Dededo
	Rt. 1 and Rt. 16 (Army Drive)	Dededo
	Rt. 1 and Rt. 26 (Macheche Avenue)	Dededo
	Rt. 1 and Rt. 27 (Harmon Loop/Salisbury)	Dededo
	Rt. 1 and Rt. 28 (Y-Sengsong Road)	Dededo
	Rt. 1 and Rt. 3	Dededo
	Rt. 1 and Wusstig Rd.	Dededo
	Rt. 27 and Compadres Mall	Dededo
	Rt. 27 and JM Guerrero School	Dededo
	Rt. 3 and Rt. 28 (Y-Sengsong Road)	Dededo
	Rt. 1 and Aspinall Avenue (Boat Basin)	Hagatna
	Rt. 4 and Chalan Santo Papa	Hagatna
	Rt. 4 And Rt. 7A, O'Brien Dr.	Hagatna
	Rt. 1 and 5th Street	Hagatna
	Rt. 1 and Rt. 4 (Paseo Loop)	Hagatna
	Rt. 7A and Chalan Obispo (San Ramon)	Hagatna
	Rt. 10 and Corten Torres St.	Mangilao

Table E-3 Transportation Systems

Category	Name	Village
Traffic Signals (cont'd.)	Rt. 10 and Rt. 32 (University of Guam)	Mangilao
	Rt. 25 and Rt. 26	Mangilao
	Rt. 10 and Rt. 15	Mangilao
	Rt. 8 and Rt. 7A (East O'Brien Dr.)	Mongmong-Toto-Maite
	Rt. 1 and Polaris Point	Piti
	Rt. 1 and Rt. 11 (USO)	Piti
	Rt. 1 and Rt. 6 (Piti Cemetery)	Piti
	Rt. 1 and Rt. 2A	Santa Rita
	Rt. 2A and Rt. 5	Santa Rita
	Rt. 5 and Southern High/Apra Heights	Santa Rita
	Rt. 4 and Chalan Canton Tutujan	Sinajana
	Rt. 1 and Ilipog Dr.	Tamuning/Tumon
	Rt. 1 and Citibank	Tamuning/Tumon
	Rt. 1 and Department of Public Works	Tamuning/Tumon
	Rt. 1 and Rt. 10A, Airport Rd.	Tamuning/Tumon
	Rt. 1 and Rt. 14, Upper San Vit.	Tamuning/Tumon
	Rt. 1 and Rt. 14A (Kmart)	Tamuning/Tumon
	Rt. 1 and Rt. 30 (Gov. Camacho Rd.)	Tamuning/Tumon
	Rt. 1 and Rt. 14B (Ypao Rd.)	Tamuning/Tumon
	Rt. 1 and Rt. 8	Tamuning/Tumon
	Rt. 1 and Saint John	Tamuning/Tumon
	Rt. 1 and Tumon Lane (Pia Marine)	Tamuning/Tumon
	Rt. 1 and Upper San Vitores	Tamuning/Tumon
	Rt. 10 A and Home Depot	Tamuning/Tumon

Table E-3 Transportation Systems

Category	Name	Village
Traffic Signals (cont'd.)	Rt. 14 and Blessed Diego Church	Tamuning/Tumon
	Rt. 14 and Dai-Ichi ped. (Fiesta Resort)	Tamuning/Tumon
	Rt. 14 and Fujita Rd./Happy Landing Rd.	Tamuning/Tumon
	Rt. 14 and Guam Premier Outlets	Tamuning/Tumon
	Rt. 14 and Guam Visitors Bureau	Tamuning/Tumon
	Rt. 14 and Marata Ct. (Sand Castle)	Tamuning/Tumon
	Rt. 14 and PIC (Pedestrian Crossing)	Tamuning/Tumon
	Rt. 14 and Rivera Lane (DFS)	Tamuning/Tumon
	Rt. 14 and Rt. 30 A (Farenholt Ave.)	Tamuning/Tumon
	Rt. 14 and St. Anthony (Pedestrian Crossing)	Tamuning/Tumon
	Rt. 14 and Tumon Sands (Pedestrian Crossing)	Tamuning/Tumon
	Rt. 14 and Westin Hotel	Tamuning/Tumon
	Rt. 14 and Rt. 14A (Marriott Resort)	Tamuning/Tumon
	Rt. 14 and Rt. 14B (Hilton)	Tamuning/Tumon
	Rt. 30 and Rt. 30A	Tamuning/Tumon
	Rt. 1 and Chln. Lujuna (Perez Acres)	Yigo
	Rt. 1 amd Juan Jacinto Rd. (Simon Sanchez)	Yigo
	Rt. 1 amd Rt. 29 (Gayinero Rd.)	Yigo
	Rt. 1 and Rt. 9 (Andersen Air Force Base)	Yigo
	Rt. 4 and Rt. 17	Yona

Table E-3 Transportation Systems

Category	Name	Village
Bridges	Bridge	Asan/Maina
	Bridge	Chalan Pago-Ordot
	Bridge	Hagatna
	Bridge	Hagatna
	Bridge	Hagatna
	Bridge	Inarajan
	Bridge	Inarajan
	Bridge	Inarajan
	Bridge	Inarajan
	Bridge	Merizo
	Bridge	Piti
	Bridge	Tamuning/Tumon
	Bridge	Umatac
	Bridge	Umatac
	Ylig Bridge	Yona
	Pago Bay Bridge	Yona
Bus SubStations	Bus SubStation	Barrigada
	Bus SubStation	Chalan Pago Ordot
	Bus SubStation	Dededo
	Bus SubStation	Inarajan
	Bus SubStation	Agat
	Bus SubStation	Yigo

* Facility identified and analyzed in the 2014 Guam HMP. To be removed from future versions of the plan b/c it to be demolished and removed as part of the PAG modernization effort., ** Sites identified in Table E-1 but not included in the 2014 Guam HMP vulnerability analysis.

Table E-4 Transportation Systems (Major Roads)

Category	Name	Distance (miles)
Major Roads	Pedro Roberto Dr./Route 12	1.50
	Pedro Roberto Dr./Route 5	1.26
	Purple Heart Memorial Hwy.	3.14
	Route 3	5.59
	Route 10a	1.93
	Route 11	2.11
	Route 12	0.47
	Route 15	11.57
	Route 2	9.53
	Route 25	0.60
	Route 2a	0.18
	Route 2a	1.66
	Route 4a	3.24
	Route 6	4.95
	Route 7a	0.01
	Route 7b	0.26
	Route 8	1.74
	Route 9	3.07
	Sgt Roy T Damian Jr. St.	2.96
	Vietnam Veterans Memorial Hwy.	3.57
	Ypao Rd.	0.88
	Army Dr./Route 16	4.32
	Carnation Rd./Route 26	1.41

APPENDIX F – VULNERABILITY ANALYSIS RESULTS BY VILLAGE

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Table F-1 Vulnerability Analysis Results by Village: Total Assets

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	1.03	3,808	6	5,401,284	4	5,878,978	1	17,229	906	83,197,861
Agat	10.62	4,917	20	43,596,355	9	24,031,168	2	331,760	1372	117,024,341
Asan	5.67	2,137	5	9,621,711	10	23,236,184	3	1,019,093	720	70,635,437
Barrigada	8.50	8,875	24	28,497,484	17	11,722,547	15	7,602,065	2833	344,645,729
Chalan Pago-Ordot	5.65	6,822	8	6,516,256	19	12,738,197	7	1,745,815	1782	160,219,478
Dededo	30.25	44,943	35	40,617,894	96	125,123,786	18	4,137,438	9889	1,577,218,233
Hagatna (Agana)	0.85	1,051	40	28,789,709	4	6,796,932	10	3,763,639	628	218,363,375
Inarajan	18.74	2,273	15	19,998,666	17	41,029,583	6	2,878,632	1028	70,729,139
Mangilao	10.28	15,191	28	61,267,439	28	37,309,527	5	1,192,445	3169	469,487,557
Merizo	6.12	1,850	10	4,148,678	16	13,337,842	2	775,820	674	55,473,231
Mongmong-Toto-Maite	1.82	6,825	8	8,212,577	7	4,492,942	2	300,159	1319	204,600,900
Piti	7.35	1,454	19	12,150,068	13	275,906,861	11	75,342,599	811	115,581,405
Santa Rita	16.42	6,084	7	26,332,798	12	28,483,393	5	972,823	2662	209,615,321
Sinajana	0.89	2,592	7	3,273,776	9	3,006,870	2	261,408	699	70,123,657
Talofofo	17.80	3,050	8	2,753,783	9	19,811,254	1	74,411	971	88,713,439
Tamuning/Tumon	5.70	19,685	83	520,299,536	23	72,745,137	30	7,875,362	3547	1,463,769,916
Umatac	6.09	782	9	3,116,080	19	46,126,248	3	1,451,186	264	17,304,647
Yigo	35.78	20,539	11	12,811,622	33	55,674,951	6	1,189,513	4906	450,131,582
Yona	20.25	6,480	12	68,620,072	17	77,406,715	4	1,776,834	1889	333,241,884
Total	209.82	159,358	355	906,025,789	362	884,859,115	133	112,708,230	40069	6,120,077,132

Table F-2 Vulnerability Analysis Results by Village: Proportion of Total Assets

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	0.49	2.39	1.69	0.60	1.10	0.66	0.75	0.02	2.26	1.36
Agat	5.06	3.09	5.63	4.81	2.49	2.72	1.50	0.29	3.42	1.91
Asan	2.70	1.34	1.41	1.06	2.76	2.63	2.26	0.90	1.80	1.15
Barrigada	4.05	5.57	6.76	3.15	4.70	1.32	11.28	6.74	7.07	5.63
Chalan Pago-Ordot	2.69	4.28	2.25	0.72	5.25	1.44	5.26	1.55	4.45	2.62
Dededo	14.42	28.20	9.86	4.48	26.52	14.14	13.53	3.67	24.68	25.77
Hagatna (Agana)	0.41	0.66	11.27	3.18	1.10	0.77	7.52	3.34	1.57	3.57
Inarajan	8.93	1.43	4.23	2.21	4.70	4.64	4.51	2.55	2.57	1.16
Mangilao	4.90	9.53	7.89	6.76	7.73	4.22	3.76	1.06	7.91	7.67
Merizo	2.92	1.16	2.82	0.46	4.42	1.51	1.50	0.69	1.68	0.91
Mongmong - Toto-Maite	0.87	4.28	2.25	0.91	1.93	0.51	1.50	0.27	3.29	3.34
Piti	3.50	0.91	5.35	1.34	3.59	31.18	8.27	66.85	2.02	1.89
Santa Rita	7.83	3.82	1.97	2.91	3.31	3.22	3.76	0.86	6.64	3.43
Sinajana	0.42	1.63	1.97	0.36	2.49	0.34	1.50	0.23	1.74	1.15
Talofofo	8.48	1.91	2.25	0.30	2.49	2.24	0.75	0.07	2.42	1.45
Tamuning/Tumon	2.72	12.35	23.38	57.43	6.35	8.22	22.56	6.99	8.85	23.92
Umatac	2.90	0.49	2.54	0.34	5.25	5.21	2.26	1.29	0.66	0.28
Yigo	17.05	12.89	3.10	1.41	9.12	6.29	4.51	1.06	12.24	7.35
Yona	9.65	4.07	3.38	7.57	4.70	8.75	3.01	1.58	4.71	5.45

Table F-3 Vulnerability Analysis Results by Village: Total Affected by Fault Proximity

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.37	1,373	1	1,180,000	1	190,359	1	12,530	149	13,682,670
Agat	2.19	1,014	1	33,345,000	0	0	2	266,047	140	11,941,300
Asan	2.66	1,003	1	8,260,000	4	6,741,404	2	294,960	323	31,687,915
Barrigada	2.12	2,213	4	10,820,000	5	1,383,008	7	5,949,496	620	75,425,480
Chalan Pago-Ordot	0.74	894	1	1,180,000	0	0	0	0	47	4,225,770
Dededo	2.56	3,805	1	750,000	10	13,001,100	3	580,624	591	94,259,772
Hagatna (Agana)	0.43	535	25	17,847,998	2	744,542	7	2,457,094	461	160,295,232
Inarajan	6.11	7,42	3	711,714	4	11,550,650	2	725,776	102	7,017,906
Mangilao	0.81	1,198	0	0	3	6,119,832	1	7,288	442	65,482,300
Merizo	1.74	526	2	688,844	8	4,541,363	1	24,961	217	17,859,968
Mongmong-Toto-Maite	0.51	1,912	3	2,830,000	2	811,931	2	269,460	261	40,485,798
Piti	1.17	232	0	0	0	0	1	966	32	4,560,544
Santa Rita	4.19	1,553	2	1,394,743	6	17,003,114	1	50,703	786	61,892,784
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	5.15	883	23	82,619,589	4	12,017,065	1	13,461	53	4,842,239
Tamuning/Tumon	1.74	6,008	0	0	10	34,523,314	7	1,991,188	942	388,742,676
Umatac	2.28	293	0	0	4	16,114,062	1	28,671	25	1,638,700
Yigo	7.48	4,295	4	7,275,745	16	28,633,454	3	340,995	1065	97,714,815
Yona	3.61	1,155	0	0	4	23,790,352	1	14,704	129	22,757,148
Total	45.86	29,634	71	168,903,633	83	177,165,550	43	13,028,925	6,385	1,104,513,017

Table F-4 Vulnerability Analysis Results by Village: Proportion Affected by Fault Proximity

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	35.92	36.06	16.67	21.85	25.00	3.24	100.00	72.73	16.45	16.45
Agat	20.62	20.62	5.00	76.49	0.00	0.00	100.00	80.19	10.20	10.20
Asan	46.91	46.93	20.00	85.85	40.00	29.01	66.67	28.94	44.86	44.86
Barrigada	24.94	24.94	16.67	37.97	29.41	11.80	46.67	78.26	21.88	21.88
Chalan Pago-Ordot	13.10	13.10	12.50	18.11	0.00	0.00	0.00	0.00	2.64	2.64
Dededo	8.46	8.47	2.86	1.85	10.42	10.39	16.67	14.03	5.98	5.98
Hagatna (Agana)	50.59	50.90	62.50	61.99	50.00	10.95	70.00	65.29	73.41	73.41
Inarajan	32.60	32.64	20.00	3.56	23.53	28.15	33.33	25.21	9.92	9.92
Mangilao	7.88	7.89	0.00	0.00	10.71	16.40	20.00	0.61	13.95	13.95
Merizo	28.43	28.43	20.00	16.60	50.00	34.05	50.00	3.22	32.20	32.20
Mongmong - Toto-Maite	28.02	28.01	37.50	34.46	28.57	18.07	100.00	89.77	19.79	19.79
Piti	15.92	15.96	0.00	0.00	0.00	0.00	9.09	0.00	3.95	3.95
Santa Rita	25.52	25.53	28.57	5.30	50.00	59.69	20.00	5.21	29.53	29.53
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofo	28.93	28.95	287.50	3000.22	44.44	60.66	100.00	18.09	5.46	5.46
Tamuning/Tumon	30.53	30.52	0.00	0.00	43.48	47.46	23.33	25.28	26.56	26.56
Umatac	37.44	37.47	0.00	0.00	21.05	34.93	33.33	1.98	9.47	9.47
Yigo	20.91	20.91	36.36	56.79	48.48	51.43	50.00	28.67	21.71	21.71
Yona	17.83	17.82	0.00	0.00	23.53	30.73	25.00	0.83	6.83	6.83
Total	21.86	18.60	20.00	18.64	22.93	20.02	32.33	11.56	15.94	18.05

Table F-5 Vulnerability Analysis Results by Village: Total Affected by Very High Liquefaction

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0	0	0	0	0	0	0	0	0	0
Agat	0	0	0	0	0	0	0	0	0	0
Asan	0	0	0	0	0	0	0	0	0	0
Barrigada	0	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0	0	0	0	0	0	0	0	0	0
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.12	150	14	12,498,834	0	0	4	907,323	103	35,814,336
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	0	0	0	0	0	0	0	0	0	0
Merizo	0	0	0	0	0	0	0	0	0	0
Mongmong-Toto-Maite	0	0	0	0	0	0	0	0	0	0
Piti	0.17	34	1	1,180,000	2	132,319,860	1	55,125,000	62	8,836,054
Santa Rita	0.22	82	0	0	0	0	1	55	40	3,149,760
Sinajana	0	0	0	0	0	0	0	0	0	0
Talofofo	0	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	0	0	0	0	0	0	0	0	0	0
Umatac	0	0	0	0	0	0	0	0	0	0
Yigo	0	0	0	0	0	0	0	0	0	0
Yona	0	0	0	0	0	0	0	0	0	0
Total	0.51	266	15	13,678,834	2	132,319,860	6	56,032,379	205	47,800,150

Table F-6 Vulnerability Analysis Results by Village: Proportion Affected by Very High Liquefaction

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barrigada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chalan Pago-Ordot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dededo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	14.12	14.27	35.00	43.41	0.00	0.00	40.00	24.11	16.40	16.40
Inarajan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mangilao	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Merizo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mongmong - Toto-Maite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piti	2.31	2.34	5.26	9.71	15.38	47.96	9.09	73.17	7.64	7.64
Santa Rita	1.34	1.35	0.00	0.00	0.00	0.00	20.00	0.01	1.50	1.50
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tamuning/Tumon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Umatac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yigo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.24	0.17	4.23	1.51	0.55	14.95	4.51	49.71	0.51	0.78

Table F-7 Vulnerability Analysis Results by Village: Total Affected by High Liquefaction

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.00	0	0	0	0	0	0	0	0	0
Agat	0.00	0	0	0	0	0	0	0	0	0
Asan	0.00	0	0	0	0	0	0	0	0	0
Barrigada	00.0	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.00	0	0	0	0	0	0	0	0	0
Dededo	0.11	164	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.01	13	0	0	1	621,572	2	252,512	25	8,692,800
Inarajan	0.00	0	0	0	0	0	0	0	0	0
Mangilao	0.00	0	0	0	0	0	0	0	0	0
Merizo	0.12	37	1	237,238	0	0	0	0	0	0
Mongmong - Toto-Maite	0.00	0	0	0	0	0	0	0	0	0
Piti	0.74	147	1	1,180,000	5	69,139,550	4	10,056,237	125	17,814,625
Santa Rita	1.12	415	0	0	2	674,118	2	20,935	173	13,622,712
Sinajana	0.00	0	0	0	0	0	0	0	0	0
Talofofo	0.00	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	0.16	553	9	60,064,238	3	1,864,716	5	1,250,000	54	22,284,612
Umatac	0.00	0	0	0	0	0	0	0	0	0
Yigo	0.23	133	0	0	0	0	0	0	2	183,502
Yona	0.00	0	0	0	0	0	0	0	0	0
Total	2.49	1,462	11	61,481,476	11	72,299,956	13	11,579,684	379	62,598,251

Table F-8 Vulnerability Analysis Results by Village: Proportion Affected by High Liquefaction

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barrigada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chalan Pago-Ordot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dededo	0.36	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	1.18	1.24	0.00	0.00	25.00	9.14	20.00	6.71	3.98	3.98
Inarajan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mangilao	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Merizo	1.96	2.00	10.00	5.72	0.00	0.00	0.00	0.00	0.00	0.00
Mongmong - Toto-Maite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piti	10.07	10.11	5.26	9.71	38.46	25.06	36.36	13.35	15.41	15.41
Santa Rita	6.82	6.82	0.00	0.00	16.67	2.37	40.00	2.15	6.50	6.50
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tamuning/Tumon	2.81	2.81	10.84	11.54	13.04	2.56	16.67	15.87	1.52	1.52
Umatac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yigo	0.64	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04
Yona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	1.19	0.92	3.10	6.79	3.04	8.17	9.77	10.27	0.95	1.02

Table F-9 Vulnerability Analysis Results by Village: Total Affected by Flooding

Village	Area	Populati on	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Squ are Mil es	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.02	75	0	0	0	0	1	1,365	0	0
Agat	0.83	385	9	36,625,640	2	1,243,144	2	288,554	364	31,047,380
Asan	0.12	46	0	0	0	0	2	691,223	22	2,158,310
Barrigada	0.01	11	0	0	0	0	0	0	2	243,308
Chalan Pago- Ordot	0.40	484	1	237,238	4	2,055,075	2	254,256	36	3,236,760
Dededo	0.07	105	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.54	672	25	16,767,415	2	6,483,603	8	2,751,184	402	139,780,224
Inarajan	1.10	134	7	1,535,607	3	1,433,503	5	2,802,413	161	11,077,283
Mangilao	0.15	222	0	0	0	0	0	0	8	1,185,200
Merizo	0.84	254	2	277,238	10	6,215,720	2	748,490	372	30,617,088
Mongmong- Toto- Maite	0.34	1275	0	0	0	0	0	0	48	7,445,664
Piti	1.08	214	11	7,323,428	2	25,384,984	8	66,323,573	227	32,351,359
Santa Rita	1.58	586	0	0	0	0	1	6,757	194	15,276,336
Sinajana	0.18	523	0	0	0	0	0	0	7	702,240
Talofofo	1.19	204	1	237,238	0	0	1	5,298	21	1,918,623
Tamuning/Tum on	0.55	1,900	15	70,392,649	3	2,454,050	3	965,274	286	118,025,908
Umatac	0.29	38	3	809,173	1	621,572	2	692,052	25	1,638,700
Yigo	0.28	161	0	0	0	0	0	0	0	0
Yona	0.83	266	2	474,476	0	0	3	1,385,882	7	1,234,884
Total	10.4	7,555	76	134,680,102	27	45,891,651	40	76,916,320	2,182	397,939,267

Table F-10 Vulnerability Analysis Results by Village: Proportion Affected by Flooding

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	1.94	1.97	0.00	0.00	0.00	0.00	100.00	7.92	0.00	0.00
Agat	7.82	7.83	45.00	84.01	22.22	5.17	100.00	86.98	26.53	26.53
Asan	2.12	2.15	0.00	0.00	0.00	0.00	66.67	67.83	3.06	3.06
Barrigada	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07
Chalan Pago-Ordot	7.08	7.09	12.50	3.64	21.05	16.13	28.57	14.56	2.02	2.02
Dededo	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	63.53	63.94	62.50	58.24	50.00	95.39	80.00	73.10	64.01	64.01
Inarajan	5.87	5.90	46.67	7.68	17.65	3.49	83.33	97.35	15.66	15.66
Mangilao	1.46	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25
Merizo	13.73	13.73	20.00	6.68	62.50	46.60	100.00	96.48	55.19	55.19
Mongmong - Toto-Maite	18.68	18.68	0.00	0.00	0.00	0.00	0.00	0.00	3.64	3.64
Piti	14.69	14.72	57.89	60.27	15.38	9.20	72.73	88.03	27.99	27.99
Santa Rita	9.62	9.63	0.00	0.00	0.00	0.00	20.00	0.69	7.29	7.29
Sinajana	20.22	20.18	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Talofofo	6.69	6.69	12.50	8.61	0.00	0.00	100.00	7.12	2.16	2.16
Tamuning/Tumon	9.65	9.65	18.07	13.53	13.04	3.37	10.00	12.26	8.06	8.06
Umatac	4.76	4.86	33.33	25.97	5.26	1.35	66.67	47.69	9.47	9.47
Yigo	0.78	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yona	4.10	4.10	16.67	0.69	0.00	0.00	75.00	78.00	0.37	0.37
Total	4.96	4.74	21.41	14.86	7.46	5.19	30.08	68.24	5.45	6.50

Table F-11 Vulnerability Analysis Results by Village: Total Affected by Air Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.67	2,485	6	5,401,284	3	5,688,619	1	9,839	797	73,278,637
Agat	0	0	0	0	0	0	0	0	0	0
Asan	0.03	12	0	0	0	0	0	0	2	196,210
Barrigada	0.76	794	2	3,014,000	0	0	2	314,200	331	40,267,474
Chalan Pago-Ordot	0	0	0	0	0	0	0	0	0	0
Dededo	7.29	10,833	25	28,004,521	37	72,251,718	17	3,797,676	4642	740,361,864
Hagatna (Agana)	0.69	859	38	27,372,471	3	6,673,962	9	3,064,914	442	153,688,704
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	0.03	45	0	0	0	0	0	0	19	2,814,850
Merizo	0	0	0	0	0	0	0	0	0	0
Mongmong - Toto-Maite	1.05	3,935	4	4,784,000	4	3,059,439	2	281,478	746	115,718,028
Piti	3.39	671	15	9,315,592	12	275,285,289	6	1,543,271	485	69,120,745
Santa Rita	1.52	564	0	0	0	0	3	538,405	252	19,843,488
Sinajana	0.41	1,190	7	3,273,776	5	1,383,008	2	256,148	466	46,749,120
Talofofo	3.12	535	5	2,042,069	8	19,189,682	1	31,968	681	62,218,203
Tamuning/ Tumon	2.45	8,460	34	137,056,130	6	49,150,250	11	3,052,637	1761	726,725,958
Umatac	0	0	0	0	0	0	0	0	0	0
Yigo	4.80	2,756	6	6,932,426	14	25,773,353	4	570,727	1461	134,048,211
Yona	3.15	1,008	0	0	7	45,940,111	0	0	259	45,690,708
Total	29.37	34,147	142	227,196,269	99	504,395,431	58	13,461,264	12,344	2,230,722,200

Table F-12 Vulnerability Analysis Results by Village: Proportion Affected by Air Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	65.05	65.26	100.00	100.00	75.00	96.76	100.00	57.11	87.97	88.08
Agat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asan	0.53	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28
Barrigada	8.94	8.95	8.33	10.58	0.00	0.00	13.33	4.13	11.68	11.68
Chalan Pago-Ordot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dededo	24.10	24.10	71.43	68.95	38.54	57.74	94.44	91.79	46.94	46.94
Hagatna (Agana)	81.18	81.73	95.00	95.08	75.00	98.19	90.00	81.43	70.38	70.38
Inarajan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mangilao	0.29	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.60
Merizo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mongmong - Toto-Maite	57.69	57.66	50.00	58.25	57.14	68.09	100.00	93.78	56.56	56.56
Piti	46.12	46.15	78.95	76.67	92.31	99.77	54.55	2.05	59.80	59.80
Santa Rita	9.26	9.27	0.00	0.00	0.00	0.00	60.00	55.34	9.47	9.47
Sinajana	46.07	45.91	100.00	100.00	55.56	45.99	100.00	97.99	66.67	66.67
Talofofo	17.53	17.54	62.50	74.16	88.89	96.86	100.00	42.96	70.13	70.13
Tamuning/Tumon	42.98	42.98	40.96	26.34	26.09	67.56	36.67	38.76	49.65	49.65
Umatac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yigo	13.42	13.42	54.55	54.11	42.42	46.29	66.67	47.98	29.78	29.78
Yona	15.56	15.56	0.00	0.00	41.18	59.35	0.00	0.00	13.71	13.71
Total	14.00	21.43	40.00	25.08	27.35	57.00	43.61	11.94	30.81	36.45

Table F-13 Vulnerability Analysis Results by Village: Total Affected by Water Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.45	1,669	2	3,023,000	3	5,688,619	1	15,109	246	22,590,180
Agat	0	0	0	0	0	0	0	0	606	51,688,770
Asan	0.04	16	0	0	0	0	0	0	136	13,342,280
Barrigada	1.72	1,796	5	4,933,007	4	1,192,649	5	5,347,047	834	101,459,436
Chalan Pago-Ordot	1.21	1,462	1	237,238	4	7,295,534	3	526,070	415	37,312,650
Dededo	2.02	3,002	0	0	4	6,864,321	1	3,866	3816	608,621,472
Hagatna (Agana)	0.63	784	38	27,372,471	3	6,606,573	9	3,067,584	31	10,779,072
Inarajan	1.78	216	1	237,238	4	11,550,650	2	711,124	425	29,241,275
Mangilao	0.99	1,464	12	32,887,192	1	190,359	2	268,576	1043	154,520,450
Merizo	0.67	203	0	0	2	1,243,144	1	14,392	288	23,703,552
Mongmong - Toto-Maite	0.04	150	1	1,400,000	0	0	2	254,864	400	62,047,200
Piti	3.17	628	16	11,438,354	13	275,906,861	10	75,053,531	149	21,235,033
Santa Rita	6.97	2,583	3	23,417,849	7	17,055,660	3	611,710	1009	79,452,696
Sinajana	0	0	0	0	0	0	0	0	88	8,828,160
Talofofo	2.00	343	1	237,238	4	11,427,733	1	22,919	426	38,920,638
Tamuning/Tumon	2.10	7,251	18	17,950,913	8	36,167,854	13	3,493,448	706	291,350,668
Umatac	1.08	139	7	2,766,663	11	19,015,666	3	1,401,061	175	11,470,900
Yigo	0	0	0	0	0	0	0	0	2,150	197,264,650
Yona	5.76	1,843	2	64,804,564	7	16,249,516	2	740,243	718	126,663,816
Total	30.63	23,549	107	190,705,727	75	416,455,139	58	91,531,545	13,661	1,890,492,898

Table F-14 Vulnerability Analysis Results by Village: Proportion Affected by Water Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	43.69	43.83	33.33	55.97	75.00	96.76	100.00	87.70	27.15	27.15
Agat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.17	44.17
Asan	0.71	0.75	0.00	0.00	0.00	0.00	0.00	0.00	18.89	18.89
Barrigada	20.24	20.24	20.83	17.31	23.53	10.17	33.33	70.34	29.44	29.44
Chalan Pago-Ordot	21.42	21.43	12.50	3.64	21.05	57.27	42.86	30.13	23.29	23.29
Dededo	6.68	6.68	0.00	0.00	4.17	5.49	5.56	0.09	38.59	38.59
Hagatna (Agana)	74.12	74.60	95.00	95.08	75.00	97.20	90.00	81.51	4.94	4.94
Inarajan	9.50	9.50	6.67	1.19	23.53	28.15	33.33	24.70	41.34	41.34
Mangilao	9.63	9.64	42.86	53.68	3.57	0.51	40.00	22.52	32.91	32.91
Merizo	10.95	10.97	0.00	0.00	12.50	9.32	50.00	1.86	42.73	42.73
Mongmong - Toto-Maite	2.20	2.20	12.50	17.05	0.00	0.00	100.00	84.91	30.33	30.33
Piti	43.13	43.19	84.21	94.14	100.00	100.00	90.91	99.62	18.37	18.37
Santa Rita	42.45	42.46	42.86	88.93	58.33	59.88	60.00	62.88	37.90	37.90
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.59	12.59
Talofofo	11.24	11.25	12.50	8.61	44.44	57.68	100.00	30.80	43.87	43.87
Tamuning/Tumon	36.84	36.84	21.69	3.45	34.78	49.72	43.33	44.36	19.90	19.90
Umatac	17.73	17.77	77.78	88.79	57.89	41.23	100.00	96.55	66.29	66.29
Yigo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.82	43.82
Yona	28.44	28.44	16.67	94.44	41.18	20.99	50.00	41.66	38.01	38.01
Total	14.60	14.78	30.14	21.05	20.72	47.06	43.61	81.21	34.09	30.89

Table F-15 Vulnerability Analysis Results by Village: Total Affected by Hardfill Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights	0.71	2,633	6	5,401,284	3	5,688,619	1	17,229	694	63,730,020
Agat	0	0	0	0	0	0	0	0	0	0
Asan	0.31	117	1	140,932	2	5,498,260	1	5,878	148	14,519,540
Barrigada	1.61	1,681	0	0	2	811,931	1	1,596	615	74,817,210
Chalan Pago-Ordot	3.52	4,251	6	5,099,018	14	5,252,304	6	1,038,848	1319	118,591,290
Dededo	0	0	0	0	0	0	0	0	0	0
Hagatna	0.75	933	38	27,372,471	4	6,796,932	9	3,073,201	597	207,584,064
Inarajan	0	0	0	0	0	0	0	0	0	0
Mangilao	3.69	5,454	12	9,249,458	8	2,385,298	4	858,693	1122	166,224,300
Merizo	0	0	0	0	0	0	0	0	0	0
Mongmong-Toto-Maite	0.14	525	1	1,400,000	0	0	2	258,432	134	20,785,812
Piti	0	0	0	0	0	0	0	0	0	0
Santa Rita	0	0	0	0	0	0	0	0	0	0
Sinajana	0.07	204	1	112,179	2	811,931	0	0	99	9,931,680
Talofofo	0	0	0	0	0	0	0	0	0	0
Tamuning/T	0.07	242	3	809,173	0	0	3	948,953	47	19,395,866
Umatac	0	0	0	0	0	0	0	0	0	0
Yigo	11.06	6,350	6	7,091,303	13	30,455,766	4	604,906	3649	334,799,399
Yona	0.4	128	0	0	0	0	0	0	0	0
Total	22.33	22,518	74	56,675,818	48	57,701,041	31	6,807,736	8,424	1,030,379,18

Table F-16 Vulnerability Analysis Results by Village: Proportion Affected by Hardfill Permitted Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	68.93	69.14	100.00	100.00	75.00	96.76	100.00	100.00	76.60	76.60
Agat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asan	5.47	5.47	20.00	1.46	20.00	23.66	33.33	0.58	20.56	20.56
Barrigada	18.94	18.94	0.00	0.00	11.76	6.93	6.67	0.02	21.71	21.71
Chalan Pago-Ordot	62.30	62.31	75.00	78.25	73.68	41.23	85.71	59.51	74.02	74.02
Dededo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	88.24	88.77	95.00	95.08	100.00	100.00	90.00	81.66	95.06	95.06
Inarajan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mangilao	35.89	35.90	42.86	15.10	28.57	6.39	80.00	72.01	35.41	35.41
Merizo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mongmong-Toto- Maite	7.69	7.69	12.50	17.05	0.00	0.00	100.00	86.10	10.16	10.16
Piti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Santa Rita	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sinajana	7.87	7.87	14.29	3.43	22.22	27.00	0.00	0.00	14.16	14.16
Talofofo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tamuning/Tumon	1.23	1.23	3.61	0.16	0.00	0.00	10.00	12.05	1.33	1.33
Umatac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yigo	30.91	30.92	54.55	55.35	39.39	54.70	66.67	50.85	74.38	74.38
Yona	1.98	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.64	14.13	20.85	6.26	13.26	6.52	23.31	6.04	21.02	16.84

Table F-17 Vulnerability Analysis Results by Village: Total Affected by Pre-CERCLIS Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	1.03	3,808	6	5,401,284	4	5,878,978	1	17,229	906	83,288,107
Agat	5.51	2,551	14	40,196,698	5	17,720,977	2	301,023	1189	101,415,755
Asan	5.48	2,065	5	9,621,711	10	23,236,184	3	1,016,273	713	69,948,865
Barrigada	7.98	8,329	22	19,057,484	16	6,414,646	15	7,600,494	2609	317,395,286
Chalan Pago-Ordot	5.51	6,654	8	6,516,256	19	12,738,197	7	1,745,426	1755	157,792,050
Dededo	18.27	27,149	23	25,760,873	33	25,372,311	16	3,578,919	4575	729,675,900
Hagatna (Agana)	0.85	1,051	40	28,789,709	4	6,796,932	10	3,763,639	628	218,363,136
Inarajan	4.18	507	2	571,935	2	380,718	3	1,416,910	357	24,562,671
Mangilao	5.23	7,730	26	60,792,963	23	36,357,732	5	1,138,555	2633	390,078,950
Merizo	2.19	662	1	237,238	4	2,486,288	1	31,561	267	21,975,168
Mongmong - Toto-Maite	1.82	6,820	8	8,212,577	7	4,492,942	2	300,159	1319	204,600,642
Piti	6.98	1,381	19	12,150,068	13	275,906,861	11	75,342,599	772	110,023,124
Santa Rita	7.02	2,601	7	26,332,798	8	22,932,587	4	653,479	1258	99,059,952
Sinajana	0.89	2,584	7	3,273,776	9	3,006,870	2	261,408	699	70,123,680
Talofofu	8.77	1,503	7	2,516,545	9	19,811,254	1	69,312	962	87,891,206
Tamuning/Tumon	5.70	19,682	83	520,299,536	23	72,745,137	30	7,875,362	3547	146,376,886
Umatac	4.41	567	5	2,203,916	13	38,449,996	2	742,811	176	11,536,448

Yigo	29.90	17,165	8	12,224,967	32	55,053,379	5	917,171	4073	373,701,823
Yona	17.90	5,727	10	68,145,596	17	77,406,715	4	1,754,081	1768	311,896,416
Total	139.62	118,555	301	852,305,930	251	707,188,704	124	108,526,413	30,206	3,529,706,065

Table F-18 Vulnerability Analysis Results by Village: Proportion Affected by Pre-CERCLIS Facilities

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.11
Agat	51.88	51.88	70.00	92.20	55.56	73.74	100.00	90.74	86.66	86.66
Asan	96.65	96.63	100.00	100.00	100.00	100.00	100.00	99.72	99.03	99.03
Barrigada	93.88	93.85	91.67	66.87	94.12	54.72	100.00	99.98	92.09	92.09
Chalan Pago-Ordot	97.52	97.54	100.00	100.00	100.00	100.00	100.00	99.98	98.48	98.48
Dededo	60.40	60.41	65.71	63.42	34.38	20.28	88.89	86.50	46.26	46.26
Hagatna (Agana)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Inarajan	22.31	22.31	13.33	2.86	11.76	0.93	50.00	49.22	34.73	34.73
Mangilao	50.88	50.89	92.86	99.23	82.14	97.45	100.00	95.48	83.09	83.09
Merizo	35.78	35.78	10.00	5.72	25.00	18.64	50.00	4.07	39.61	39.61
Mongmong-Toto-Maite	100.00	99.93	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Piti	94.97	94.98	100.00	100.00	100.00	100.00	100.00	100.00	95.19	95.19
Santa Rita	42.75	42.75	100.00	100.00	66.67	80.51	80.00	67.17	47.26	47.26
Sinajana	100.00	99.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Talofofo	49.27	49.28	87.50	91.39	100.00	100.00	100.00	93.15	99.07	99.07
Tamuning/Tumon	100.00	99.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	10.00
Umatac	72.41	72.51	55.56	70.73	68.42	83.36	66.67	51.19	66.67	66.67
Yigo	83.57	83.57	72.73	95.42	96.97	98.88	83.33	77.10	83.02	83.02
Yona	88.40	88.38	83.33	99.31	100.00	100.00	100.00	98.72	93.59	93.59
Total	66.54	74.40	84.79	94.07	69.34	79.92	93.23	96.29	75.38	57.67

Table F-19 Vulnerability Analysis Results by Village: Total Affected by Severe Wind

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.03	112	0	0	0	0	0	0	0	0
Agat	6.71	3,107	9	36,721,946	5	13,034,648	2	310,878	288	24,564,960
Asan	3.84	1,447	2	8,497,238	5	11,618,092	2	751,662	329	32,276,545
Barrigada	3.19	3,330	2	9,440,000	5	6,069,337	3	638,130	807	98,174,778
Chalan Pago-Ordot	0.11	133	2	1,417,238	1	5,862,031	0	0	50	4,495,500
Dededo	25.53	37,937	27	31,737,229	80	119,325,547	7	1,522,280	7339	117,051,178
Hagatna (Agana)	0.23	287	12	6,234,242	2	6,483,603	5	1,459,248	252	87,623,424
Inarajan	7.20	874	7	1,633,066	7	18,101,695	4	2,139,592	572	39,355,316
Mangilao	4.85	7,169	6	22,934,545	18	29,425,969	2	334,654	1502	222,521,300
Merizo	2.30	696	4	1,163,320	11	6,406,079	2	760,832	302	24,855,808
Mongmong - Toto-Maite	0.04	150	0	0	1	621,572	0	0	24	3,722,832
Piti	2.78	550	8	5,668,952	9	113,515,688	9	74,789,855	332	47,315,644
Santa Rita	4.98	1,845	0	0	6	16,812,755	1	66,247	715	56,301,960
Sinajana	0.00	0	0	0	0	0	0	0	0	0
Talofofo	8.43	1,445	4	1,966,678	5	16,735,634	1	43,863	491	44,859,233
Tamuning/Tumon	0.87	3,004	25	312,625,666	5	27,249,700	4	1,212,866	271	111,835,738
Umatac	3.26	419	6	2,566,213	16	40,716,307	2	742,894	127	8,324,596
Yigo	33.10	19,002	11	12,811,622	33	55,674,951	6	1,189,513	4905	450,038,655
Yona	8.41	291	6	66,040,063	8	39,473,201	2	761,071	354	62,449,848
Total	115.86	84,197	131	521,458,018	217	527,126,809	52	86,723,585	18,660	1,435,767,315

Table F-20 Vulnerability Analysis Results by Village: Proportion Affected by Severe Wind

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	2.91	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agat	63.18	63.19	45.00	84.23	55.56	54.24	100.00	93.71	20.99	20.99
Asan	67.72	67.71	40.00	88.31	50.00	50.00	66.67	73.76	45.69	45.69
Barrigada	37.53	37.52	8.33	33.13	29.41	51.77	20.00	8.39	28.49	28.49
Chalan Pago-Ordot	1.95	1.95	25.00	21.75	5.26	46.02	0.00	0.00	2.81	2.81
Dededo	84.40	84.41	77.14	78.14	83.33	95.37	38.89	36.79	74.21	7.42
Hagatna (Agana)	27.06	27.31	30.00	21.65	50.00	95.39	50.00	38.77	40.13	40.13
Inarajan	38.42	38.45	46.67	8.17	41.18	44.12	66.67	74.33	55.64	55.64
Mangilao	47.18	47.19	21.43	37.43	64.29	78.87	40.00	28.06	47.40	47.40
Merizo	37.58	37.62	40.00	28.04	68.75	48.03	100.00	98.07	44.81	44.81
Mongmong - Toto-Maite	2.20	2.20	0.00	0.00	14.29	13.83	0.00	0.00	1.82	1.82
Piti	37.82	37.83	42.11	46.66	69.23	41.14	81.82	99.27	40.94	40.94
Santa Rita	30.33	30.33	0.00	0.00	50.00	59.03	20.00	6.81	26.86	26.86
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofo	47.36	47.38	50.00	71.42	55.56	84.48	100.00	58.95	50.57	50.57
Tamuning/Tumon	15.26	15.26	30.12	60.09	21.74	37.46	13.33	15.40	7.64	7.64
Umatac	53.53	53.58	66.67	82.35	84.21	88.27	66.67	51.19	48.11	48.11
Yigo	92.51	92.52	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.98
Yona	41.53	4.49	50.00	96.24	47.06	50.99	50.00	42.83	18.74	18.74
Total	55.22	52.84	36.90	57.55	59.94	59.57	39.10	76.95	46.57	23.46

Table F-21 Vulnerability Analysis Results by Village: Total Affected by Very High Landslide

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.09	334	0	0	0	0	0	0	7	642,810
Agat	2.74	1,269	0	0	1	5,307,901	1	7,651	1	85,295
Asan	0.98	370	0	0	2	5,498,260	1	9,855	41	4,022,305
Barrigada	0.02	21	0	0	0	0	1	459	0	0
Chalan Pago-Ordot	0.19	230	0	0	0	0	1	72	5	449,550
Dededo	0.88	1,308	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.05	63	0	0	1	122,970	1	1,242	45	15,647,040
Inarajan	14.37	1,743	4	6,121,072	5	11,186,879	5	2,809,430	255	17,544,765
Mangilao	0.54	799	1	237,238	0	0	0	0	6	888,900
Merizo	3.38	1,022	1	40,000	2	1,243,144	1	28,901	76	6,255,104
Mongmong - Toto-Maite	0.01	38	0	0	0	0	0	0	1	155,118
Piti	0.92	182	0	0	0	0	1	2,053	16	2,280,272
Santa Rita	1.85	686	0	0	0	0	0	0	8	629,952
Sinajana	0.05	146	0	0	1	190,359	0	0	7	702,240
Talofofo	12.91	2,213	3	674,926	3	10,806,161	1	15,007	38	3,471,794
Tamuning/Tumon	0.20	691	2	474,476	1	24,763,412	1	5,333	40	16,507,120
Umatac	2.48	319	2	1,519,802	2	4,788,369	1	16,579	36	2,359,728
Yigo	2.21	1,269	0	0	0	0	0	0	1	91,751
Yona	2.78	890	0	0	0	0	1	6,815	20	3,528,240
Total	46.65	13,593	13	9,067,514	18	63,907,455	16	2,903,397	603	75,261,984

Table F-22 Vulnerability Analysis Results by Village: Proportion Affected by Very High Landslide

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	8.74	8.77	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.77
Agat	25.80	25.81	0.00	0.00	11.11	22.09	50.00	2.31	0.07	0.07
Asan	17.28	17.31	0.00	0.00	20.00	23.66	33.33	0.97	5.69	5.69
Barrigada	0.24	0.24	0.00	0.00	0.00	0.00	6.67	0.01	0.00	0.00
Chalan Pago-Ordot	3.36	3.37	0.00	0.00	0.00	0.00	14.29	0.00	0.28	0.28
Dededo	2.91	2.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	5.88	5.99	0.00	0.00	25.00	1.81	10.00	0.03	7.17	7.17
Inarajan	76.68	76.68	26.67	30.61	29.41	27.27	83.33	97.60	24.81	24.81
Mangilao	5.25	5.26	3.57	0.39	0.00	0.00	0.00	0.00	0.19	0.19
Merizo	55.23	55.24	10.00	0.96	12.50	9.32	50.00	3.73	11.28	11.28
Mongmong-Toto-Maite	0.55	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08
Piti	12.52	12.52	0.00	0.00	0.00	0.00	9.09	0.00	1.97	1.97
Santa Rita	11.27	11.28	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30
Sinajana	5.62	5.63	0.00	0.00	11.11	6.33	0.00	0.00	1.00	1.00
Talofofu	72.53	72.56	37.50	24.51	33.33	54.55	100.00	20.17	3.91	3.91
Tamuning/Tumon	3.51	3.51	2.41	0.09	4.35	34.04	3.33	0.07	1.13	1.13
Umatac	40.72	40.79	22.22	48.77	10.53	10.38	33.33	1.14	13.64	13.64
Yigo	6.18	6.18	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Yona	13.73	13.73	0.00	0.00	0.00	0.00	25.00	0.38	1.06	1.06
Total	22.23	8.53	3.66	1.00	4.97	7.22	12.03	2.58	1.50	1.23

Table F-23 Vulnerability Analysis Results by Village: Total Affected by High Landslide

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.00	0	0	0	0	0	0	0	0	0
Agat	2.25	1,042	3	2,784,249	4	6,310,191	1	31,704	286	24,394,370
Asan	0.00	0	0	0	0	0	0	0	0	0
Barrigada	0.00	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.00	0	0	0	0	0	0	0	0	0
Dededo	0.00	0	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.00	0	0	0	0	0	0	0	0	0
Inarajan	0.00	0	0	0	0	0	0	0	0	0
Mangilao	0.00	0	0	0	0	0	0	0	0	0
Merizo	2.45	741	8	3,871,440	11	10,229,982	2	736,105	537	44,197,248
Mongmong - Toto-Maite	0.00	0	0	0	0	0	0	0	0	0
Piti	00.0	0	0	0	0	0	0	0	0	0
Santa Rita	0.00	0	0	0	0	0	0	0	0	0
Sinajana	0.00	0	0	0	0	0	0	0	0	0
Talofofo	0.00	0	0	0	0	0	0	0	0	0
Tamuning/Tumon	0.01	0	0	0	0	0	0	0	0	0
Umatac	3.61	464	7	1,596,278	17	41,337,879	3	1,434,607	228	14,944,944
Yigo	0.61	351	0	0	3	10,806,161	1	11,531	76	6,973,076
Yona	0.00	0	0	0	0	0	0	0	0	0
Total	8.93	2,598	18	8,251,967	35	68,684,213	7	2,213,947	1,127	90,509,638

Table F-24 Vulnerability Analysis Results by Village: Proportion Affected by High Landslide

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agat	21.19	21.19	15.00	6.39	44.44	26.26	50.00	9.56	20.85	20.85
Asan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barrigada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chalan Pago-Ordot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dededo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inarajan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mangilao	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Merizo	40.03	40.05	80.00	93.32	68.75	76.70	100.00	94.88	79.67	79.67
Mongmong-Toto-Malte	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Santa Rita	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sinajana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tamuning/Tumon	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Umatac	59.28	59.34	77.78	51.23	89.47	89.62	100.00	98.86	86.36	86.36
Yigo	1.70	1.71	0.00	0.00	9.09	19.41	16.67	0.97	1.55	1.55
Yona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4.26	1.63	5.07	0.91	9.67	7.76	5.26	1.96	2.81	1.48

Table F-25 Vulnerability Analysis Results by Village: Total Affected by Tsunami Inundation

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.002	8	0	0	0	0	1	277	0	0
Agat	0.70	325	9	37,642,213	4	7,726,747	2	298,743	553	47,168,135
Asan	0.23	87	3	9,243,541	1	621,572	3	966,321	142	13,930,910
Barrigada	0.00	0	0	0	0	0	0	0	0	0
Chalan Pago-Ordot	0.28	339	1	237,238	2	6,483,603	1	6,438	77	6,923,070
Dededo	0.16	238	0	0	0	0	0	0	0	0
Hagatna (Agana)	0.68	846	33	22,546,588	3	6,606,573	8	2,762,021	568	197,500,416
Inarajan	1.31	159	7	1,535,607	3	1,433,503	5	2,816,536	245	16,856,735
Mangilao	0.23	340	1	8,288,700	0	0	0	0	1	148,150
Merizo	0.82	248	2	688,844	11	6,837,292	2	769,670	434	35,719,936
Mongmong-Toto-Maite	0.27	1,012	0	0	0	0	0	0	29	4,498,422
Piti	1.96	388	13	9,548,203	11	245,835,548	11	75,318,444	369	52,588,773
Santa Rita	2.11	782	0	0	1	52,546	2	34,441	367	28,899,048
Sinajana	0.15	436	0	0	0	0	0	0	0	0
Talofofo	0.83	143	1	237,238	0	0	1	18,905	82	7,491,766
Tamuning/Tumon	0.64	2,210	19	82,269,731	7	4,940,338	10	2,716,620	333	137,421,774
Umatac	0.20	26	3	809,173	3	1,864,716	3	1,386,681	51	3,342,948
Yigo	0.33	190	0	0	0	0	0	0	0	0
Yona	0.84	269	1	237,238	0	0	3	1,413,343	19	3,351,828
Total	11.74	8,046	93	173,284,314	46	282,402,438	52	88,508,439	3,270	555,841,911

Table F-26 Vulnerability Analysis Results by Village: Proportion Affected by Tsunami Inundation

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	0.19	0.21	0.00	0.00	0.00	0.00	100.00	1.61	0.00	0.00
Agat	6.59	6.61	45.00	86.34	44.44	32.15	100.00	90.05	40.31	40.31
Asan	4.06	4.07	60.00	96.07	10.00	2.68	100.00	94.82	19.72	19.72
Barrigada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chalan Pago-Ordot	4.96	4.97	12.50	3.64	10.53	50.90	14.29	0.37	4.32	4.32
Dededo	0.53	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hagatna (Agana)	80.00	80.49	82.50	78.31	75.00	97.20	80.00	73.39	90.45	90.45
Inarajan	6.99	7.00	46.67	7.68	17.65	3.49	83.33	97.84	23.83	23.83
Mangilao	2.24	2.24	3.57	13.53	0.00	0.00	0.00	0.00	0.03	0.03
Merizo	13.40	13.41	20.00	16.60	68.75	51.26	100.00	99.21	64.39	64.39
Mongmong-Toto-Maite	14.84	14.83	0.00	0.00	0.00	0.00	0.00	0.00	2.20	2.20
Piti	26.67	26.69	68.42	78.59	84.62	89.10	100.00	99.97	45.50	45.50
Santa Rita	12.85	12.85	0.00	0.00	8.33	0.18	40.00	3.54	13.79	13.79
Sinajana	16.85	16.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Talofofo	4.66	4.69	12.50	8.61	0.00	0.00	100.00	25.41	8.44	8.44
Tamuning/Tumon	11.23	11.23	22.89	15.81	30.43	6.79	33.33	34.50	9.39	9.39
Umatac	3.28	3.32	33.33	25.97	15.79	4.04	100.00	95.56	19.32	19.32
Yigo	0.92	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yona	4.15	4.15	8.33	0.35	0.00	0.00	75.00	79.54	1.01	1.01
Total	5.60	5.05	26.20	19.13	12.71	31.91	39.10	78.53	8.16	9.08

Table F-27 Vulnerability Analysis Results by Village: Total Affected by Very High Wildland Fire

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.26	965	0	0	0	0	0	0	132	12,121,560
Agat	5.78	2,676	1	64,680	2	5,929,473	2	275,601	256	21,835,520
Asan	2.19	826	4	9,480,779	5	11,618,092	1	34,647	351	34,434,855
Barrigada	0.62	648	0	0	1	5,307,901	1	3,974	108	13,138,632
Chalan Pago-Ordot	3.02	3647	1	112,179	6	2,004,580	2	273,869	686	61,678,260
Dededo	14.34	21,309	5	4,709,417	31	30,346,601	2	287,153	2273	362,525,316
Hagatna (Agana)	0.18	224	0	0	1	190,359	1	5,979	36	12,517,632
Inarajan	5.88	714	3	1,733,541	4	1,192,649	3	1,427,751	240	16,512,720
Mangilao	2.50	3,695	2	1,417,238	3	4,375,564	2	269,541	233	34,518,950
Merizo	2.50	756	0	0	6	3,298,219	2	734,594	350	28,806,400
Mongmong-Toto-Maite	0.39	1,462	1	2,332,857	0	0	1	1,316	142	22,026,756
Piti	2.79	552	5	2,364,627	0	0	2	292,051	270	38,479,590
Santa Rita	5.57	2,064	0	0	5	12,126,426	4	555,331	730	57,483,120
Sinajana	0.66	1,916	5	2,516,329	7	1,763,726	2	259,429	416	41,733,120
Talofofo	8.03	1,377	0	0	0	0	1	5,375	109	9,958,567
Tamuning/Tumon	0.62	2,141	5	76,301,476	1	24,763,412	2	253,465	69	28,474,782
Umatac	2.29	294	1	237,238	7	16,685,139	2	723,218	88	5,768,224

Yigo	19.29	11,074	3	1,757,040	8	16,875,498	1	70,406	993	91,108,74 3
Yona	5.75	1,840	0	0	3	6,673,962	2	715,962	466	82,207,99 2
Total	82.66	58,180	36	103,027,4 01	90	143,151,60 1	33	6,189,662	7,948	975,330,7 39

Table F-28 Vulnerability Analysis Results by Village: Proportion Affected by Very High Wildland Fire

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% Sq. Miles	% of No.	% of Value	% of Value	of No.	of Value	of No.	of Value	of No.	of Value
Agana Heights (Passan)	25.24	25.34	0.00	0.00	0.00	0.00	0.00	0.00	14.57	14.57
Agat	54.43	54.42	5.00	0.15	22.22	24.67	100.00	83.07	18.66	18.66
Asan	38.62	38.65	80.00	98.54	50.00	50.00	33.33	3.40	48.75	48.75
Barrigada	7.29	7.30	0.00	0.00	5.88	45.28	6.67	0.05	3.81	3.81
Chalan Pago-Ordot	53.45	53.46	12.50	1.72	31.58	15.74	28.57	15.69	38.50	38.50
Dededo	47.40	47.41	14.29	11.59	32.29	24.25	11.11	6.94	22.99	22.99
Hagatna (Agana)	21.18	21.31	0.00	0.00	25.00	2.80	10.00	0.16	5.73	5.73
Inarajan	31.38	31.41	20.00	8.67	23.53	2.91	50.00	49.60	23.35	23.35
Mangilao	24.32	24.32	7.14	2.31	10.71	11.73	40.00	22.60	7.35	7.35
Merizo	40.85	40.86	0.00	0.00	37.50	24.73	100.00	94.69	51.93	51.93
Mongmong-Toto-Maite	21.43	21.42	12.50	28.41	0.00	0.00	50.00	0.44	10.77	10.77
Piti	37.96	37.96	26.32	19.46	0.00	0.00	18.18	0.39	33.29	33.29
Santa Rita	33.92	33.93	0.00	0.00	41.67	42.57	80.00	57.08	27.42	27.42
Sinajana	74.16	73.92	71.43	76.86	77.78	58.66	100.00	99.24	59.51	59.51
Talofofo	45.11	45.15	0.00	0.00	0.00	0.00	100.00	7.22	11.23	11.23
Tamuning/Tumon	10.88	10.88	6.02	14.66	4.35	34.04	6.67	3.22	1.95	1.95
Umatac	37.60	37.60	11.11	7.61	36.84	36.17	66.67	49.84	33.33	33.33
Yigo	53.91	53.92	27.27	13.71	24.24	30.31	16.67	5.92	20.24	20.24
Yona	28.40	28.40	0.00	0.00	17.65	8.62	50.00	40.29	24.67	24.67
Total	39.40	36.51	10.14	11.37	24.86	16.18	24.81	5.49	19.84	15.94

Table F-29 Vulnerability Analysis Results by Village: Total Affected by High Wildland Fire

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	Square Miles	No.	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)	No.	Value (\$)
Agana Heights (Passan)	0.20	742	2	2,491,844	2	5,498,260	1	1,816	246	22,590,180
Agat	4.02	1,861	8	36,310,459	4	10,996,520	1	37,831	606	51,688,770
Asan	2.73	1,029	1	140,932	3	5,688,619	1	9,879	136	13,342,280
Barrigada	3.49	3,643	9	17,950,630	5	2,650,775	4	546,406	834	101,459,436
Chalan Pago-Ordot	1.11	1,341	4	3,348,646	3	1,002,290	1	13,042	415	37,312,650
Dededo	10.67	15,855	13	12,318,461	43	58,343,652	6	1,318,771	3816	608,621,472
Hagatna (Agana)	0.06	75	5	4,904,000	0	0	2	302,330	31	10,779,072
Inarajan	10.39	1,261	5	14,143,458	10	33,717,102	2	34,479	425	29,241,275
Mangilao	4.17	6,164	7	21,997,560	16	24,378,338	1	51,722	1043	154,520,450
Merizo	3.40	1,028	8	2,856,499	10	10,039,623	1	38,345	288	23,703,552
Mongmong-Toto-Maite	0.43	1,612	0	0	2	811,931	2	267,448	400	62,047,200
Piti	3.14	622	3	2,597,238	2	30,071,313	1	14,804	149	21,235,033
Santa Rita	6.61	2,449	2	983,541	2	5,498,260	1	75,061	1009	79,452,696
Sinajana	0.07	204	0	0	0	0	0	0	88	8,828,160
Talofofo	8.02	1,375	3	586,655	5	7,794,189	1	33,594	426	38,920,638
Tamuning/Tumon	1.27	4,386	24	126,113,750	6	6,071,719	7	1,536,285	706	291,350,668
Umatac	3.68	473	8	2,878,842	10	23,511,636	2	725,571	175	11,470,900
Yigo	7.37	4,231	5	6,695,188	20	38,013,017	4	587,853	2150	197,264,650
Yona	11.47	3,670	2	1,394,743	6	53,430,452	2	310,352	718	126,663,816
Total	82.30	52,021	109	257,712,447	149	317,517,696	40	5,905,588	13,661	1,890,492,898

Table F-30 Vulnerability Analysis Results by Village: Proportion Affected by High Wildland Fire

Village	Area	Population	Essential Facilities		Major Utilities		Transportation Systems		GBS	
	% of Sq. Miles	% of No.	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value	% of No.	% of Value
Agana Heights (Passan)	19.42	19.49	33.33	46.13	50.00	93.52	100.00	10.54	27.15	27.15
Agat	37.85	37.85	40.00	83.29	44.44	45.76	50.00	11.40	44.17	44.17
Asan	48.15	48.15	20.00	1.46	30.00	24.48	33.33	0.97	18.89	18.89
Barrigada	41.06	41.05	37.50	62.99	29.41	22.61	26.67	7.19	29.44	29.44
Chalan Pago-Ordot	19.65	19.66	50.00	51.39	15.79	7.87	14.29	0.75	23.29	23.29
Dededo	35.27	35.28	37.14	30.33	44.79	46.63	33.33	31.87	38.59	38.59
Hagatna (Agana)	7.06	7.14	12.50	17.03	0.00	0.00	20.00	8.03	4.94	4.94
Inarajan	55.44	55.48	33.33	70.72	58.82	82.18	33.33	1.20	41.34	41.34
Mangilao	40.56	40.58	25.00	35.90	57.14	65.34	20.00	4.34	32.91	32.91
Merizo	55.56	55.57	80.00	68.85	62.50	75.27	50.00	4.94	42.73	42.73
Mongmong - Toto-Maite	23.63	23.62	0.00	0.00	28.57	18.07	100.00	89.10	30.33	30.33
Piti	42.72	42.78	15.79	21.38	15.38	10.90	9.09	0.02	18.37	18.37
Santa Rita	40.26	40.25	28.57	3.74	16.67	19.30	20.00	7.72	37.90	37.90
Sinajana	7.87	7.87	0.00	0.00	0.00	0.00	0.00	0.00	12.59	12.59
Talofofo	45.06	45.08	37.50	21.30	55.56	39.34	100.00	45.15	43.87	43.87
Tamuning/Tumon	22.28	22.28	28.92	24.24	26.09	8.35	23.33	19.51	19.90	19.90
Umatac	60.43	60.49	88.89	92.39	52.63	50.97	66.67	50.00	66.29	66.29
Yigo	20.60	20.60	45.45	52.26	60.61	68.28	66.67	49.42	43.82	43.82
Yona	56.64	56.64	16.67	2.03	35.29	69.03	50.00	17.47	38.01	38.01
Total	39.22	32.64	30.70	28.44	41.16	35.88	30.08	5.24	34.09	30.89

APPENDIX G – PLAN MAINTENANCE DOCUMENTS

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Annual Review Questionnaire

PLAN SECTION	QUESTIONS	YES	NO	COMMENTS
PLANNING PROCESS	Are there internal or external organizations and agencies that have been invaluable to the planning process or implementing a mitigation project and should be added to the HMAC?			
	Are there procedures (e.g., meeting announcements, plan updates) that can be done more efficiently?			
HAZARD PROFILES	Has a natural and/or human-caused disaster occurred in this reporting period?			
	Are there natural and/or human-caused hazards that have not been addressed in this HMP and should be?			
	Are additional maps or new hazard studies available? If so, what have they revealed?			
VULNERABILITY ANALYSIS	Are there any new essential facilities, lifeline utility systems, or transportation systems that need to be added to the current asset list?			
	Have there been changes in development patterns that could influence the effects of hazards or create additional risks?			
MITIGATION STRATEGY	Are there new or additional financial capabilities that are available for funding mitigation actions/projects?			
	Are the goals still applicable?			
	Do additional mitigation actions/projects need to be added to the Implementation Strategy?			
	Does the Implementation Strategy need to be reprioritized?			

QUARTERLY REPORT

FEMA HAZARD MITIGATION GRANT PROGRAM SUBGRANTEE QUARTERLY REPORT FORM FOR PERIOD _____ to _____

NAME
ORGANIZATION
ADDRESS
PHONE (S)
FAX
E-MAIL

PROJECT NAME:

PROJECT NUMBER:

1. *PROJECT START DATE:*

2. *PROJECT AMOUNT: \$*

3. *ANTICIPATED COMPLETION DATE*

4. *TOTAL COST EXPENDED TO DATE* \$ _____ 0 _____

5. *TOTAL FEDERAL REIMBURSEMENT RECEIVED* \$ 0

6. TOTAL FEDERAL REIMBURSEMENT PENDING \$ 0

7. ANTICIPATED COST OVERRUN (UNDERRUN)

8. SUMMARY OF PROGRESS ON PROJECT for the time frame [INSERT DATE]
by task as listed on the state/local work agreement or contract. (Attach
additional sheets if necessary.)

9. PROBLEMS ENCOUNTERED:

10. ASSISTANCE NEEDED:

11. STATUS (Please check pertinent information.):

PROJECT STATUS

- (1) _____ Project on schedule
- (2) _____ PROJECT SUSPENDED
- (3) _____ Project delayed
- (4) _____ Project cancelled
- (5) _____ Project completed
- (6) _____ Final

PROJECT COST STATUS

- (1) _____ Cost unchanged
- (2) _____ COST OVERRUN
- (3) _____ Cost under-run

HAZARD MITIGATION GRANT PROGRAM

FINAL CLAIM

Upon completion of all work and payment of expenditures, please submit this sheet with your final Request for Reimbursement to:

Anthony M. Babauta

Governor's Authorized Representative / Governor's Chief of
Staff c/o **Leo Rustum J. Espia**, Guam Hazard Mitigation
Officer Guam Homeland Security/Office of Civil Defense
221-B Chalan Palasyo
Agana Heights, GU
96910

APPLICANT NAME:

PHONE NUMBER:

HAZARD MITIGATION PROJECT #:

FEDERAL DISASTER #:

SUBGRANTEE CERTIFICATION:

I HEREBY CERTIFY THAT, TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL WORK AND COSTS CLAIMED ARE ELIGIBLE IN ACCORDANCE WITH THE GRANT CONDITIONS; ALL WORK CLAIMED HAS BEEN COMPLETED; AND ALL COSTS CLAIMED HAVE BEEN PAID IN FULL.

SIGNED: _____ **DATE:** _____

Authorized Applicant's Agent

TITLE OF AUTHORIZED AGENT:

GOVERNMENT OF GUAM CERIFICATION:

I CERTIFY THAT ALL FUNDS WERE ACTUAL DIRECT EXPENDITURES IN ACCORDANCE WITH THE PROVISION OF THE FEMA-STATE AGREEMENT AND I RECOMMEND AN APPROVED AMOUNT OF \$ _____.

SIGNED: _____ **DATE:** _____

GOVERNOR'S Authorized Representative

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