CHAPTER 3. GEOLOGICAL AND SOIL RESOURCES

3.1 INTRODUCTION

This chapter describes the potential environmental impacts to geological and soil resources associated with implementation of the alternatives within the region of influence (ROI). Geology describes the surface and subsurface materials of which a land area is composed, including soils and rocks. The characteristics of soils and underlying rocks include stability, slope, compatibility, shear strength, and agricultural productivity. This chapter assesses how the action alternatives would potentially affect geological and soil resources. Because the geology and soils relate to the physical foundation of Guam, the proposed land uses would affect characteristics of erosion and surface changes, such as land clearing and slope cuts, but not the overall geological and soil conditions. Instead, geology and soils are more likely to affect the placement or location of a land use; for example a sinkhole could provide an obstacle to establishing a housing land use.

For a description of the affected environment for all resources, refer to the respective chapters of Volume 2 (Marine Corps Relocation – Guam); those chapters are presented in the same order as the resource areas contained in this Volume. The locations described in Volume 2 also include the ROI for the Army Air and Missile Defense Task Force (AMDTF) component of the proposed action.

This chapter first discusses existing conditions, then identifies impacts by alternatives and components, and concludes with identification and discussion of proposed mitigation measures that apply to impacts.

3.2 ENVIRONMENTAL CONSEQUENCES

3.2.1 Approach to Analysis

3.2.1.1 Methodology

The methodology for identifying, evaluating, and mitigating impacts to geology and soil resources was established through review of geologic and soil studies, federal laws and regulations, state and local building codes, and grading ordinances. Previously published National Environmental Policy Act (NEPA) documents for actions in the Mariana Islands Range Complex (MIRC) and surrounding area were also reviewed. A site-specific geotechnical investigation was not undertaken for this Environmental Impact Statement (EIS).

Light Detection and Ranging (LIDAR) Contour Data was used to identify potential sinkholes on proposed sites. Analysis of topography, soil, and vegetation was completed during site characterization using LIDAR Contour Data, geotechnical reports, and site visits to ensure minimal impacts to geological and soil resources.

Geologic and soil impacts include any resulting effects that the proposed action would have on the geology and soils of each geographic area as described in the affected environment section. Effects can occur during construction or during operations, and may include:

Construction

- Cut and fill activities leading to soil erosion
- Removal of vegetation leading to soil erosion

- Use of heavy equipment resulting in soil compaction
- Impacts to karst topography (surface collapse)

Operation

- Impervious surface increase resulting in increased soil erosion
- Vehicle movements on unpaved surfaces resulting in increased soil erosion and compaction
- Troop movements on unpaved surfaces resulting in increased soil erosion
- Munitions impacts resulting in soil and subsurface contamination
- Fires resulting in reduced vegetation and increased soil erosion

The potential effects of these activities and their significance within the areas of occurrence under the alternative actions are described below. The analysis of potential impacts to geology and soils considers both direct and indirect impacts. Such disturbance may cause increased erosion and loss of productive soil. Direct impacts result from physical soil disturbances or topographic alterations, while indirect impacts include risks to individuals from geologic hazards, as well as impacts to water or marine biological resources away from the construction/operation site. Factors considered in determining whether an impact would be significant include the potential for substantial change in soil or slope stability. An impact to geological resources would be considered significant if the action would have the potential to disrupt geologic features, or if actions were to be affected by potential geologic hazards.

Many effects are associated with the training operations activities. Increases in runoff due to the removal of ground cover may increase sedimentation. Siltation and formation of sediment plumes and heavy metals and hazardous materials may be leached from munitions and explosives of concern.

Indirect groundwater impacts associated with the construction and operational activities include direct contamination of groundwater resources through percolation from surface runoff. Stormwater runoff can contribute to groundwater contamination. Water impacts are addressed in Chapter 4.

Construction activities are major sources of karst collapse, which can occur as a result of excavation, change of drainage patterns, or lowering the groundwater table (Islam 2005). Soil disturbance from construction can cause deposits to form in openings near the bedrock surface, which get heavier when saturated causing the underlying structure to collapse.

Potential geology and soil impacts addressed in this chapter are limited to elements of the proposed actions that could affect onshore land forms or that could be affected by geologic hazards. Potential soil contamination issues are addressed in Chapter 17 (Hazardous Materials and Wastes). Increased soil erosion also may indirectly impact water quality and aquatic ecosystems. Potential impacts to these resources are described in Chapter 4, Water Resources, Chapter 10, Terrestrial Biological Resources, and Chapter 11, Marine Biological Resources.

Regulatory Standards

The United States (U.S.) Environmental Protection Agency (USEPA) Region 9 grants the Guam Environmental Protection Agency (GEPA) authority to enforce portions of federal statutes via a Memorandum of Agreement (MOA). Under this MOA, the Safe Drinking Water Program, Water Resources Management Program, and the Water Pollution Control Program are administered by GEPA. GEPA's Water Pollution Control Program is responsible for protecting Guam's resources from point and non-point source pollution that includes administration of the National Pollutant Discharge Elimination System (NPDES) program. NPDES permits are required for large and small construction activities. Requirements include a Notice of Intent, a Notice of Termination, and a construction site Stormwater

Pollution Prevention Plan (SWPPP). Permits are required for projects that disturb greater than 1 acre (ac) (0.4 hectare [ha]) of soil, including lay-down, ingress and egress area. Phase I regulates construction activities disturbing 5 ac (2 ha) or more of total land area and Phase II regulates small construction activities disturbing between 1 and 5 ac (0.4 and 2 ha) of total land area. Erosion and sediment control plans would be typically included in the General Permits under NPDES for construction projects greater than 1 ac (0.4 ha).

An Environmental Protection Plan (EPP) is required for projects at the discretion of the GEPA Administrator**.** EPPs are specifically identified in 22 Guam Annotated Regulations, Division II, Chapter 10, Section 10103.C.5 (d). EPPs would include nonpoint source control management measures including erosion and sedimentation control, vegetation, wildlife resource protection measures, fugitive dust control, solid and hazardous waste management and disposal procedures, nutrient management plan, integrated pest management strategy/plan, confined animal facilities management plan, irrigation water management plan, personnel safety procedures, work site maintenance, and typhoon contingency plans, as necessary, depending on the work, project, activity and facility function.

Seismic, liquefaction, and ground shaking are reduced by following Unified Facilities Criteria (UFC) 3-31-04 (U.S. Army Corps of Engineers [USACE] 2007), that provides the Department of Defense (DoD) requirements for:

- Earthquake-resistant design for new buildings
- Evaluating and rehabilitating existing buildings for earthquake resistance
- Guidance on applying seismic design principles to specialized structural and non-structural elements

The new UFC adopts the seismic design provisions of the 2003 *International Building Code* for use in DoD building design.

3.2.1.2 Determination of Significance

For geology and soils, the significance of potential project impacts is determined by subjective criteria, as well as by regulatory standards. An impact to geological resources would be considered significant if the proposed action would have the potential to disrupt geologic features, or if the proposed action would be affected by potential geologic hazards. To be considered a significant impact, the following factors are considered for each project area:

- Any increase in rate of erosion and soil loss from physical disturbance
- Reduced amounts of productive soils
- Alteration of surrounding landscape and effect on important geologic features (including soil or rock removal that would adversely affect site drainage)
- Diminished slope stability
- Increased vulnerability to a geologic hazard (e.g., seismic activity, tsunami, liquefaction), and the probability that such an event could result in injury

3.2.1.3 Issues Identified During Public Scoping Process

The following analysis focuses on possible effects to geologic and soils resources that could be impacted by the proposed actions. As part of the analysis, related concerns expressed by the public, including regulatory stakeholders, during scoping meetings were considered. These include:

- Implementing erosion control measures for construction and post-construction phases

- Ensuring the proper permitting and local government clearances are sought where applicable

3.2.2 Headquarters/Housing Alternatives

This description of environmental consequences addresses all components of the proposed actions for the Army AMDTF. This includes the headquarters/housing component and the munitions storage component, each of which has three alternatives. A full analysis of each alternative is presented beneath the individual headings of this chapter. The weapons emplacement component has four alternatives. Detailed information on the weapons emplacements is contained in a Classified Appendix (Appendix L). A summary of impacts specific to each set of alternatives (including an unclassified summary of weapons emplacement impacts) is presented at the end of this chapter.

3.2.2.1 Headquarters/Housing Alternative 1 (Preferred Alternative)

Under Alternative 1, the Army administration/headquarters (HQ) and maintenance facility would be co-located with the Marine Corps in the northern portion of Naval Computer and Telecommunications Station (NCTS) Finegayan. Unaccompanied personnel housing facilities would also be located within NCTS Finegayan. Accompanied personnel housing facilities would be co-located with the Main Cantonment housing areas in South Finegayan. Recreational and quality of life (QOL) facilities would be co-located within and adjacent to the housing areas.

North

NCTS Finegayan

Construction. The proposed Alternative 1 development would disturb soil during construction. There is a risk of increased rate of erosion, compaction, and soil loss from physical disturbance caused by construction activity; however, construction Standard Operating Procedures (SOPs) would be implemented to minimize impacts. Erosion potential for soils found at Finegayan is shown in Table 3.2-1.

Table 3.2-1. Soil Erosion Potential at Proposed Sites

Soil Type	*Location*	*Erosion Potential*
Guam Cobbly Clay Loam at 3-7% slope	Andersen AFB	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen AFB	slight
Guam Urban Land Complex at 0-3% slope	Andersen AFB	slight
Guam Urban Land Complex at 0-3% slope	NCTS Finegayan	slight
Guam Cobbly Clay Loam at 3-7% slope	NCTS Finegayan	slight
Guam-Yigo Complex at 0-7% slope	South Finegayan	slight
Guam Cobbly Clay Loam at 3-7% slope	South Finegayan	slight
Guam Urban Land Complex at 0-3% slope	South Finegayan	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen South	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen South	slight
Guam Urban Land Complex at 0-3% slope	Andersen South	slight
Guam Cobbly Clay Loam at 7-15% slope	Navy Barrigada	slight
Pulantat Clay at 3-7% slope	Navy Barrigada	slight
Pulantat Clay at 7-10% slope	Navy Barrigada	slight
Urban Land Coastal Fill at 0 -3% slope	Navy Barrigada	slight
Guam Cobbly Clay Loam at 3-7% slope	Air Force Barrigada	slight
Chacha Clay at 0-5% slope	Air Force Barrigada	slight
Pulantat-Kagman Clays at 0-7% slope	Air Force Barrigada	slight

Source: Young 1988.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would include requirements for stormwater compliance and Best Management Practices (BMPs), including the use of hay bales and silt fences around disturbed soil areas, to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. A more detailed explanation of regulatory permitting requirements is available in Volume 8. Implementation of measures noted in the geology and soils column would prevent erosion; therefore, the impacts from soil erosion would be less than significant. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Therefore, Alternative 1 impacts to soil erosion, compaction, and loss of agriculturally productive soil would be less than significant.

Construction activities under Alternative 1 would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. Therefore, changes to the landscape associated with Alternative 1 would result in less than significant impacts to unique geological resources.

There are at least ten sinkholes in the vicinity of the proposed Main Cantonment area. Known sinkholes in the Army AMDTF project area would be avoided and a buffer zone of vegetation would be left around all sinkholes as a proposed mitigation measure to prevent further erosion or expansion. As a result of the proposed mitigation, these sinkholes would not be affected by construction activities. A survey by a licensed geologist is required prior to construction to ensure that all sinkholes have been identified. If additional sinkholes are discovered, significant impacts to these sinkholes would be determined and projects would be designed in consideration of these sinkholes as appropriate. Any known sinkholes, along with any others found in proximity to the planned headquarters/housing area that are deemed hazardous would be fenced off and signs put in place to warn of the potential danger. With the proposed mitigation, less than significant impacts are expected.

Finegayan is located in a potentially active seismic zone. Hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). The Alternative 1 proposed developments would be located on a relatively level area that would not be subject to slope instability. This would result in less than significant impacts associated with geologic hazards during construction.

Operation. Topography and landscape features would not change substantively under Alternative 1. The topography is relatively level thus slope stability would not be diminished. The action area is located in an area with karst geologic features that are of concern for the operation of these facilities. Operations would not occur over unstable karst features. Sinkholes that are deemed to be hazardous would be avoided and a buffer zone of vegetation would be left around all sinkholes as a proposed mitigation measure to prevent further erosion or expansion, with fences and signs put in place to warn of the potential danger. Operations activities would not disturb or compact soil or cause an increase in erosion. Therefore, with proposed mitigation, Alternative 1 would result in less than significant impacts to unique geological resources and it would not result in erosion or compaction.

NCTS Finegayan is located in a potentially active seismic zone. The Alternative 1 proposed developments would be located on a relatively level area that would not be subject to slope instability. The predominant limestone bedrock is not subject to liquefaction. Hazards associated with earthquakes and fault ruptures would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings

(USACE 2007). Therefore, Alternative 1 would result in less than significant impacts associated with geologic hazards during the operations phase of the proposed action.

South Finegayan

Construction. The proposed Alternative 1 development would disturb soil during construction. There would be a risk of an increased rate of erosion, compaction, and soil loss from physical disturbance caused by construction activity; however, SOPs would be implemented to minimize impacts. Erosion potential for soils found at Finegayan is shown in Table 3.2-1.

Soil types disturbed would not be agriculturally productive soils. Soil erosion is primarily a concern for discharge into surface or near shore waters that are not located near the proposed construction. Construction SOPs, including use of hay bales and silt fences to surround disturbed areas, would be followed to minimize soil erosion. Therefore, Alternative 1 impacts to soil erosion and loss of agriculturally productive soil would be less than significant.

Construction SOPs would include requirements for stormwater compliance and BMPs to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. A more detailed explanation of regulatory permitting requirements is available in Volume 8. Implementation of measures noted in the geology and soils column would prevent erosion; therefore, the impacts from soil erosion would be less than significant. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Alternative 1 would result in less than significant impacts to soil compaction and agriculturally productive soil.

Construction activities under Alternative 1 would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. Therefore, changes to the landscape associated with Alternative 1 would result in less than significant impacts to unique geological resources.

South Finegayan is located in a potentially active seismic zone. Hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). This would result in less than significant impacts associated with geologic hazards.

Operation. Topography and landscape features would not change substantively under Alternative 1. The topography is level, thus slope stability would not be diminished. The action area would be located in an area with karst geologic features that are of concern for the operation of these facilities. Operations would not occur over unstable karst features. Operations activities would not disturb or compact soil or cause an increase in erosion. Therefore, Alternative 1 would result in less than significant impacts to unique geological resources and it would not result in erosion or compaction.

South Finegayan is located in a potentially active seismic zone. The Alternative 1 proposed developments would be located on a relatively level area that would not be subject to slope instability. The predominant limestone bedrock is not subject to liquefaction. Hazards associated with earthquakes and South fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Alternative 1 would result in less than significant impacts associated with geologic hazards during the operations phase of the proposed action.

Central

Navy Barrigada

Navy Barrigada lands would not be used; therefore, there would be no impacts to those lands under Alternative 1.

Air Force Barrigada

Air Force Barrigada lands would not be used; therefore, there would be no impacts to those lands under Alternative 1.

Alternative 1 Proposed Mitigation Measures

Known sinkholes would be avoided and a buffer zone of vegetation would be left around them as a mitigation measure to prevent further erosion or expansion. As a result of mitigation, the sinkholes would not be affected by construction activities. A survey by a licensed geologist would be required prior to construction to ensure that all sinkholes have been identified. If additional sinkholes are discovered, significant impacts to these sinkholes would be determined and projects would be designed in consideration of these sinkholes as appropriate. Any known sinkholes, along with any others found, that are deemed hazardous would be fenced off and signs put in place to warn of the potential danger. With the proposed mitigation, less than significant impacts would occur.

3.2.2.2 Headquarters/Housing Alternative 2

Under Alternative 2, the Army AMDTF HQ would be co-located with the unaccompanied housing at the 1,081-ac (438-ha) Navy Barrigada site.

North

NCTS Finegayan

Finegayan land would not be used; therefore, there would be no impacts to Finegayan under Alternative 2.

South Finegayan

South Finegayan would not be used under Alternative 2; therefore, there would be no impacts to South Finegayan under Alternative 2.

Central

Navy Barrigada

Construction. The proposed Alternative 2 at Navy Barrigada would disturb soil during construction. There is a potential for soil loss and an increased rate of erosion and/or compaction from physical disturbance caused by construction activity. SOPs would be implemented to minimize these impacts. Erosion potential for soils found at Navy Barrigada is shown in Table 3.2-1.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would include requirements for stormwater compliance and BMPs, including the use of hay bales and silt fences around disturbed soil areas, to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. A more detailed explanation of regulatory permitting requirements is available in Volume 8. Implementation of measures noted in the geology and soils column would prevent erosion; therefore, the impacts from soil erosion

would be less than significant. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Therefore, Alternative 2 impacts to soil erosion, compaction, and loss of agriculturally productive soil would be less than significant.

Construction activities under Alternative 2 would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. There are no known sinkholes at Navy Barrigada. Therefore, changes to the landscape associated with Alternative 2 would result in less than significant impacts to unique geological resources.

Navy Barrigada is located in a potentially active seismic zone; however, there are no known bedrock faults in Navy Barrigada. The predominant limestone bedrock is not vulnerable to liquefaction. The Alternative 2 proposed developments would be located on a relatively level plateau that would not be subject to slope instability. During project design and construction, hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). This would result in less than significant impacts associated with geologic hazards.

Operation. Topography and landscape features would not change substantively under Alternative 2. The topography is level, thus slope stability would not be diminished. The action area is located in an area with karst geologic features that are of concern for the operation of these facilities. Operations would not occur over unstable karst features. Operations activities would not disturb or compact soil or cause an increase in erosion. Therefore, Alternative 2 would result in less than significant impacts to unique geological resources and would not result in significant erosion or compaction.

Although Navy Barrigada is located in a potentially active seismic zone, the hazards associated with earthquakes, fault rupture and slope instability would be minimized during construction. Hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). The Alternative 2 proposed developments would be located on a relatively level area that would not be subject to slope instability. The predominant limestone bedrock is not vulnerable to liquefaction. Therefore, Alternative 2 would result in less than significant impacts associated with geologic hazards.

Air Force Barrigada

Air Force Barrigada lands would not be used; therefore, there would be no impacts to those lands under Alternative 2.

Alternative 2 Proposed Mitigation Measures

Because impacts on geological and soil resources are less than significant, there are no mitigation measures proposed. SOPs and BMPs for erosion and sedimentation controls would protect geological and soil resources during construction. During the operations phase of the proposed action, BMPs such as sound stormwater management practices would minimize impacts to these resources.

3.2.2.3 Headquarters/Housing Alternative 3

Under Alternative 3, the Administration/HQ and Maintenance Facility would be co-located with Marine Corps facilities in the northern portion of NCTS Finegayan. The unaccompanied personnel housing facilities would also be located on NCTS Finegayan. Accompanied personnel housing would be co-located with Marine Corps housing at Navy Barrigada and Air Force Barrigada. Recreational and QOL facilities would be co-located within and adjacent to the housing areas.

North

NCTS Finegayan

Construction. The impacts for NCTS Finegayan would be the same as those for Alternative 1.

Operation. The impacts for NCTS Finegayan would be the same as those for Alternative 1.

South Finegayan

South Finegayan would not be developed under Alternative 3; therefore, there would be no impacts to South Finegayan.

Central

Navy Barrigada

Construction. The impacts would be the same as those for Alternative 2 at Navy Barrigada.

Operation. Impacts would be the same as those for Alternative 2 at Navy Barrigada.

Air Force Barrigada

Construction. The proposed Alternative 3 at Air Force Barrigada would disturb soil during construction. There is a potential for soil loss and an increased rate of erosion and/or compaction from physical disturbance caused by construction activity. SOPs would be implemented to minimize these impacts. Erosion potential for soils found at Barrigada is shown in Table 3.2-1.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would include requirements for stormwater compliance and BMPs, including the use of hay bales and silt fences around disturbed soil areas, to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. A more detailed explanation of regulatory permitting requirements is available in Volume 8. Implementation of measures noted in the geology and soils column would prevent erosion; therefore, the impacts from soil erosion would be less than significant. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Therefore, Alternative 3 impacts to soil erosion, compaction, and loss of agriculturally productive soil would be less than significant.

Construction activities under Alternative 3 would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. There are no known sinkholes at Air Force Barrigada. Therefore, changes to the landscape associated with Alternative 3 would result in less than significant impacts to unique geological resources.

Air Force Barrigada is located in a potentially active seismic zone. However, there are no known bedrock faults at Air Force Barrigada. The predominant limestone bedrock is not vulnerable to liquefaction. The Alternative 3 proposed developments would be located on a relatively level plateau that would not be subject to slope instability. During project design and construction, hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). This would result in less than significant impacts associated with geologic hazards.

Operation. Topography and landscape features would not change substantively under Alternative 3. The topography is level, thus slope stability would not be diminished. There are no known sinkholes at Air

Force Barrigada. Operations activities would not disturb or compact soil or cause an increase in erosion. Therefore, Alternative 3 would result in less than significant impacts to unique geological resources and would not result in significant erosion or compaction.

Although Air Force Barrigada is located in a potentially active seismic zone, the Alternative 3 proposed developments would be located on a relatively level area that would not be subject to slope instability. The predominant limestone bedrock is not vulnerable to liquefaction. Hazards associated with earthquakes and fault rupture would be minimized during project design and construction by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007); therefore, Alternative 3 would result in less than significant impacts associated with geologic hazards.

Alternative 3 Proposed Mitigation Measures

Known sinkholes at NCTS Finegayan would be avoided and a buffer zone of vegetation would be left around them as a mitigation measure to prevent further erosion or expansion. As a result of proposed mitigation, the sinkholes would not be affected by construction activities. A survey by a licensed geologist would be required prior to construction to ensure that all sinkholes have been identified. If additional sinkholes are discovered, significant impacts to these sinkholes would be determined and projects would be designed in consideration of these sinkholes as appropriate. Any known sinkholes, along with any others found, that are deemed hazardous would be fenced off and signs put in place to warn of the potential danger. With proposed mitigation, less than significant impacts would occur.

3.2.3 Munitions Storage Alternatives

3.2.3.1 Munitions Storage Alternative 1 (Preferred Alternative)

Construction

The proposed Alternative 1 magazine construction would occur near the Habitat Management Unit (HMU) (see Figure 2.4-2). Proposed construction would disturb 6.6 ac (2.7 ha) of soil during construction. Erosion potential for soils found at Andersen Air Force Base (AFB) is shown in Table 3.2-1. The type of soil disturbed by the construction of the ECMs would be Guam Urban Land Complex. There is a risk of increased rate of erosion, compaction, and soil loss from physical disturbance caused by construction activity; however, construction SOPs would be implemented to minimize impacts.

Soil types disturbed near the HMU during construction of the munitions storage facilities would not be agriculturally productive soils. Construction SOPs would be followed to minimize soil erosion. The construction SOPs would include requirements for stormwater compliance and BMPs, including use of hale bales and silt fences, to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Implementation of measures noted in the geology and soils column would prevent erosion, thus the impacts from soil erosion would be less than significant. A more detailed explanation of regulatory permitting requirements is available in Volume 8.

Construction activities under Alternative 1 would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. Therefore, changes to the landscape associated with Alternative 1 would result in less than significant impacts to unique geological resources.

Sinkholes are common in Northern Guam. Known sinkholes would be avoided and a buffer zone of vegetation would be left around all sinkholes as a mitigation measure to prevent further erosion or expansion. As a result of mitigation, the sinkholes would not be affected by construction activities. A survey by a licensed geologist would be required prior to construction to ensure that all sinkholes have been identified. If additional sinkholes are discovered, significant impacts to these sinkholes would be determined and projects would be designed in consideration of these sinkholes as appropriate. Any known sinkholes, along with any others found, that are deemed hazardous would be fenced off and signs put in place to warn of the potential danger. With proposed mitigation, less than significant impacts are expected.

Andersen AFB is located in a potentially active seismic zone. The predominant limestone bedrock is not vulnerable to liquefaction. The Alternative 1 proposed magazine construction would be located on a relatively level plateau that would not be subject to slope instability. During project design and construction, hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007) and applicable military requirements for munitions storage facilities. This would result in less than significant impacts associated with geologic hazards.

Operation

Under Munitions Storage Alternative 1 operations at Andersen AFB MSA 1 would be minimal because the magazines would be primarily used for storage. In accordance with established ammunitions storage requirements, native grassy vegetation would be established on and around the earth-covered magazines and would be maintained (e.g., periodically mowed) to minimize fire hazard. Storage operations would not directly or indirectly impact soil or geological resources.

3.2.3.2 Munitions Storage Alternative 2

Existing conditions do not vary between the three munitions storage alternatives at Andersen AFB MSA 1. Therefore, impacts for Munitions Storage Alternative 2 are identical those described for Munitions Storage Alternative 1.

3.2.3.3 Munitions Storage Alternative 3

Existing conditions do not vary between the three munitions storage alternatives at Andersen AFB MSA 1. Therefore, impacts for Munitions Storage Alternative 3 are identical those described for Munitions Storage Alternative 1.

3.2.4 Weapons Emplacement Alternatives

Detailed information on the weapons emplacements is contained in a Classified Appendix (Appendix L). An unclassified summary of impacts specific to each set of alternatives is presented at the end of this chapter.

3.2.5 No-Action Alternative

Under the no-action alternative, the Army AMDTF would not be established on Guam. No construction or operation would occur. Existing activities on Guam would continue; therefore, the no-action alternative has no impacts to geology or soils.

3.2.6 Summary of Impacts

Tables 3.2-2, 3.2-3, and 3.2-4, summarize the potential impacts of each major component – headquarters/housing, munitions storage, and weapons emplacement, respectively. A text summary is provided below.

Table 3.2-1. Summary of Headquarters/Housing Impacts – Alternatives 1, 2, and 3

Alternative 1	*Alternative 2*	*Alternative 3*
Construction		
LSI • Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings • Less than significant impacts to topography and slope stability • Less than significant impacts to soil erosion and compaction through use of construction SOPs and BMPs	LSI • The impacts would be the same as for Alternative 1; additionally impacts to sinkholes would be less than significant as there are no known sinkholes at Navy Barrigada	LSI • The impacts would be the same as for Alternative 1
SI-M • Potential for erosion of sinkholes and/or collapse of unstable karst bedrock. With proposed mitigation, less than significant impacts to sinkholes would occur under Alternative 1		SI-M • The impacts would be the same as for Alternative 1
Operation		
LSI • Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings • Less than significant impacts to topography and slope stability • Less than significant impacts to soil erosion and compaction	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1
SI-M • Potential for erosion of sinkholes and/or collapse of unstable karst bedrock. With proposed mitigation, less than significant impacts to sinkholes would occur under Alternative		SI-M • The impacts would be the same as for Alternative 1

Legend: LSI = Less than significant impact; SI-M = Significant impact mitigable to less than significant

Table 3.2-2. Summary of Munitions Storage Impacts – Alternatives 1, 2, and 3

Alternative 1	*Alternative 2*	*Alternative 3*
Construction		
LSI • Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings and applicable military requirements for munitions storage facilities • Less than significant impacts to topography and slope stability • Less than significant impacts to soil erosion and compaction through use of construction SOPs and BMPs	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1
SI-M • Potential for erosion of sinkholes and/or collapse of unstable karst bedrock. With proposed mitigation, less than significant impacts to sinkholes would occur under Alternative 1	SI-M • The impacts would be the same as for Alternative 1	SI-M • The impacts would be the same as for Alternative 1
Operation		
• Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings • Less than significant impacts topography and slope stability • Less than significant impacts to soil erosion and compaction	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1

Legend: LSI = Less than significant impact; SI-M = Significant impact mitigable to less than significant

Table 3.2-3. Summary of Weapons Emplacement Impacts – Alternatives 1, 2, 3 and 4

Alternative 1	*Alternative 2*	*Alternative 3*	*Alternative 4*
Construction			
LSI • Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings and applicable military requirements for munitions storage facilities • Less than significant impacts to topography and slope stability • Less than significant impacts to soil erosion and compaction through use of construction SOPs and BMPs	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1
Operation			
LSI • Less than significant impacts due to seismic hazards through adherence to UFC 3-310-04 Seismic Design for Buildings • Less than significant impacts topography and slope stability • Less than significant impacts to soil erosion and compaction	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1	LSI • The impacts would be the same as for Alternative 1

Legend: LSI = Less than significant impact

Construction

Construction activities under the proposed action would include clearing, grading and grubbing, demolition of existing road pavement, earthwork, and planting vegetation. Temporary loss of vegetation would occur; however, replanting and ground maintenance would promote regrowth. There are at least ten sinkholes in the vicinity of the proposed Main Cantonment area. Sinkholes are also common in northern Guam in the areas proposed for the munitions storage areas. Known sinkholes would be avoided and a buffer zone of vegetation would be left around all sinkholes as a proposed mitigation measure to prevent further erosion or expansion. A survey by a licensed geologist would be required prior to construction of Headquarters/Housing Alternatives 1 and 3, and the munitions storage areas, to ensure that all sinkholes have been identified. If additional sinkholes are discovered, significant impacts to these sinkholes would be determined and projects would be designed in consideration of these sinkholes as appropriate. Any known sinkholes, along with any others found, that are deemed hazardous would be fenced off and signs put in place to warn of the potential danger. Through the use of proposed mitigation measures, the sinkholes would not be affected by construction activities of Headquarters/Housing Alternatives 1 and 3, or by the construction associated with the munitions storage area alternatives and the

weapons emplacement sites. There are no known sinkholes in the location of Headquarters/Housing Alternative 2. Therefore, changes to the landscape and topography associated with the proposed action would result in less than significant impacts to unique geological resources.

Andersen AFB, Finegayan, and Barrigada are located in a potentially active seismic zone. Hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). In addition, munitions storage areas and the weapons emplacement sites would be constructed in accordance with applicable military requirements. These measures would result in less than significant impacts associated with geologic hazards.

Soil types disturbed during construction of the headquarters/housing facilities, munitions storage areas, and weapons emplacement sites at would not be agriculturally productive soils. Construction SOPs would be followed to minimize soil erosion. Indirect impacts to geological resources, water resources, and marine biological resources from soil erosion would be prevented by implementation of BMPs. Replanting and ground maintenance would promote regrowth of vegetation; therefore, changes to the landscape associated with the constructing the munitions storage facilities would result in less than significant impacts to unique geological resources.

Operation

Topography and landscape features would not be changed substantively by the proposed action. Operational activities associated with the Headquarters/Housing Alternatives would be residential/recreational and administrative and would not involve activities such as excavation that would have a potential to diminish slope stability. For Headquarters/Housing Alternatives 1 and 3, the action area is located in an area with karst geologic features that are of concern for the operation of these facilities. Under either of those alternatives operations would not occur over unstable karst features. If deemed hazardous, any sinkholes found in the headquarters/housing area would be fenced off and signs put in place to warn of the potential danger. With proposed mitigation, less than significant impacts relative to sinkholes are expected. Headquarters/Housing activities would not disturb or compact soil or cause an increase in soil erosion. Therefore, the proposed action would result in less than significant impacts due to erosion, compaction, or changes to unique geological resources.

Andersen AFB, Finegayan, and Barrigada are located in a potentially active seismic zone. Hazards associated with earthquakes and fault rupture would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007) and applicable military requirements for munitions storage facilities. This would result in less than significant impacts associated with geologic hazards. In accordance with established ammunitions storage requirements, native grassy vegetation would be established on and around the earth-covered magazines and would be maintained (e.g., periodically mowed) to minimize fire hazard. Munitions storage operations would be minimal and would have less than significant impacts to soil or geological resources. All of the four alternatives for the weapons emplacement component would have the same (less than significant) impact upon geological and soil resources.

3.2.7 Summary of Proposed Mitigation Measures

Table 3.2-5 summarizes the proposed mitigation measures.

Table 3.2-4. Summary of Proposed Mitigation Measures

Headquarters/Housing Alternatives	*Munitions Storage Alternatives*	*Weapons Emplacement Alternatives*
Topography		
• None	• None	• None
Geology		
• Known sinkholes would be avoided and a buffer zone of vegetation would be left around them to prevent further erosion or expansion. Any sinkholes discovered would be evaluated to determine significant impacts and projects would be designed in consideration of these sinkholes as appropriate. With proposed mitigation, less than significant impacts to sinkholes would occur.	• The mitigation measures would be the same as those proposed for the Headquarters/ Housing Alternatives	• None
Geologic Hazards		
• None	• None	• None

Adaptive program management of construction is another mitigation measure intended for implementation by DoD to potentially reduce and avoid environmental impacts associated with the proposed expansion of the military mission on Guam overall. Adaptive program management of construction (reducing the number of concurrent construction projects) would reduce concurrent disturbance of soil and topography and therefore lessen the amount of erosion resulting from construction at a given time.