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SPECIAL REPORT

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STRATEGIC ENGINEERING STUDY
No. 116

CLASSIFICATION CHANGED TO *Restricted*
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NAME DATE

PALAWAN PROVINCE
(PHILIPPINE ISLANDS)

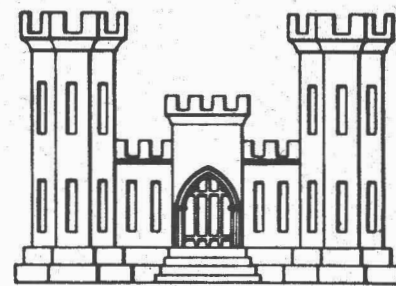
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TERRAIN INTELLIGENCE

Prepared by
GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR
Under direction of
CHIEF OF ENGINEERS, U.S. ARMY

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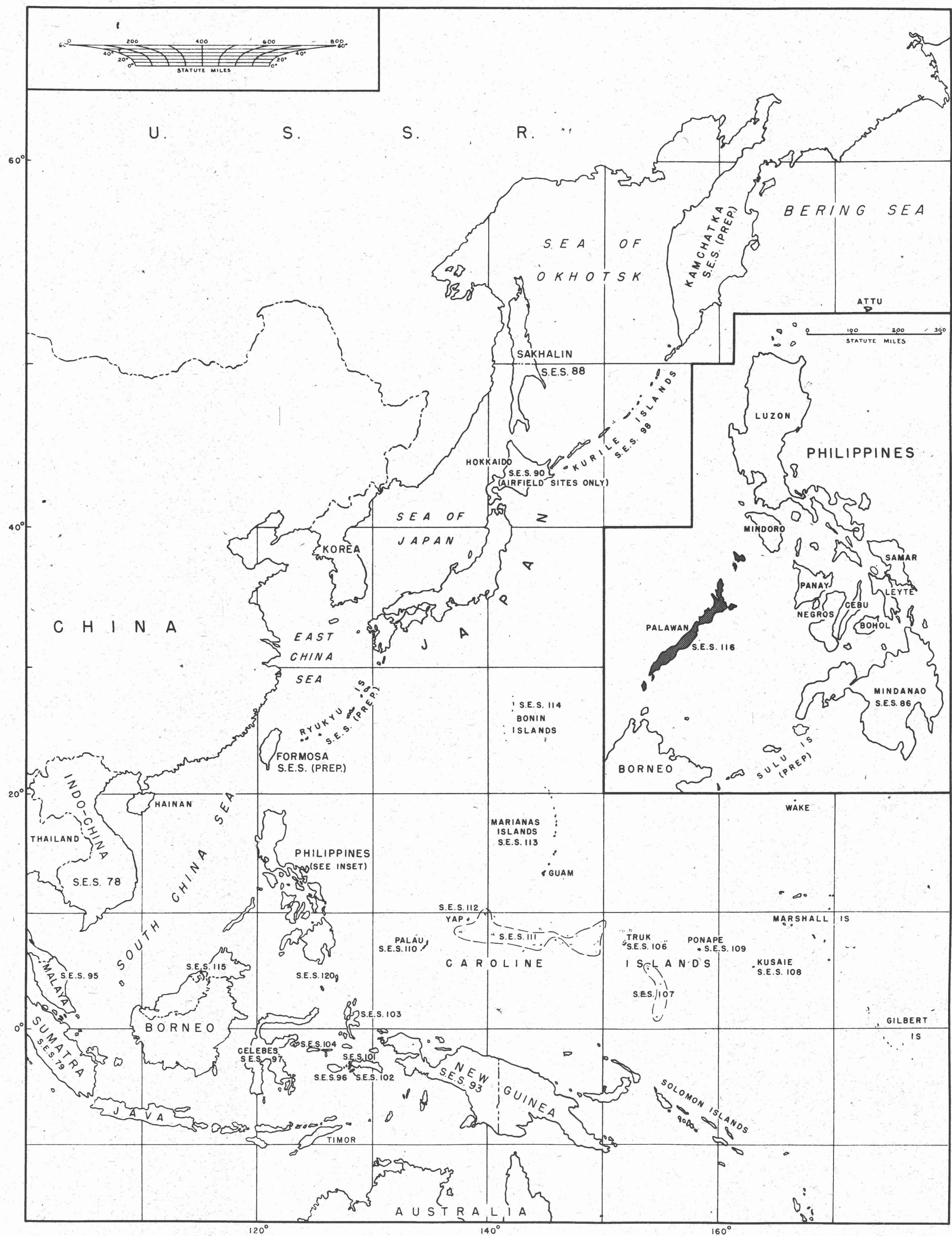
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JULY, 1944



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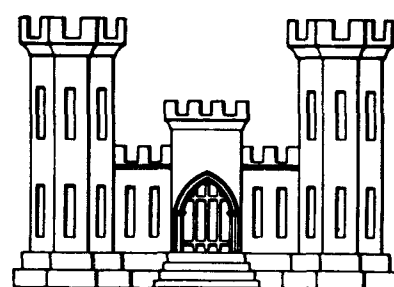
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SECTION OF MILITARY GEOLOGY
GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR
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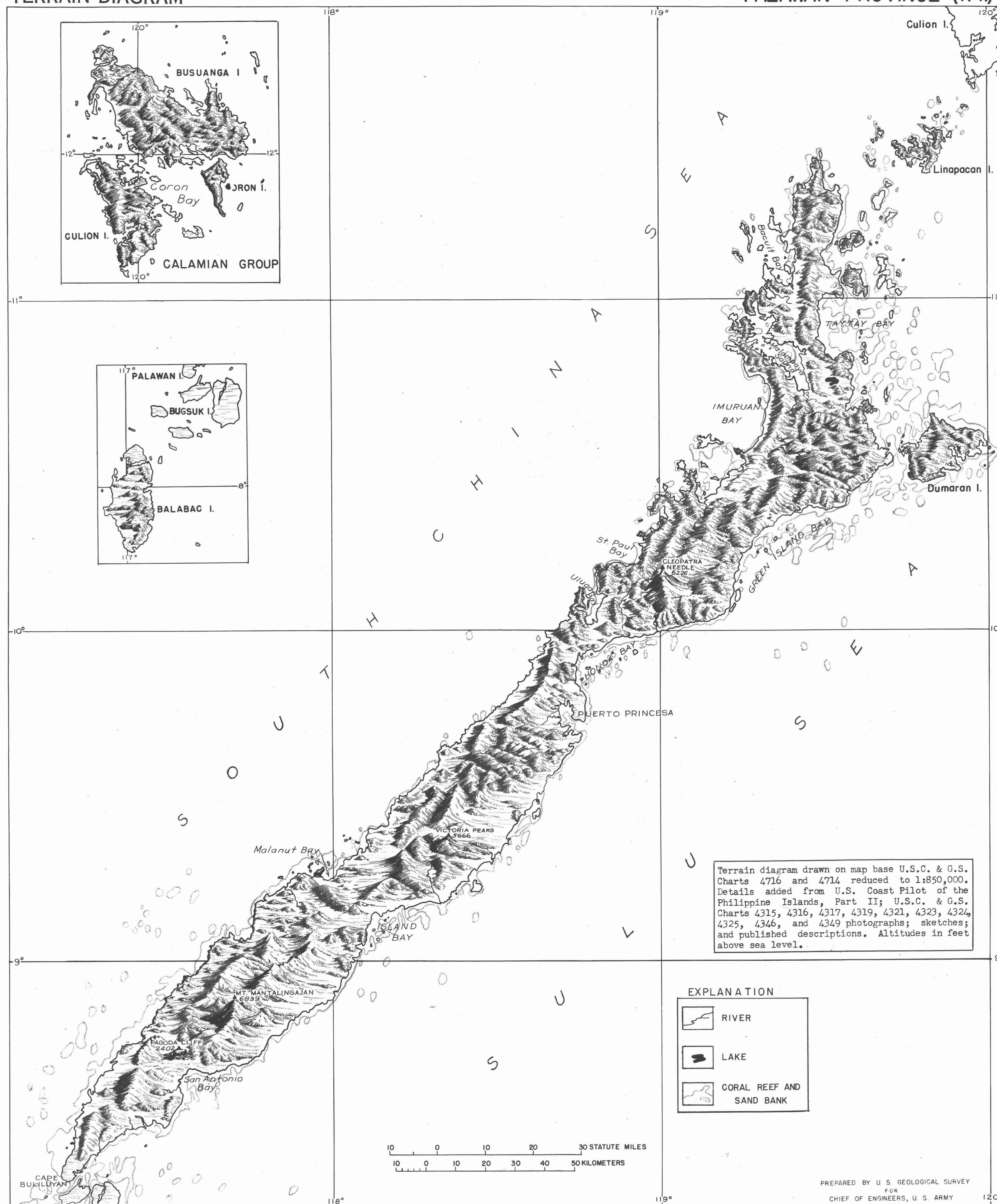
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JULY, 1944

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TERRAIN DIAGRAM

PALAWAN PROVINCE (P. I.)



PALAWAN PROVINCE (P. I.)

MILITARY ASPECTS OF TERRAIN

- A. Introduction: Palawan Province, one of the least known and least populated parts of the Philippine Islands, comprises 1,169 islands with a total land area of 5,693 square miles. The elongate and mountainous Palawan Island, largest of the group (4,550 square miles) trends northeast and separates the Sulu Sea from the South China Sea between the islands of Borneo and Mindoro. Small island groups lie at either end of Palawan and to the east. Because of the lack of mineral resources (except for the manganese deposits on Busuanga Island), the lack of extensive areas suitable for cultivation, and the relative isolation from large commercial centers, Palawan Province is relatively unknown and undeveloped.
- B. Terrain:
1. Palawan Island: Mountainous Palawan Island has discontinuous coastal lowlands seldom over two or three miles wide. These are most extensive on the east coast south of Puerto Princesa and in the Cape Buliluyan area at the southern tip of the island. Elsewhere hills and mountain spurs terminate in steep slopes or cliffs along the reef-fringed shore. The shoreline is generally irregular with many small islands and deep bays, especially in the northern part. Puerto Princesa and Malampaya Sound are the most important harbors. Small mangrove swamps fringe shores where the coast is low, especially at heads of small bays. Terrain of the island interior and the character of the west coast south of Ulugan Bay are not known in detail, but in the interior slopes are steep, stream valleys deep and narrow with only small floodplains. Mt. Mantalingajan, altitude 6,839 feet, is the highest summit on the island. Crossings from west to east coasts can be made with ease at only a few places: from the west coast to San Antonio Bay, from Ulugan Bay to Honda Bay, and from Malampaya Sound to Taytay Bay. Elsewhere mountainous terrain makes crossings difficult.
 2. Busuanga, Culion, and Coron Islands: Busuanga and Culion Islands, north of Palawan, have irregular coasts with many small bays and offshore islands; narrow coastal lowlands in places; elsewhere steep slopes descend directly to sea. Hilly terrain (relief to 2,000 feet), steep slopes, and lack of alignment of valleys hinder cross-island movement. Nearby Coron Island has a bold cliffed coast and rugged cliffed interior terrain unsuited for landings or movement. Small islands similar to Coron are scattered throughout Palawan Province.
 3. Balabac and Nearby Islands: The heavily forested islands to the south of Palawan, with the exception of Balabac, are low coral islands with sandy reef-fringed shores. Balabac is partly hilly with altitudes of more than 1,800 feet, steep slopes, and deep, narrow valleys. In the north and west, coastal lowlands are heavily forested. Coasts are fringed by coral reefs and in large part bordered by narrow belts of mangrove.
 4. Cuyo and Cagayan Islands: The small reef-fringed Cuyo and Cagayan Islands (not shown on terrain diagram) lie east of Palawan. Cuyo, the largest, is hilly with narrow stretches of coastal lowlands. Along the coasts of these small islands sandy beaches alternate with narrow belts of mangrove swamp.
- C. Climate: Hot, humid climate characterized by northeast winds from October to April and southwest winds from May to September. Maximum reported rainfall ranges from 79 to 126 inches with pronounced wet and dry seasons. Mean annual temperature reported to be about 82° F.; little variation throughout the year. Temperature decreases and rainfall increases with altitude. In the mountains the climate may be uncomfortably cool and damp. Climate is generally enervating.
- D. Water Supply:
1. Existing Supply: There are few existing water facilities in Palawan Province. Shallow wells and springs have been developed near some of the larger settlements; elsewhere drinking water is obtained from rain-water cisterns and streams. Some facilities can be further developed to furnish adequate and reliable supplies.
 2. Emergency Supply: Streams, springs, shallow dug wells or pits, and plant sources will furnish adequate emergency supplies for personnel except in areas of mangrove swamp, on narrow beaches, and on some of the smaller islands. Smaller streams commonly dry during dry season. Permanent streams cross coastal regions at intervals rarely exceeding 12 miles; may be brackish near mouths.
 3. Permanent Supply: Permanent sources can usually be developed from surface supplies along larger streams or shallow wells in coastal lowlands and stream alluvium. In areas of limestone bedrock, large springs can be developed for permanent supplies.
- E. Problems of Road Construction:
1. Existing Roads and Routes of Communication: In 1940 there were about 150 miles of roads in Palawan Province; only about 10 percent of the mileage was surfaced and all-weather. Road nets are present in the Puerto Princesa area (Palawan Island) and on Busuanga and Cuyo Islands. Additional mileage was projected in 1941; some may have been completed. The main project was the construction of roads along the eastern coast of Palawan Island from Taytay to San Antonio Bays. Cross-island roads were planned to follow the trails from Taytay Bay to Bacuit Bay and from San Antonio Bay to the west coast. Elsewhere, cross-island routes of communication are poor trails. Throughout the province numerous trails connect the more important settlements.
 2. Ease of Constructing Additional Roads: The mountainous terrain of much of Palawan Province will seriously interfere with road construction. Construction will be relatively easy only in coastal lowlands and the few cross-country lowlands, most of which have already been selected for the projected roads.
 3. Major Construction Problems: Stream crossings may be a major problem; it is reported that streams are numerous and mostly unmapped. Many small streams are dry during the dry season, but are subject to occasional flash floods. Drainage is probably a serious problem in some coastal areas. Construction materials may be scarce, but where rock exposures are lacking, stream channels may yield adequate quantities of sand and gravel. Locally, clearing may be difficult; however, in most areas suitable for roads, settlements with cleared and cultivated land are common.
- F. Airfield Construction:
1. Areas Suitable for Airfields: Extensive flat areas suitable for construction of large airfields are generally lacking in Palawan Province. Most flat land is in coastal areas where runways must be oriented parallel to the coastline. Areas most suitable for airfield sites are on the west coast of Busuanga Island (Outob Bay), along east coast of Palawan Island from region of Puerto Princesa to Cape Buliluyan, and on small flat coral islands south of Cape Buliluyan (Bugsuk and adjacent islands).
 2. Major Construction Problems: Little grading generally necessary; can be accomplished by graders and dozers. The major problem, drainage, may necessitate the use of subdrains, side collection channels, and raised subgrades. Clearing and grubbing in some heavily forested areas will require blasting and power equipment; elsewhere graders and dozers can clear low vegetation. Small streams and sea water near proposed runway sites will generally furnish sufficient water for construction. Suitable construction material generally available near the sites.
- G. Construction Materials Available: Coral reef limestone, commonly available on fringing coastal reefs which are bare at low tide, may furnish best construction material for use on coastal roads and airfields. Upraised coral reef limestone is reported in southern part of Palawan Island and the adjacent small islands. Sand and gravel are locally available on coastal beaches and in small stream channels. In north part of area, bedrock is mainly sandstone and shale; in south part, granite and sandstone with some limestone. Bedrock will generally require use of power tools and blasting for quarrying. Granite and sandstone (where hard) will require special equipment for crushing. Abundant supplies of timber suitable for heavy construction are locally available.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

PALAWAN PROVINCE (P. I.)

INTRODUCTION

This report was prepared by the Geologic Survey, U. S. Department of Interior, for the Chief of Engineers, U. S. Army during the period of March to June 1944. It presents a general regional picture of Palawan Province (P.I.) and also discusses detailed problems and features that have military significance. By means of tables and maps, the report considers the relationship of terrain, ground, and vegetation to movement, the problems of air-field construction and water supply, and data on construction materials, vegetation and climate.

Note: No road construction sheet is included in this folio; brief notes regarding problems of road alignment and construction are given under Terrain Appreciation, Movement.

RELIABILITY OF INFORMATION

Knowledge of Palawan Province is generally incomplete. For only a few areas are aerial photographs available. Maps include U. S. Coast and Geodetic Survey charts (various scales, mainly 1:100,000) and AMS quadrangles (scale 1:500,000). Coastal lines are carefully surveyed and location and altitude of prominent peaks and hills are probably reliable. Topography is shown by contour or form lines and hachures; relief features and drainage are incompletely mapped; it is reported that numerous streams are entirely unmapped. Settlements near the coasts are probably located accurately.

Reliability of map information and tables ranges from Class B (good) to Class D (poor), and ratings are shown on each table.

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Maps Consulted:

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 NB 50-2 Balabac Strait
 NC 50-3 Sibaltan
 NC 50-5 Sarap
 NC 50-6 Puerta Princesa
 NC 51-1 Cuyo Islands
 NC 51-4 Cagayan Islands
 ND 50-6 Western Busuanga Island
 ND 51-4 Mindoro Island

Army Map Service: Philippines (South), Special strategic map (1:2,000,000).

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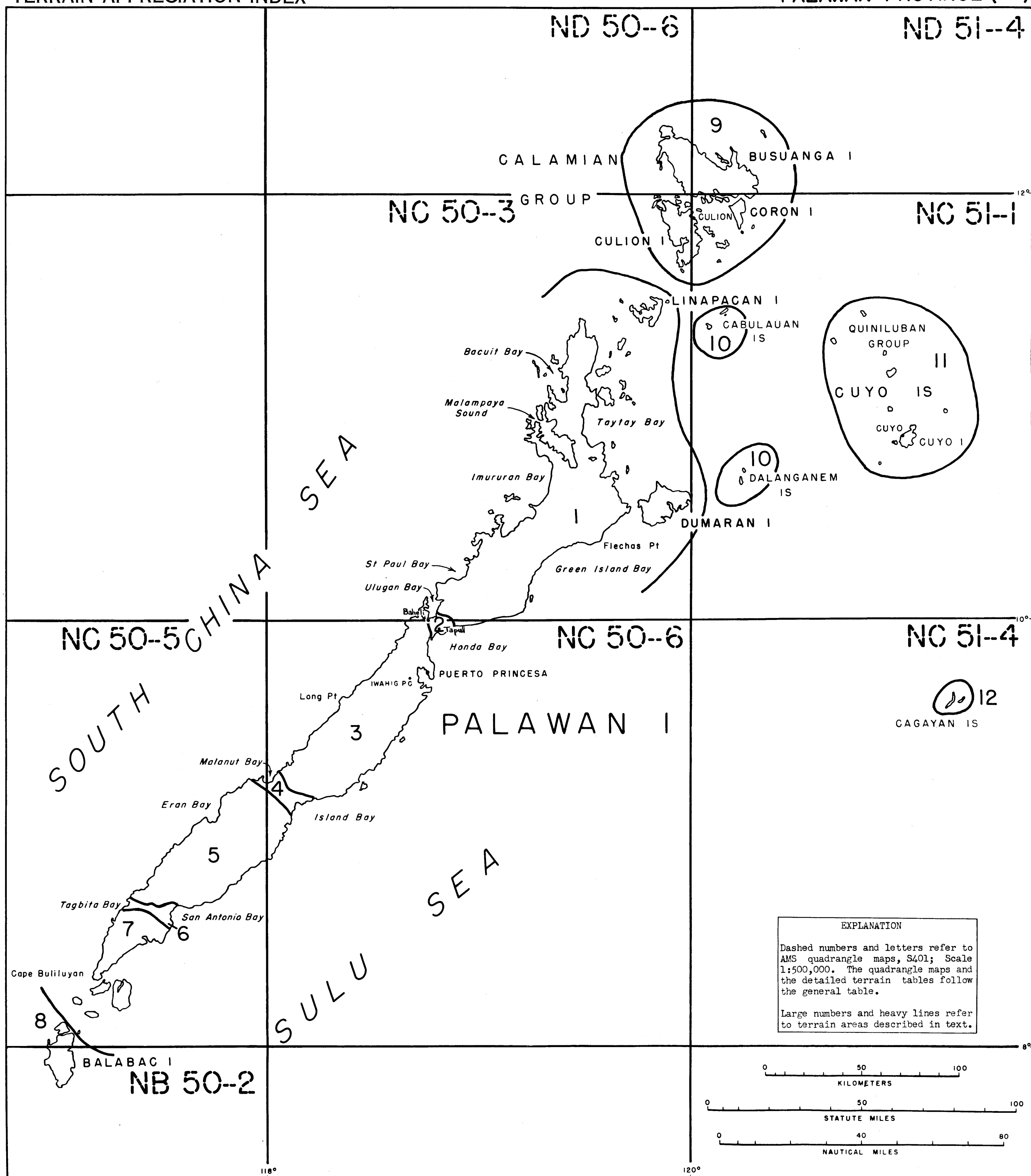
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U. S. Coast and Geodetic Survey Charts:
 4707 Philippine Islands, Southwestern part
 4716 Palawan
 4720 Balabac Strait and approaches
 4309 Balabac Strait
 4326 North Balabac Strait and vicinity
 4325 Nariz Point to Bugsuk Island
 4324 Southern Palawan
 4323 Malanao Island to Nariz Point
 4321 Bold Point to Malanao Island
 4319 Green Island Bay and vicinity
 4317 Shark Fin Bay to Flechas Point
 4316 Northwestern Palawan
 4347 Harbors of Balabac and Ramos Islands
 4346 Harbors of Palawan Island
 4349 Malampaya Sound and approaches
 4343 Puerto Princesa
 4334 Anchorages on the east coast of Palawan
 4355 Harbors on Dumaran Island
 4315 Palawan to Culion Island
 4350 Western entrance to Coron Bay
 4351 Coron Bay
 4314 Northern part of Busuanga
 4714 Southwestern Luzon and Mindoro
 4342 Halsey Harbor and Dicabaito Anchorage
 4335 Harbors on the north coast of Busuanga
 4312 Cuyo Islands
 4336 Anchorages in Cuyo Islands
 4356 Cagayan Islands

Prepared by U. S. Geological Survey
 for Chief of Engineers, U. S. Army.

TERRAIN APPRECIATION INDEX

PALAWAN PROVINCE (P.I.)



PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

PALAWAN PROVINCE (P. I.)

TERRAIN APPRECIATION

Reliability rating: Class B: Cagayan Islands and Balabac Strait Quadrangles; the Calamian Group; Coast of Palawan Island, except central western coast. Class D: all other areas.					
INTRODUCTION For further information, see quadrangle maps and detailed terrain descriptions following this table. General Statement Palawan Province is one of the least known and least populous parts of the Philippines. It comprises 1,169 islands with a total land area of 5,693 square miles. Palawan Island, the largest division, has an area of 4,550 square miles; it is 278 miles long and from 4.5 to 30 miles wide (average width 17 miles). The next largest islands, with their areas in square miles, are Busuanga (344), Culion (150), Dumaran (126), and Balabac (125). According to the 1939 Census, Palawan Province has a population of 93,673. The main settlements are Puerto Princesa (the capital), Culion (Culion Island), and Coron (Busuanga Island). The population of the Puerto Princesa district was 10,887. The southeastern coast of Palawan Island and Cuyo Island are also relatively populous districts. Most settlements consist of small native habitations; a few settlements have permanent structures. Busuanga Island has probably been developed more than other islands in recent years, owing to the establishment of a mining industry. The climate is hot and humid, but is moderated by frequent breezes. Rainfall ranges from about 79 to 126 inches per year; the rainy season is from May to December. Most of the islands are heavily forested. Because of the scanty population, relatively little land is cleared or under cultivation. Mangrove swamp, which is extensive in the coastal areas of other Philippine Islands, is generally limited in this region to narrow belts. Roads and Trails Palawan Province had only about 150 miles of completed roads in 1940. Much additional mileage was proposed; some of it may have been completed since that time. Not more than 10 percent of the completed mileage was surfaced all-weather road; probably all of this is in the Puerto Princesa area and constitutes the main road net of Palawan. This network of roads extends north to Honda Bay and south of Puerto Princesa Bay for about 30 miles along the eastern coast. In Busuanga Island, roads cover part of the southern coast and connect the mining districts in the interior with the north central coast. Poor roads cover much of Cuyo Island. In Palawan Island, a proposed road from Bacuit Bay to Malampaya Sound on the northwestern coast was to connect with a road extending northward from Honda Bay to Taytay Bay on the eastern coast. A section near Taytay Bay was completed and other sections were under construction in 1941. The road south of Puerto Princesa was to be continued to San Antonio Bay with branches to the western coast from Island Bay and San Antonio Bay. On the eastern coast, this road probably is to follow the route of the telegraph line. Extension of the southern coastal road in Busuanga Island and roads around the coasts of the Balabac and Dumaran Islands were also proposed. In northern Palawan Island and Busuanga Island trails are numerous. In the past, trails have been the main routes of overland travel between settlements. Water routes probably are most-used for transportation in the province. The mountainous terrain in much of the province is unfavorable for road construction. Steep slopes and deep, narrow ravines in the mountains of Palawan Island and the entire areas of rocky islands, such as Coron, will make road construction difficult. It is probable that the proposed roads are projected on the most suitable routes. They are almost everywhere confined to coastal lowlands and open valleys. Moderate slopes prevail in these areas. Near settlements much of the land has already been cleared. Stream crossings may be one of the most difficult problems. The maps, particularly of Palawan Island, are reported to show only a few of the numerous streams draining from the interior mountains. The channels may be dry during part of the year, but floods and high water can be expected in the rainy season. A careful survey will be necessary to determine the number of stream crossings. Sufficient supplies of sand, gravel, and crushed rock should be available in most areas, but it may be necessary to obtain rock from stream channels and banks because rock exposures are generally scarce. Drainage problems may be serious in some coastal areas. For details on drying and other properties of soils, see Soils: Engineering Data Sheet.					
Map Area	Topography	Movement	Observation	Concealment	Cover
1 NORTHERN PALAWAN AND ADJACENT ISLANDS	Relief: Mountainous and hilly region; many peaks over 2,000 feet; main ridges parallel coasts; slopes of 30 to 40% common; largely forested; some grassy lowlands. Very rugged small islands off northwestern coast; islands to east and northeast topographically similar to Palawan. Drainage: Many streams from interior mountains, mostly unmapped; some navigable to small boats in lower courses. Coastal Features: Discontinuous lowlands, some 4 to 5 miles long and wide; separated by cliffed headlands. Much mangrove swamp on eastern coast and in embayments on western coast of Palawan.	Existing Routes: Numerous trails. Road projected from Bacuit Bay to Malampaya Sound, thence to eastern coast and south; was not completed by 1941. Areas Favorable for Cross-country Movement: In general, barrier area; open valleys and coastal lowlands probably allow movement of foot troops and vehicles. Ease of Cross-country Movement: Many slopes too steep for vehicles. Footing poor in wet weather; generally good in dry weather. Forest permits movement, but thickets are obstacles; tall grass and underbrush require clearing in cultivated and grassland areas; mangrove swamps impenetrable for vehicles, difficult for foot troops.	Mountain slopes command routes, cultivated areas, settlements. Offshore islands overlook important embayments. Visibility limited in forest, in areas with much undergrowth or thickets, and in mangrove swamp; generally good elsewhere. ground observation, good where grass is tall, shrubs and trees are abundant; poor in park-like areas, in open cultivated land and on beaches.	Concealment from aerial and ground observation good in forest, thickets, mangrove swamp; from aerial observation, good in coconut groves, poor in grassland; from	Existing Cover: Mountain slopes good; in coastal areas, base of slopes, caves, shore bluffs, and undercut stream banks provide cover. Construction of Shelters: Excavation generally easy; lower slopes in mountains have 10 feet or more of soil; drainage adequate. Coastal soils may be very thick, but are commonly water-logged. Blasting necessary on rocky islands and cliffed headlands. Timber for protected shelters available; rock scarce in many places, but probably obtainable from streams.
2 TAPUL-BAHELI LOWLAND	Relief: Forested hilly lowland; maximum relief below 1,200 feet; valleys on east and west; hill slopes up to 40%. Drainage: Major stream extends about 20 miles inland; takes small craft about 7 miles upstream. Salt-water channel at southwest (not shown on quadrangle maps) extends 2 miles inland. Coastal Features: Narrow lowlands on both coasts, fringed mostly with mangrove swamp; slopes on east about 2 1/2%, on west 8 to 10%.	Existing Routes: Eastern coastal road from Puerto Princesa (Area 3) crosses area. Connecting road from Honda Bay to Ulugan Bay proposed; stage of construction unknown. Areas Favorable for Cross-country Movement: Relatively easy movement for foot troops; for vehicles in valleys and on coast. Ease of Cross-country Movement: Hill slopes too steep for vehicles. Wet-weather footing best in southwestern part of area. (See discussion under Area 1.)	Best observation points in higher mountainous areas to north and south (Areas 1 and 3). (See discussion of visibility under Area 1.)	See discussion under Area 1.	Existing Cover: Probably good in hills; however, area is commanded by mountains to north and south. Construction of Shelters: Blasting probably required in many places; soil on east and northeast thin; to west and southwest, excavation easy; soils 10 feet and more deep. Timber and rock readily available.
3 CENTRAL PALAWAN ISLAND	Relief: Heavily forested mountainous region with ranges paralleling coasts; numerous peaks over 2,000 feet; slopes of 30 to 50% common. On east, plain slopes gently, 3 to 4%, from mountains; in places 6 to 8 miles wide. Lowland around Puerto Princesa Bay. Western part of area poorly surveyed. Drainage: Many streams (mostly unmapped) drain interior mountains; some navigable by small craft in lower courses. Coastal Features: Mangrove swamps and short sandy beaches on eastern coast; low wooded plain in south part of western coast; hills extend to coast south of Puerto Princesa.	Existing Routes: Road net around Puerto Princesa, extends along eastern coast to Honda Bay on north and for about 30 miles south on eastern coast. Proposed road continues to south. Areas Favorable for Cross-country Movement: In general, barrier area; open valleys and coastal lowlands probably allow movement of foot troops and vehicles. Ease of Cross-country Movement: See discussion under Area 1.	Eastern coastal lowland can be observed from interior hills. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Inner edge of coastal lowlands, undercut stream banks, shore bluffs. Permanent buildings and structures in Puerto Princesa and nearby settlements. Construction of Shelters: Similar to Area 1.
4 ISLAND BAY-MALANUT BAY LOWLAND	Relief: Wooded lowland, between hills of Areas 3 and 5, near eastern coast. Hills on western coast. Maximum relief 500 to 1,000 feet; little information regarding slopes on north and south. Drainage: Small unmapped streams empty into bays on both coasts. Coastal Features: Low sandy plain on Island Bay coast fringed with mangrove swamp.	Existing Routes: Trail across island, may have been converted into road. Eastern coastal road projected through area; stage of construction unknown. Areas Favorable for Cross-country Movement: Generally easy east-west movement for foot troops and possibly for vehicles. Access to Areas 3 and 5 along coasts. Ease of Cross-country Movement: Free movement for vehicles. Good dry-weather footing; generally poor in wet weather. (See discussion under Area 1.)	Hills within area, also bordering mountain slopes in Areas 3 and 5, offer observation points. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Poor in general; probably good at base of hills at north and south and in caves on western coast. Construction of Shelters: Easy excavation; soils 10 feet or more deep; inland soils drain well; coastal soils may be water-logged. Timber available; rock for construction scarce.
5 SOUTHERN PALAWAN MOUNTAINS	Relief: High forested mountains in central part; numerous peaks over 3,000 feet; slopes 30 to 50%. Hills less than 1,000 feet high on west. Open lowland, about 3 miles wide, along much of eastern coast, slopes gently from mountains. Drainage: Many small streams (mostly unmapped) flow from central mountains. Coastal Features: Low, heavily wooded land, in places giving way to grassy plain. Scattered sandy beaches; mangrove swamp around Island Bay. Western coast poorly surveyed.	Existing Routes: Trail on western coast from Eran Bay south. Proposed eastern-coastal road from Puerto Princesa (Area 3) to extend through area; was to connect with western coast via Area 6; stage of construction unknown. Areas Favorable for Cross-country Movement: In general a barrier area; easiest movement on eastern coast. Ease of Cross-country Movement: See discussion under Area 1.	Mountain slopes overlook eastern lowland and lowlands of Areas 4 and 6. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Mountain slopes in interior provide cover; in coastal areas, base of slopes, shore bluffs, and undercut stream banks afford cover. Construction of Shelters: Soils 10 feet or more deep; excavation generally easy except in western hills and in southern part of eastern coast where soils are thinner. Drainage on coasts may be poor. Timber is available; rock for construction scarce except in southeastern coastal area and western hills.

(continued)

TERRAIN APPRECIATION

PALAWAN PROVINCE (P.I.)

Reliability rating: Class B: Cagayan Islands and Balabac Strait Quadrangles; the Calamian Group; Coast of Palawan Island, except central western coast. Class D: all other areas					
Map Area	Topography	Movement	Observation	Concealment	Cover
6 SAN ANTONIO BAY- TAGBITA BAY AREA	Relief: Wooded lowland extending inland from San Antonio Bay; inadequate information on western end of area; probably extends to coast at Tagbita Bay. Hills near western coast. Slopes of about 10% in hills on north and south. Drainage: Largest stream of south Palawan (Iwahig River) empties into San Antonio Bay; drains open fertile valley. Coastal Features: Low cleared and cultivated land on eastern coast. Sandy beach and bluffs on western coast. Mangrove swamp fringes low areas.	Existing Routes: Proposed road (1941) linking eastern and western coasts to cross lowland near San Antonio Bay; stage of construction unknown. Areas Favorable for Cross-country Movement: East-west movement probably easy; inadequate information on western part of area. Ease of Cross-country Movement: Slopes are generally not an obstacle. Slippery footing in wet weather; dry-weather footing good except in swampy coastal areas. (See discussion under Area 1.)	Hills in Areas 5 and 7 offer observation points. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Generally poor; best at inner rim of lowland against slopes of Areas 5 and 7. Construction of Shelters: Soil mostly thick; excavation easy; drainage fair except at coasts where soils may be waterlogged. Timber available; rock from hill slopes in Areas 5 and 7 adjoining lowland.
7 SOUTHERN PALAWAN AND ADJACENT ISLANDS	Relief: Forested mountains in north central part of area; maximum altitude about 3,500 feet; bordering hills are commonly less than 1,000 feet high; slopes in mountains 40% or more; in hills, 10%. Low plains with some hills fringe coasts; slopes of 4%. Small islands offshore are low and wooded; no prominent relief features. Drainage: Several streams drain from interior upland; other unmapped streams probably exist. Coastal Features: Mangrove swamp at southern tip of Palawan and along eastern coast; less extensive on western coast. Sandy beach inland from swamp in places. Larger islands bordered by mangrove swamp; smaller ones have sandy beaches.	Existing Routes: Trail from Cape Buliluyan north along eastern coast. Areas Favorable for Cross-country Movement: Foot troops and vehicles can move easily in coastal areas except swamps; low hills may permit movement of foot troops. Ease of Cross-country Movement: Free movement except in northern mountains. Wet-weather footing poor; low coastal areas, especially swamps, may be waterlogged at all times. (For effect of vegetation, see discussion under Area 1.)	Some hills may command coastal areas; interior mountains probably overlook eastern and western coasts. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Coasts and off-shore islands provide poor cover; best cover provided by forested mountains in north. Construction of Shelters: Easy excavation in interior (soils 10 to 20 feet deep). Blasting may be necessary in coastal areas where soils may be thin. Drainage poor along coasts. Timber available throughout area; rock scarce except in some coastal areas especially at northeast.
8 BALABAC AND RAMOS ISLANDS	Relief: Balabac Island is hilly and locally mountainous; maximum altitude 1,867 feet; hill slopes range from 10 to 20%; low hills extend along western coast; lowland reported across southern part of island. Ramos Island is low and wooded; few hills, highest 350 feet. Drainage: Streams known to be present; no details available. Coastal Features: Mangrove swamp and low coastal plain on western coast of Balabac and in bays on east; bluffs and cliffs on eastern coast. Mangrove swamp and sandy beach on Ramos Island coasts.	Existing Routes: Trail from Balabac Town to western coast. Proposed road around entire coast of Balabac Island; stage of construction unknown. Areas Favorable for Cross-country Movement: Western coastal area and southern lowland probably best; may permit use of vehicles. Ease of Cross-country Movement: Footing good in dry weather except in swampy coastal areas. (For effect of vegetation, see discussion under Area 1.)	Southern hills provide best observation points. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Interior hills and shore bluffs afford cover. Construction of Shelters: Easy excavation; most soils 10 feet or more deep; near settlements, may be thin and rock excavation may be necessary. Drainage satisfactory, except in coastal areas. Timber available; rock for construction may be scarce.
9 CALAMIAN GROUP	Relief: Busuanga and Culion Islands are composed of low mountains and open valleys; maximum relief in Busuanga, 2,140 feet; in Culion, 1,558 feet; slopes from 15 to 60%, with steeper ones more common in Busuanga. Coron Island is extremely rugged throughout; almost vertical cliffs, hundreds of feet high, and knife-like crests are predominant features; highest altitude about 2,000 feet. Many small islands; topographically resemble Busuanga. Drainage: Meandering streams along coasts of Busuanga and Culion; low interior plains may be flooded at times. No permanent channels on Coron Island. For the most part, streams are unmapped. Coastal Features: Mangrove swamp is common on coasts of Busuanga and Culion; on north and east coasts of Busuanga and on west and south coasts of Culion, bluffs and cliffs common. Coron Island is faced with very steep cliffs (commonly over 100% slope) that rise several hundred feet; are undercut at base and contain caves.	Existing Routes: Roads in southern and central Busuanga; some are under construction. Road in northern Culion. Numerous trails in Busuanga, some in Culion; mostly unmapped. No routes known in Coron. Areas Favorable for Cross-country Movement: Relatively easy movement for foot troops and vehicles in most of Busuanga and Culion. Difficult movement throughout Coron for foot troops; no known routes for vehicles. Ease of Cross-country Movement: Open low areas in Busuanga and Culion permit easy movement. Slopes are a barrier in all parts of Coron. Footing adequate in dry weather. (For effect of vegetation, see discussion under Area 1.)	Ridge crests and peaks command extensive areas of Busuanga and Culion; shore cliffs of Coron overlook lower islands to east and north. (See discussion of visibility under Area 1.)	Similar to Area 1.	Existing Cover: Cover provided by mountain slopes, permanent buildings in settlements of Busuanga, caves in Coron, and coastal bluffs. Construction of Shelters: Blasting may be required to excavate; soil probably thin except in coastal areas of Busuanga and Culion; drainage is poor. Timber and rock available.
10 CABULAUAN AND DALANGANEM ISLANDS	Relief: Small rocky islands and islets; highest peak 1,024 feet. Slopes of 30 to 70%. Dalanganem Islands most rugged. Drainage: Small streams indicated; probably few permanent channels. Coastal Features: Clifed coasts common; small rocky inlets; lowland at northwest of Cabulauan Island.	Existing Routes: None indicated. Areas Favorable for Cross-country Movement: Difficult movement in most places. Ease of Cross-country Movement: Steep slopes are barrier; little level land. Footing adequate in dry weather, poor in wet weather. Vegetation not an obstacle.	Hilltops and ridge crests overlook islands. Visibility good except where undergrowth is abundant.	Generally poor; (for discussion see Area 1.)	Existing Cover: Generally poor; coastal cliffs and interior hill slopes provide some cover. Construction of Shelters: Blasting probably necessary; soils thin throughout. Timber and rock available.
11 CUYO ISLANDS	Relief: Small hilly islands and low reef islets. Cuyo Island is largest; composed of two prominent hills connected by low neck; slopes of 6 to 8% in larger, southern part of Cuyo. Quiniluban Group at north are rugged; maximum altitude 1,010 feet; slopes of 30 to 55%. Drainage: Few permanent stream channels; inadequate data. Coastal Features: Mangrove swamp most common on Cuyo Island; sandy beach on east coast and in central islands. Northern islands clifed; local beaches.	Existing Routes: Several fair to poor roads on Cuyo Island. Trails on other islands. Areas Favorable for Cross-country Movement: Easy movement on Cuyo Island and southern islands; Quiniluban Group probably difficult. Ease of Cross-country Movement: Steep slopes can be avoided in most islands except Quiniluban Group. Wet-weather footing good only in interior of Cuyo Island. Much open land; vegetation is a limited obstacle.	Hilltops in all islands are observation points. Visibility generally good.	Similar to Area 1.	Existing Cover: Cliffs and ledges at coasts provide cover; poor cover in interior, except in Quiniluban Group. Construction of Shelters: Excavation easy in Cuyo Island; soil is 10 feet or more deep; drains well in interior. Thin soil on other islands; blasting may be required. Timber and rock available.
12 CAGAYAN ISLANDS	Relief: Low, narrow, wooded islands on extensive coral reef. Smooth, level topped ridges, 150 to 200 feet high; many slopes 5 to 15%, maximum 35%. Drainage: No streams mapped. Coastal Features: Bluffs and sandy beach.	Existing Routes: None indicated. Areas Favorable for Cross-country Movement: Easy movement except on bluffed shores. Ease of Cross-country Movement: Slopes gentle on some coasts. Low trees and shrubs may impede movement. Footing satisfactory at all times, except in low coastal areas and on small islets.	Ridge tops overlook islands; visibility may be limited where vegetation is dense.	Generally poor; heavy cover of low trees and shrubs give best concealment.	Existing Cover: Generally poor; coastal bluffs best. Construction of Shelters: Excavation generally easy; soils are 10 to 30 feet deep; drain well. On low-lying islets and in some coastal areas, soils may be thin; blasting necessary. Timber and rock available.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

PHILIPPINE ISLANDS 1:500,000 TERRAIN APPRECIATION



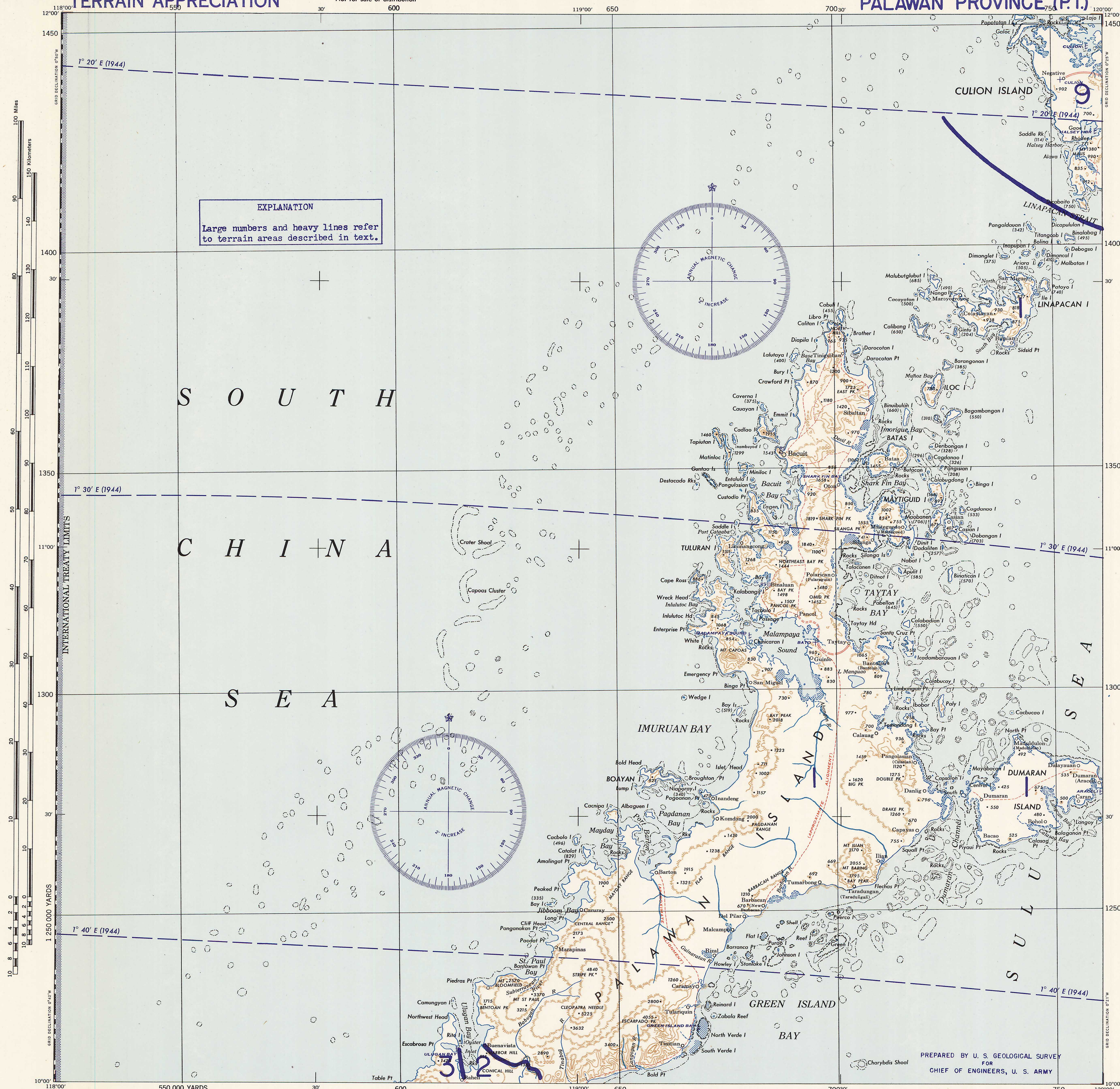
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SIBALTAN

SECOND EDITION-AMS 2

NC 50-3

PALAWAN PROVINCE (P.I.)



A.M.S. S401

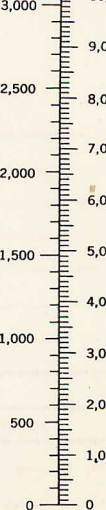
First Edition (AMS 1), 1943
Second Edition (AMS 2), 1944
Prepared under the direction of the Chief of Engineers, U.S. Army, by
the Army Map Service (AMS), U.S. Army, Washington, D.C., 1944.
Compiled from: Sectional Aeronautical Chart 1:600,000 USC & GS, No. 5, 1941. USC & GS Charts 4315, 1917;
4316, 1938, 4317, 1918, 4319, 1920, 4321, 1920, 4714, 1936, 4716, 1938.
Volumes I and V, Commission of the Census, Commonwealth of the Philippines, 1940. Intelligence Data, 1943.
Roads from: Official Road Map of the Philippines, 1:500,000 Bureau Public Works, No. 14, 1941.

L.M.T. 7 hrs. 54 min. ahead G.M.T.

7 hrs. 56 min.
Scale 1:500,000

L.M.T. 7 hrs. 58 min. ahead G.M.T.

CONVERSION
GRAPH
NOT at the scale
of the map.



- LEGEND**
- Road, surfaced, all-weather
 - Road, partially surfaced, generally all-weather
 - Track, Trail
 - Road under construction, 1941
 - Boundary, International Treaty Limits
 - Boundary, Provincial
 - Boundary, Chartered City
 - Railroad, 3'6" gauge, with Station
 - Railroad, Less than 3'6" gauge
 - Railroad, Electric
 - Telephone and Telegraph Line
 - Power Transmission Line
 - City, First Importance
 - City, Second Importance
 - City or Large Town
 - Small Town
 - Village or Settlement
 - Aerodrome, Auxiliary Landing Field
 - Seaplane Base, Auxiliary Anchorage
 - Principal Navigation Light
 - Radio Station
 - Telephone Station, Telegraph Station
 - Mud Flat, Tidal Flat
 - Mangrove

MANILA

DAVAO

Tagum

Pina

Kalan

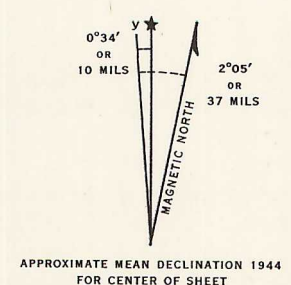
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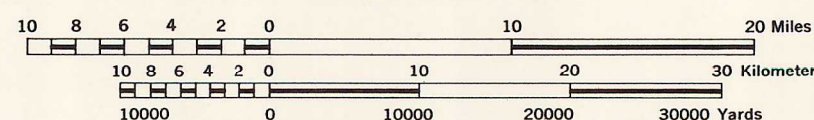
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APPROXIMATE MEAN DECLINATION 1944
FOR CENTER OF SHEET
ANNUAL MAGNETIC CHANGE 2' INCREASE
Do not use diagram except to obtain
numerical value of angles



CONTOUR INTERVAL 500 FEET

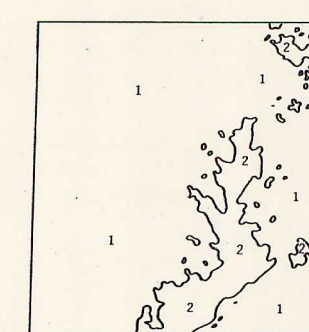
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FIFTY THOUSAND YARD PHILIPPINE POLYCONIC GRID
THE LAST THREE DIGITS OF THE GRID NUMBERS ARE OMITTED

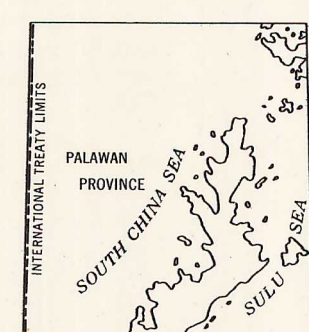
NOTE: OFFICERS USING THIS MAP WILL MARK HEREON CORRECTIONS
AND ADDITIONS WHICH COME TO THEIR ATTENTION AND MAIL
DIRECT TO THE CHIEF OF ENGINEERS, WASHINGTON, D. C.

HEIGHTS IN FEET AND DEPTHS IN FATHOMS

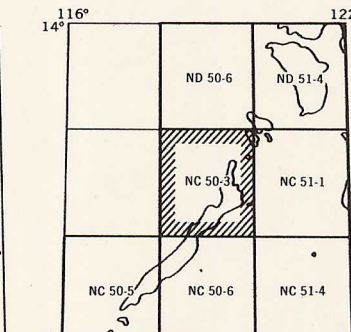
COVERAGE DIAGRAM



INDEX TO BOUNDARIES



INDEX TO ADJOINING SHEETS



1. USCGS Charts, (Reliable survey)
2. Sectional Aeronautical Chart, 1:500,000
(Compiled map - reliability fair)

Broken Shorelines Indicate Mangrove
SIBALTAN, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N1000-E11800/200

PALAWAN PROVINCE (P. I.)

SIBALTAN: AMS-S401, NC50-3

TERRAIN APPRECIATION

Reliability rating: Class B for Coastal Area
Class D for Interior Area

AREA 1. NORTHERN PALAWAN AND ADJACENT ISLANDS

Topography

Relief: Mountainous and hilly region. Main ridges of Palawan parallel coasts; in places rise directly from shore. In places lateral ridges extend from central chains to coasts. Many peaks over 2,000 feet; maximum altitude 5,225 feet (Cleopatra Needle). Some ridges have broad level tops; others, narrow knifelike crests. Slopes of 30 to 40% common; slopes of 160% present on islands off Bacuit Bay. Mountains covered with heavy rain forest. Open grassy valleys between some ridges; grassy lowlands around Taytay Bay and in interior to south.

Drainage: Numerous streams drain from central mountains; most are unmapped; few exceed 5 miles in length; head in narrow ravines. Near coasts, some streams meander across small plains and through mangrove swamp; sand bars at river mouths.

Coastal Features: Coastal lowlands are discontinuous, may be 4 to 5 miles long; possibly same maximum width; in most places bounded inland by steep slopes. Mangrove swamp common on eastern coast, in sheltered embayments and estuaries of western coast. Sandy beach very limited. Cluffed headlands separate low coastal belts.

Adjacent Islands: Dumaran and Linapacan Islands and others off eastern coast are topographically similar to Palawan. Islands outside Bacuit Bay and Malampaya Sound are extremely rugged.

Movement

Existing Routes: Numerous trails in northern Palawan; main trail crosses mountains from Malampaya Sound to Green Island Bay. Trail crosses Dumaran Island from east to west; road proposed around entire coast of Dumaran Island. Road projected (1941) from Bacuit to Malampaya Sound, east to Taytay, and south along eastern coast. Incompletely shown on map. Section west of Taytay completed and link to Pancel under construction.

Areas Favorable for Cross-country Movement: Foot troops and vehicles probably able to move readily in open valleys and coastal lowlands. Interior mountains are barrier to vehicles and will greatly impede movement of foot troops.

Ease of Cross-country Movement: Many slopes too steep to allow movement of vehicles; rocky coastal cliffs may be almost vertical. Wet-weather footing is generally poor; dry-weather footing good to adequate; coastal soils dry slowly. Where slope and ground permit, high forest allows easy movement of vehicles and troops; thickets require clearing. Tall grass slows down foot troops. Mangrove swamp excludes vehicles, hampers foot troops.

Observation

Observation points on mountain and hill slopes command coastal areas, settlements, routes, cultivated land. Offshore islands overlook embayments, e.g. Tuluran Island commanding Malampaya Sound. Visibility in forest may be limited to 20 to 30 yards; tall trees offer lookouts; thickets restrict visibility. In grasslands, cultivated land, and Casuarina forest on sandy beach, visibility is generally good; limited to few feet or yards in mangrove swamps and sandy beaches that have much low growth.

Concealment

Primary forest offers complete concealment from aerial observation; good concealment from ground observation. In secondary forest, dense growth and thickets on margins of primary forest give good concealment from aerial and ground observation; locally open park-like areas afford poor protection. In grassland areas, concealment from ground observation is excellent in tall grass and where trees and shrubs are abundant; concealment from aerial observation, generally poor, especially for vehicles. Density of vegetation varies in cultivated areas; coconut groves can conceal vehicles and personnel from aerial observation, but not from nearby ground observation; garden plots and rice paddies provide little concealment. Mangrove swamp excellent for concealment from ground and aerial observation. Forest on sandy beach conceals personnel and equipment from aerial observation; dense undergrowth provides concealment from ground observation.

Cover

Existing Cover: Good cover in hills and mountains. In coastal areas, base of wooded slopes surrounding lowlands offers best cover; where present, caves, shore bluffs, and undercut stream banks provide good cover. Beaches and cultivated land offer poor cover.

Construction of Shelters: Lower mountain slopes probably have sufficient soil (10 feet or more) to permit easy excavation; drainage generally adequate. Soil very thick in coastal areas (may be over 100 feet deep); excessive water and danger of slumping present problems. Timber for shelters available in all areas. Rock for construction scarce in most areas; boulders can probably be obtained in stream channels. Soil thin or absent on rocky islands off western coast and on cluffed headlands; blasting generally necessary for excavation.

AREA 2. TAPUL-BAHELI LOWLAND

Topography

Relief: Forested, hilly lowland; maximum relief is 1,191 feet (Conical Hill). At east, dominated by Babuyan River valley. Slopes in hilly region, about 20%.

Drainage: Babuyan River extends about 20 miles, from interior east of St. Paul Bay (Area 1) to Honda Bay (see Puerto Princessa Sheet).

Coastal Features: Mangrove swamp (unmapped) fringes coast of Ulugan Bay. Low coastal area extends inland toward hills; slope 8 to 10%.

Movement

Existing Routes: Proposed road across area from Puerto Princessa (Area 3) to northern Palawan (Area 3); partly surfaced, all-weather road from Tapul to Babuyan (see Puerto Princessa Sheet) has been completed. Road from Baheli to Tapul (see Puerto Princessa Sheet) under construction (1941).

Areas Favorable for Cross-country Movement: In general, entire area probably affords moderately easy movement for foot troops; relatively easy access to interior in Babuyan River

valley and lowland near Ulugan Bay.

Ease of Cross-country Movement: Slopes probably too steep for vehicles in many places, but open valleys may permit establishment of routes. In Babuyan River valley footing generally poor in wet weather; good in dry weather; in hilly region to south, footing in wet weather is better than in river valley, and ground can be well drained. Where slope and ground permit movement, forest is not an obstacle except for thickets; easy movement in cultivated land around Baheli, except in wet rice land; narrow mangrove swamps at Ulugan Bay obstruct movement of foot troops and vehicles.

Observation

Observation points on hills and upper slopes; best points in higher mountainous area enclosing lowland (Areas 1 and 3). (For discussion of visibility see Area 1.)

Concealment

Similar to Area 1.

Cover

Existing Cover: In general, poor cover; entire area is under observation from higher altitudes in Areas 1 and 3.

Construction of Shelters: Excavation in Babuyan River valley is difficult except in depressions; soil is thin and exposures that require blasting are probably common. In hills to south, excavation is easy; soil may be as much as 30 feet deep; sands near coast are 10 to 15 feet deep; drainage generally good. Timber for protected shelters available throughout area. Rock for construction probably available in Babuyan River valley and adjacent area.

AREA 3. CENTRAL PALAWAN ISLAND

Topography

Relief: Heavily forested mountainous region; ridges extend close to coasts. Slopes of 30 to 50% common. (See Puerto Princessa Sheet).

Drainage: See Puerto Princessa Sheet.

Coastal Features: Cliffs and bluffs line western coast and entrance to Ulugan Bay; narrow mangrove swamp (unmapped) at head of bay and in deeper indentations on western coast of bay.

Movement

Existing Routes: None indicated.

Areas Favorable for Cross-country Movement: No recommended areas; movement of foot troops possible in coastal belt along Ulugan Bay, back from mangrove.

Ease of Cross-country Movement: Similar to Area 1.

Observation

Peaks afford observation points overlooking Ulugan Bay and Tapul-Baheli lowland (Area 2). (For discussion of visibility, see Area 1.)

Concealment

Similar to Area 1.

Cover

Existing Cover: Coastal bluffs and lower slopes of ridges furnish best cover. Much of area may be exposed to Ulugan Bay and sea to west.

Construction of Shelters: Excavation probably difficult except on Ulugan Bay coast, where soil may be 10 feet deep. Drainage good except along bay. Timber for protected shelters available. Rock for construction may be obtained from cluffed coastal headlands.

AREA 9. CALAMIAN GROUP

Topography

Relief: Culion Island is second largest island of Calamian Group; topography similar to Busuanga Island (see Western Busuanga Island and Mindoro Island Sheets). Low mountains and hills with open plains characterize island. Maximum relief is 1380 feet (Mt. Maus). Slopes range from 15 to 40%; mapping incomplete in many places.

Drainage: Numerous streams, not mapped, drain interior; have meandering and branching channels. Interior plains flooded at times.

Coastal Features: Southern coast is rocky, and parts of western coast may be lined with bluffs. In Halsey Harbor and on northern coast, mangrove swamp is common. Sandy beach is present on southwestern and northwestern coasts.

Movement

Existing Routes: Road from Negative east to Culion Leper Colony (see Cuyo Islands Sheet); numerous unmapped trails.

Areas Favorable for Cross-country Movement: Foot troops and vehicles probably can move easily in most of island; mountainous terrain is barrier.

Ease of Cross-country Movement: Mountain and hill slopes can be by-passed via open plains and valleys. Rocky southern coast and mangrove swamp are obstacles to movement. Cleared and cultivated land in central and northern parts of island probably allow easiest movement.

Observation

Interior hill and mountain tops furnish observation points overlooking large part of island. Visibility good in cultivated and cleared land; limited in forested areas; mangrove swamp permits visibility for only few feet.

Concealment

Similar to Area 1.

Cover

Existing Cover: Coastal bluffs and cliffs provide cover. Little cover provided in cultivated and cleared land of interior plains.

Construction of Shelters: Bedrock exposed over wide areas; soil generally thin, possibly less than 1 foot; blasting necessary for excavation. In coastal areas, soil may be thicker. Drainage is poor. Timber for protected shelters and rock for construction available.

PHILIPPINE ISLANDS 1:500,000

TERRAIN APPRECIATION

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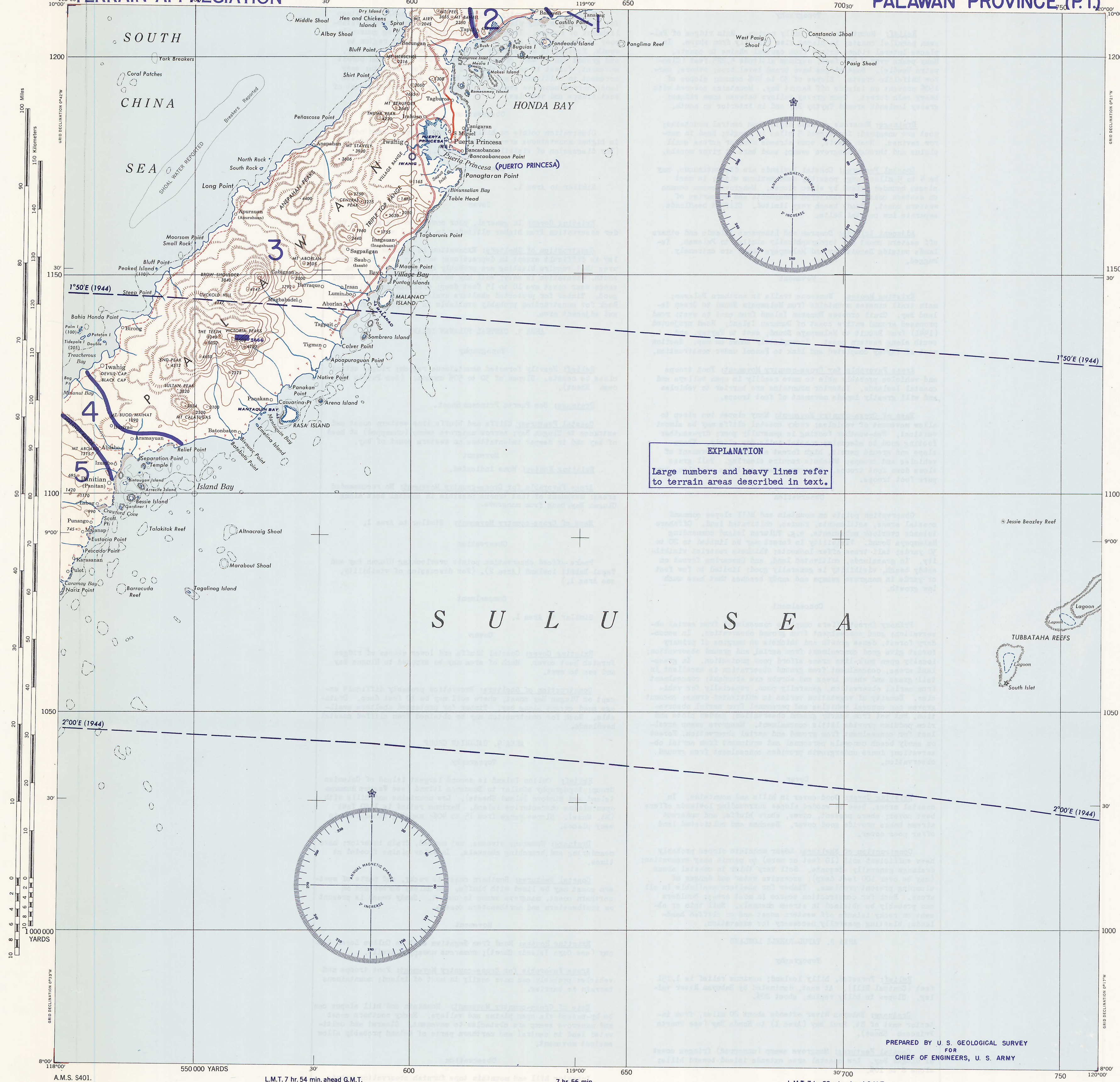
(PUERTO PRINCESA)

PUERTA PRINCESA

SECOND EDITION - AMS 2

NC 50-6

PALAWAN PROVINCE (P.I.)



First Edition (AMS 1) 1943.
Second Edition (AMS 2) 1944.
Prepared under the direction of the Chief of Engineers, U. S. Army, by the Army Map Service (AM), U. S. Army, Washington, D. C., 1944. Compiled from Sectional Aeronautical Chart, 1:600,000, USCGS, No. 5, 1941. USCGS Charts, 4321, 1920; 4323, 1922; 4716, 1938. Volumes I & V, Commission of the Census, Commonwealth of the Philippines, 1940. Intelligence Data, 1943. Roads from Official Road Map of the Philippines, 1:500,000, Bureau of Public Works Nos. 14 and 15, 1941.

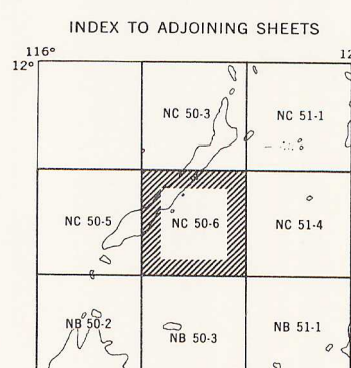
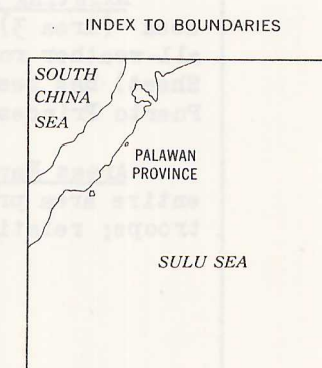
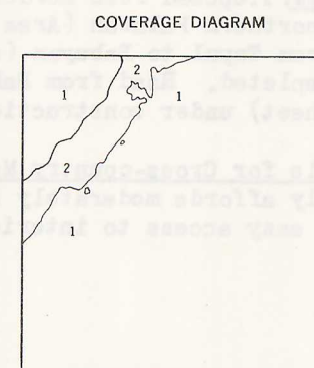
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ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C. 112096

5-44

1944



Broken shorelines indicate mangrove

PUERTA PRINCESA, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N800-E11800/200

HEIGHTS IN FEET AND DEPTHS IN FATHOMS

PALAWAN PROVINCE (P. I.)

PUERTO PRINCESA: AMS-S401, NC50-6

TERRAIN APPRECIATION

Reliability rating: Class B in eastern coastal area Class D elsewhere	
AREA 1: NORTHERN PALAWAN AND ADJACENT ISLANDS Topography Coastal lowland fringing mountains. Mangrove swamp from Castillo Point westward to Babuyan (Area 2). (See Area 1, Sibaltan Sheet, for more detailed information). AREA 2. TAPUL-BAHELI LOWLAND Topography <u>Relief:</u> Forested lowlands extending northward from Tapul and Babuyan, separated by hilly area; slopes in hills range up to 40%. <u>Drainage:</u> Babuyan River extends from interior (see Sibaltan Sheet) about 20 miles to coast at Honda Bay; navigable by small boats to rapids, about 5.5 miles north of Babuyan. Tapul River (unmapped) is a salt-water channel extending 2 miles inland; accommodates boats of 6-foot draft to dock 1.5 miles inland. <u>Coastal Features:</u> Narrow coastal lowland facing Honda Bay; gentle slopes about 2 1/2% up to hills. Mangrove swamps along much of coast and in Babuyan River valley. Movement <u>Existing Routes:</u> Graded road from Tapul north toward Baheli (see Sibaltan Sheet); partly surfaced, all-weather road from Babuyan to Tapul connects with road to Puerto Princesa (see Area 3). <u>Ease of Cross-country Movement:</u> See Sibaltan Sheet. Observation See Area 1, Sibaltan Sheet. Concealment See Area 1, Sibaltan Sheet. Cover <u>Existing Cover:</u> See Area 2, Sibaltan Sheet. <u>Construction of Shelters:</u> See Area 2, Sibaltan Sheet. AREA 3. CENTRAL PALAWAN ISLAND Topography <u>Relief:</u> Heavily forested mountainous region with ranges more or less paralleling coasts; numerous peaks over 2,000 feet, maximum altitude 5,466 feet (in Victoria Peaks); some ridges with flat-topped crests; deep ravines and gorges in interior mountains; intermountain areas not well defined, but may include level uplands. Slopes of 30 to 50% common; 90% on some summits. On eastern coast, plain slopes gently (3 to 4%) from mountains to sea (width in places 6 to 8 miles). Lowland surrounds Puerto Princesa embayment. Western part of area poorly surveyed; information unreliable. Lowland of unknown extent reported east of Treacherous Bay. <u>Drainage:</u> Main drainage is east and west from central mountains; many unmapped streams are reported. Near coasts, many streams meander across plains and through mangrove swamps; sand bars at river mouths. Katubungan River is known to have wide valley extending into interior; other valleys may be similar. Streams generally navigable only to boats drawing less than 6 feet of water. <u>Coastal Features:</u> Mangrove swamps alternate with short sandy beaches on eastern coast; Puerto Princesa embayment entirely fringed with swamp. Hills meet coast along 5-mile stretch from south of Table Head. On western coast, low wooded plain extends from Treacherous Bay to Bluff Point. Movement <u>Existing Routes:</u> Road net extends outward from Puerto Princesa to Babuyan in north (Area 1) and to Aborlan in south; proposed route (1941) continues southward along present telegraph line. Trail from Iwahig Penal Colony to western coast near Bluff Point; trail from Anepahan on western coast to Alfonso XIII (see Sarap Sheet, Area 4). <u>Areas Favorable for Cross-country Movement:</u> Foot troops and vehicles probably can move on eastern coastal plain. Open valleys and passes through mountains may permit movement of foot troops across island; east-west movement difficult and probably impossible for vehicles. Western coast may permit limited movement; information scanty. <u>Ease of Cross-country Movement:</u> Slopes generally too steep for vehicles except in coastal areas. Wet-weather footing commonly poor in all parts of area except in coastal plain where it is good at all times if drainage is maintained. Where slope and ground permit, movement of foot troops and vehicles is possible in high forest and in cultivated or cleared land; is seriously impeded by thickets at edge of forests and undergrowth on sandy beaches. Tall grass slows down foot troops. Vehicles cannot move through mangrove swamps, difficult movement for foot troops. Observation Plain on eastern coast and Puerto Princesa area are exposed to observation from inland hills; probably also from hills rising above coastal area. Interior mountains may give observation, but forest will conceal most points. Visibility in forest may be limited to 20 or 30 yards; some treetops offer lookouts; dense thickets at edge of forest restrict visibility to few yards. Cultivated and open land in coastal area generally offer good visibility; mangrove swamps and sandy beaches with much low	growth may limit visibility to few feet. Concealment See discussion under Area 1, Sibaltan Sheet. Cover <u>Existing Cover:</u> Inner edge of coastal lowlands at foot of mountains provides good cover; undercut stream banks and shore bluffs offer adequate cover. Buildings at Puerto Princesa and Iwahig Penal Colony may provide cover. <u>Construction of Shelters:</u> Excavation generally easy; depth of soil in most parts of area averages 10 feet or more; excavation more difficult in western coastal area between Table Point (see Sibaltan Sheet) and Moorsom Point, where soils are thinner. Drainage good in mountains; generally poor in low hills and coastal plain. Timber for protected shelters available in all parts of area; rock for construction scarce, except for stream boulders. AREA 4. ISLAND BAY-MALANUT BAY LOWLAND Topography <u>Relief:</u> Wooded lowland flanked by hilly country. About 3 miles west of Aboabo, hills come close together; are separated by narrow valley. Slopes on north and south not defined in detail; gentle rise to ranges on south indicated near Island Bay. Highest altitudes in area range from 500 to 1,000 feet. <u>Drainage:</u> Small unmapped streams empty into Island and Malanut Bays; sand bars and mangrove swamps obstruct river mouths at Island Bay. <u>Coastal Features:</u> Low sandy plain on Island Bay coast fringed with mangrove swamp. No information on Malanut Bay coast. (See Sarap Sheet). Movement <u>Existing Routes:</u> Trail from Aboabo to Alfonso XIII (see Sarap Sheet) may be obstructed by vegetation inasmuch as latter settlement was abandoned; however, road projected (1941) over old route may have been constructed. Proposed eastern coastal road to extend southward from Aborlan (Area 3) across area; stage of construction unknown. <u>Areas Favorable for Cross-country Movement:</u> East-west movement generally easy for foot troops; may be possible for vehicles. Access to Areas 3 and 5 along coasts. <u>Ease of Cross-country Movement:</u> Slopes generally no obstacle. Wet-weather footing poor; coastal soils rut easily when wet; good footing in dry weather. Interior forest permits movement of foot troops and vehicles; near coasts, thickets at edge of forest will obstruct movement; cultivated areas except wet rice land are not obstacles; mangrove swamp prevents movement of vehicles and hinders foot troops. Observation Observation of coastal settlements and lowland routes possible from hills within area and mountain slopes in Areas 3 and 5. For details of visibility, see discussion under Area 3. Concealment Similar to Area 1, Sibaltan Sheet. Cover <u>Existing Cover:</u> Generally poor; area commanded by heights in Areas 3 and 5. <u>Construction of Shelters:</u> Easy excavation; soil is 10 feet or more deep in most places; near coasts may exceed 100 feet; inland soils drain well, but coastal soils dry slowly after rain. Timber for protected shelters readily available; rock for construction probably scarce. AREA 5. SOUTHERN PALAWAN MOUNTAINS Topography Mountainous and hilly area; altitudes to about 1,500 feet. From Pescado Point south, grassy or park-like lowland flanks mountains on eastern coast. Mangrove swamp along much of coast from Island Bay to Pescado Point. Settlements probably on sandy beach. (See Sarap Sheet). Movement <u>Existing Routes:</u> Projected road (1941) along eastern coast into Area 5 may have been extended beyond Aborlan (Area 3); no information on stage of road construction. See Sarap Sheet. <u>Areas Favorable for Cross-country Movement:</u> See Sarap Sheet. <u>Ease of Cross-country Movement:</u> See Sarap Sheet. Observation Observation points in mountains command lowland (Area 4) to north. See Sarap Sheet. Concealment See discussion under Area 1, Sibaltan Sheet. Cover <u>Existing Cover:</u> See discussion under Area 1, Sibaltan Sheet. <u>Construction of Shelters:</u> Soils of sufficient depth for easy excavation present throughout area; drainage adequate. Timber available; rock, except stream boulders, probably scarce.

PALAWAN PROVINCE (P.I.)

SARAP: AMS S401-NC50-5

TERRAIN APPRECIATION

Reliability rating: Class B, Eastern Coast of Palawan Island; Balabac and Ramos Islands. Class D, elsewhere.

AREA 4. ISLAND BAY-MALANUT BAY LOWLAND

Topography

Low plain bounded on south by mountains (Area 5). Malanut Island, separated by narrow channel from mainland, has bold vertical cliff on northeast, several 700-foot peaks (unmapped), limestone caves of unknown size. Mangrove swamps(not shown on map) on shore of Malanut Bay and Malanut Island (except northern tip). (See Puerto Princessa Sheet.)

Movement

See Puerto Princessa Sheet.

Observation

Malanut Island commands entrance to Malanut Bay and provides observation across lowland to east coast. Similar observation from hills in Area 5. Visibility probably good except on Malanut Island and on edges of interior forest of Area 5.

Concealment

Open areas near coast afford limited concealment. Thickets provide good concealment for personnel and equipment.

Cover

Existing Cover: Cliffs and caves on Malanut Island give good cover; base of mountain slopes of Areas 3 and 5 furnish cover also. Poor cover in coastal area.

Construction of Shelters: Excavation easy; soil is 10 feet or more in depth except on Malanut Island, where rock may be close to surface or exposed and blasting will be necessary. Drainage of coastal soil good except in mangrove swamp. Rock for construction probably available in Malanut Island. Timber for protected shelters obtainable throughout area.

AREA 5. SOUTHERN PALAWAN MOUNTAINS

Topography

Relief: High forested mountains extend through central part of area; numerous peaks over 3,000 feet high; highest peak of Palawan (Mt. Mantalingajan, 6,839 feet) in southern part of area; mountains approach coast in southeastern part of area; on west, mountains give way to hills commonly less than 1,000 feet high. Grassy or open park-like lowland, generally about 3 miles wide (maximum width about 4.5 miles) flanks mountains on eastern coast from Pescado Point (see Puerto Princessa Sheet) south to San Antonio Bay; in places lowland is swampy. Slopes in mountains range from 30 to 50%, on some peaks 95%; in valleys, as much as 7 miles inland, slopes of about 15%.

Drainage: Many small streams, not mapped, drain from central mountains; channels may be dry at times; subject to flash floods. Deep gorges in headwater courses; lower courses in open valleys.

Coastal Features: Eastern coast is low; in general heavily wooded. Low sandy beach (not shown on map) is found at Sir J Brooke Point; succeeded inland by about 0.6 mile of dense forest. Grassy plain extends from this dense forest to mountain slopes. West coast is incompletely surveyed; mangrove swamp in southern part; remainder may be bluffd shore with sandy beach in some indentations; low wooded plain fringes coast from Eran Bay to Culasian Bay and may be present in places to south.

Movement

Existing Routes: Road projected (1941) along eastern coast from Puerto Princessa (Area 3) south to San Antonio Bay; no information as to stage of road construction. Trail on western coast from Eran Bay south to Culasian; road proposed (1941) from Culasian to San Antonio Bay through Area 6.

Areas Favorable for Cross-Country Movement: Movement along coasts, especially eastern, probably possible for foot troops and vehicles; information on western coast inadequate. Some valleys may permit inland penetration by foot troops, but available information indicates no routes for vehicles in interior mountains.

Ease of Cross-Country Movement: Interior slopes too steep for easy movement of foot troops; prevent movement of vehicles. Wet-weather footing poor; near coasts, soils tend to be slippery and sticky when wet. Dry-weather footing generally good. Interior forest permits movement of foot troops and vehicles where ground and slope permit; open park-like or grassy areas in coastal lowland allow easy movement; swampy areas and thickets are obstacles. Movement on sandy beach easy where undergrowth is lacking; also generally easy on cultivated land.

Observation

Observation points on mountain slopes especially command east coast lowland, and lowland of Area 6. Visibility in forest may be limited to 20 to 30 yards; some treetops offer lookouts; dense thickets at edge of forest restrict visibility to few yards. Park-like and grassy land in coastal area gives good visibility; sandy beaches without much undergrowth also good.

Concealment

Primary forest offers complete concealment from aerial observation; good concealment from ground observation. In secondary forest, dense growth and thickets on margins of primary forest give good concealment from aerial and ground observation; locally open park-like areas afford poor protection. In grassland areas, concealment from ground observation is excellent in tall grass and where trees and shrubs are abundant; concealment from aerial observation, generally poor, especially for vehicles. Density of vegetation varies in cultivated areas; coconut groves can conceal vehicles and personnel from aerial observation, but not from nearby ground observation; garden plots and rice paddies provide little concealment. Mangrove swamp excellent for concealment from ground and aerial observation. Forest on sandy beach conceals personnel and equipment from aerial observation; dense undergrowth provides concealment from ground observation.

Cover

Existing Cover: See discussion under Area 1, Sibaltan Sheet.

Construction of Shelters: Excavation easy on interior mountain slopes; soils generally 10 feet or more deep; excavation more difficult in hills on western coast and on eastern coast from Sir J Brooke Point southward where soils are thin. Drainage is good in interior; may be slow along eastern coast. Some areas are waterlogged more or less permanently and excavations will fill with water. Timber for protected shelters is readily available. Rock for construction probably scarce in interior mountains; exposures more common in hills of western coast and inland on eastern coast from Filantropia Point southward; also available on coast southward from Sir J Brooke Point.

AREA 6. SAN ANTONIO BAY-TAGBITA BAY AREA

Topography

Relief: Wooded lowland extending inland from San Antonio Bay; inadequate information on western end of area; lowland probably connected with western coast through pass between Bulanjao Range (Area 7) and Double Peak (Area 5). Relief may be greatest southwest of Pagoda Cliff (Area 5), where outliers of Bulanjao Range meet high hills of Bulaloc Bay area. Bounded on north and south by slopes of about 10%.

Drainage: Iwahig River is largest stream of southern Palawan; drains fertile populous valley; sand bar at mouth of river.

Coastal Features: On eastern coast, cleared and cultivated lowland extends into open valley of Iwahig River. Mangrove swamp (unmapped) fringes Tagbita Bay and much of San Antonio Bay. Sandy beach from Cliff Point north on western coast; and at southern part of San Antonio Bay. Bluffs on western coast.

Movement

Existing Routes: Proposed road (1941) from San Antonio Bay to Culasian on western coast (Area 5) follows lowland west of bay; stage of road construction not known.

Areas Favorable for Cross-Country Movement: Iwahig River valley probably permits easy movement of foot troops and vehicles. Lowland and pass between ranges may form corridor; little information regarding western end of area.

Ease of Cross-Country Movement: Slopes generally do not obstruct movement. Soils slippery and sticky when wet; dry-weather footing good except close to coast; may be good on sandy beach. Movement of foot troops and vehicles possible in forest, cultivated land, and sandy beach; difficult in thickets; impossible for vehicles in mangrove swamp.

Observation

Best observation from slopes and hills in Areas 5 and 7 to north and south. Visibility in forest limited to 20 to 30 yards. Near coasts, open grassy or park-like areas may be common; visibility is good; good also in cultivated land; undergrowth, tall grass, and thickets restrict observation.

Concealment

See discussion under Area 1, Sibaltan Sheet.

Cover

Existing Cover: Inner rim of lowland at foot of mountains (Areas 5 and 7) probably gives best cover, but entire area is commanded by numerous high-elevation points.

Construction of Shelters: Easy excavation in large part of area; soil is thick, possibly over 100 feet in places. Drainage fair, except on eastern coast where soils may be more or less permanently wet. Timber for protected shelters is available. Rock for construction is probably available on mountain and hill slopes adjoining lowland (Areas 5 and 7).

AREA 7. SOUTHERN PALAWAN AND ADJACENT ISLANDS

Topography

Relief: Forested mountains (Bulanjao Range) in north central part of area; maximum altitude, 3,470 feet; bordered by hills commonly less than 1,000 feet that approach eastern coast at Coral Bay. Low plains with hills fringe coasts. Mountains have long gentle slopes of 20 to 40% surmounted by sharp peaks. Slopes in hills about 10%; in plains about 4%.

Drainage: Several streams drain from central upland to Palawan coast; flow through mangrove swamps in coastal area; probably numerous other streams are present but unmapped. Bugsuk River on Bugsuk Island is a large estuary extending about 4 miles inland.

Coastal Features: Mangrove swamp is extensive at southern tip of Palawan; continues along eastern coast almost uninterruptedly to San Antonio Bay and on western coast for about 10 miles north from Cape Buliluyan. Bluff on eastern side of Cape Buliluyan. In area between San Antonio and Coral Bays, sandy beach lies inland from swamp; probably also present at settlements on other parts of coast. Bugsuk and Pandanan Islands have extensive mangrove swamps; eastern coast of Bugsuk and entire coast of Mantangule and Bancalan Islands are sandy beach.

Islands: Bugsuk, Pandanan, Mantangule, Bancalen, and several very small islands off southern coast of Palawan are low and wooded; no prominent relief features known.

Movement

Existing Routes: Trail (not mapped) from Cape Buliluyan north to vicinity of Sapa on eastern coast of Palawan; may be obscured by vegetation.

Areas Favorable for Cross-Country Movement: Foot troops and vehicles can move in most of coastal area, except in mangrove swamp

around Cape Buliluyan and on offshore islands. Low hills will probably also permit movement of foot troops. Movement more difficult in Bulanjao Range.

Ease of Cross-Country Movement: Slopes generally are not obstacles to movement except in northern mountains. Wet-weather footing is poor; coastal ground tends to be slippery and sticky when wet; dry-weather footing good except in swampy areas. Foot troops and vehicles able to move readily in forest and open or cultivated land at or near coasts; mangrove swamp prevents movement of vehicles on coasts, slows down foot troops.

Observation

Observation is poor in low areas; some hills near coasts may afford observation points; mountains in north probably command both eastern and western coasts. Visibility generally limited to short distances; better in cultivated land around settlements and park-like areas on eastern and western coasts of Palawan.

Concealment

Mangrove swamp and forested areas with much undergrowth give good concealment. (See discussion under Area 1, Sibaltan Sheet.)

Cover

Existing Cover: Coastal areas and offshore islands have little good cover. Hills and mountains in interior of Palawan offer best cover.

Construction of Shelters: Excavation easy in most coastal areas and in lower mountain slopes. Thick soil, often more than 100 feet deep, in coastal area between San Antonio and Coral Bays, and inland from mangrove swamp to south. In low hills of western coast, soils are few feet thick and rock exposures, requiring blasting for excavation, may be common. In interior, soil is probably 10 to 20 feet thick, especially on lower slopes of mountains. Drainage of thick coastal soils is poor; generally adequate for other soils. Timber for protected shelters available; also rock for construction in areas noted above, but may be scarce in rest of area.

AREA 8. BALABAC AND RAMOS ISLANDS

Topography

Relief: Northern Balabac Island is low in large part; some hills; maximum altitude in northern part is 735 feet. Ramos Island is low and wooded; few small hills, maximum altitude 350 feet. Maximum slope about 10%.

Coastal Features: Mangrove swamp and low coastal plain are present on western and northern coasts of Balabac; mangrove swamp fringes all of Ramos except northeastern coast, which consists of sandy beach. Eastern coast of Balabac is also sandy beach (not indicated on map); locally bluffs or cliffs. (See Balabac Strait Sheet.)

Drainage: No specific information available; streams indicated as flowing through mangrove belts from interior of Balabac and Ramos.

Movement

Existing Routes: Trail from Catagupan on western coast of Balabac Island to Balabac Town. (See Balabac Strait Sheet.) Proposed road (1941) around coast of Balabac Island.

Areas Favorable for Cross-Country Movement: Easy movement for foot troops and vehicles except in swampy coastal areas. Insufficient data to indicate possible routes.

Ease of Movement: Thickets on edge of forest and undergrowth in cultivated land will impede movement; mangrove swamps permit only difficult movement for foot troops. Footing in wet weather is generally poor; generally good in dry weather except in swamps.

Observation

Large part of area probably under observation from hills. Ground visibility in lowland is limited to short distances; better in open, grassy or cultivated land.

Concealment

Good concealment from ground and aerial observation is available; open, grassy land gives poor concealment from aerial observation; in plantations with little undergrowth, concealment from nearby ground observation is poor.

Cover

Existing Cover: Interior hills give adequate cover; coastal region exposed, but shore bluffs may provide cover.

Construction of Shelters: Most soils are 10 feet or more deep; excavation generally easy. On coasts near settlements, soil generally thin, excavation more difficult. Drainage is adequate except in low coastal areas. Timber for protected shelters readily available. Rock for construction may be scarce; data inadequate.

PHILIPPINE ISLANDS 1:500,000

TERRAIN APPRECIATION

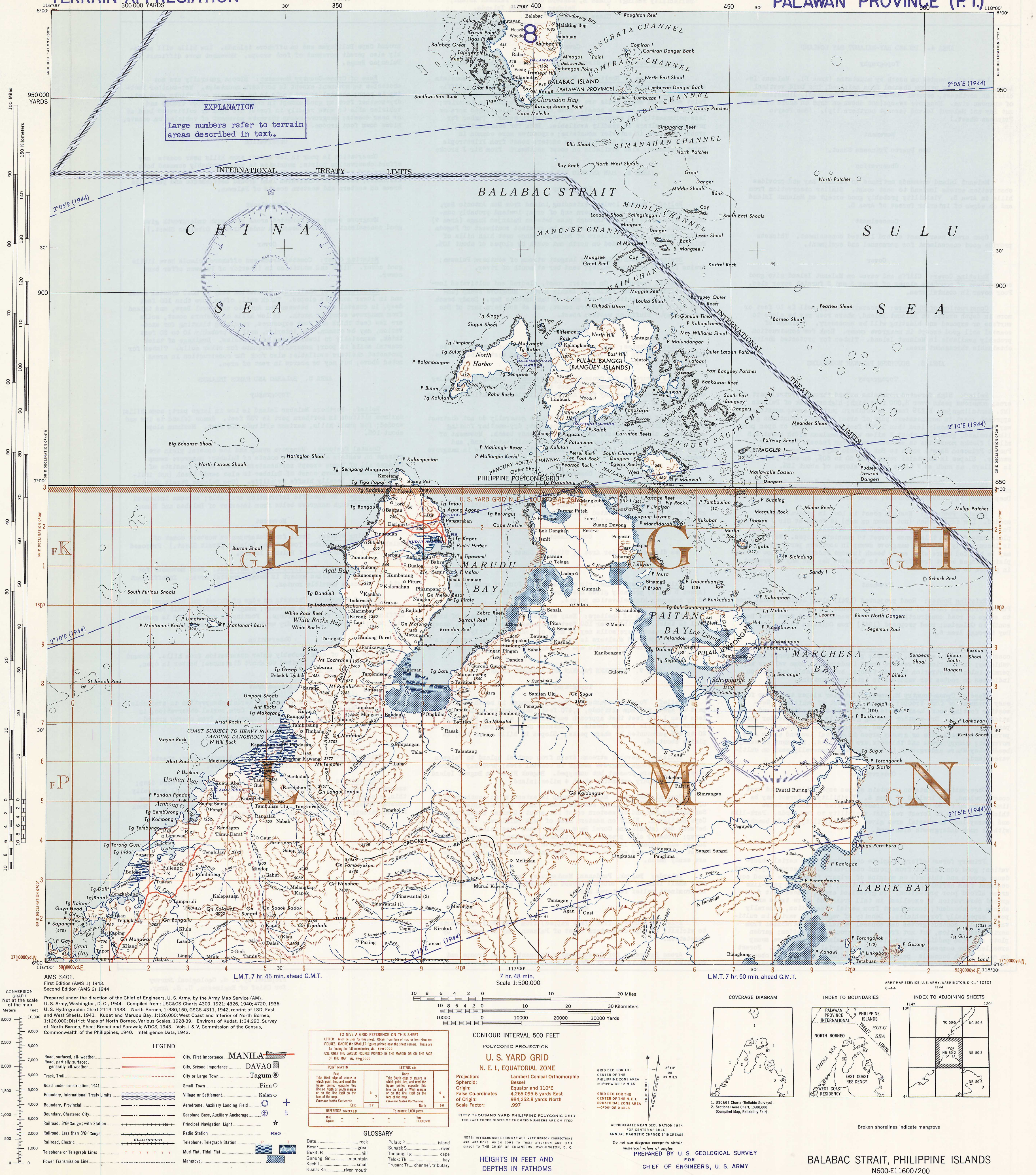
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BALABAC STRAIT

SECOND EDITION - AMS 2

NB 50-2

PALAWAN PROVINCE (P.I.)



PALAWAN PROVINCE (P. I.)

BALABAC STRAIT: AMS-S401, NB50-2

TERRAIN APPRECIATION

Reliability rating: Class B

AREA 8. BALABAC AND RAMOS ISLANDS (See also Sarap Sheet)

Topography

Relief: Balabac Island is hilly; in places mountainous. In south, several ranges of high, flat-topped hills with average altitude about 900 feet. Maximum relief is in Balabac Peak (1,867 feet). Low foot-hills extend along western coast, about 1 mile inland, between Pasig Bay and vicinity of Punagis Point (see Sarap Sheet). Slopes generally range from 10 to 20%. Lowland is reported to extend across island from Dalawan Bay in northwesterly direction between Balabac and Transept Peaks.

Drainage: Streams empty into various bays through mangrove swamps; no specific information available; stream courses generally unmapped.

Coastal Features: Western coast fringed with mangrove swamp, succeeded inland by heavily wooded hilly terrain. On eastern coast, bluffs or cliffs are common. Clarendon Bay lined with mangrove swamp; sandy beach probably near settlements in Calandorang Bay area.

Movement

Existing Routes: Proposed coastal road (1941) around entire Balabac Island. Stage of road construction not known.

Areas Favorable for Cross-country Movement: Western coastal area may provide easier movement for foot troops and vehicles than eastern coast. Lowland extending westward from Dalawan Bay may also permit easy movement.

Ease of Cross-country Movement: Forest generally open; will allow movement of foot troops and vehicles, except in thickets at edge. In cleared land, undergrowth locally will impede movement; mangrove swamp permits only difficult movement of foot troops. Footing in wet weather generally poor; in dry weather good except in swamps.

Observation

High hills in south overlook low western coastal areas and bays on east. Ground visibility is limited; best in cultivated and grassy land.

Concealment

Concealment from ground and aerial observation is generally good. Concealment from aerial observation poor in grassy land; concealment from nearby ground observation poor in plantations lacking undergrowth.

Cover

Existing Cover: Interior hills furnish adequate cover; coastal region exposed to higher hills in interior; bluffs on eastern coast may provide cover.

Construction of Shelters: Most soils are 10 feet or more deep; easy excavation in general; on coasts near settlements, soil generally thin. Drainage satisfactory except in low coastal areas. Timber for protected shelters readily available. Rock for construction may be scarce; data inadequate.

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FOR
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PHILIPPINE ISLANDS 1:500,000

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WESTERN BUSUANGA ISLAND

SECOND EDITION-AMS 2

ND 50-6

PALAWAN PROVINCE (P. I.)

WESTERN BUSUANGA ISLAND: AMS-S401, ND50-6

Reliability rating: Class B

AREA 9. CALAMIAN GROUP

Topography

Relief: Busuanga Island, the largest of the group, has low mountains and open valleys; in northwest, ranges cross island from southwest to northeast. Forested except on southwest coast where clearing is extensive and many slopes are bare. Maximum relief in western Busuanga is 1,302 feet. Slopes range from 20 to 60%, many from 45 to 60%.

Drainage: No large streams known, but numerous small ones are reported; streams generally meander in open valleys near coasts and pass through mangrove swamps at coast. Unmapped for the most part.

Coastal Features: Extensive mangrove swamps along coast, especially where steep-sided ridges at coast. On southwest coast, open cultivated valleys extend 5 or more miles inland.

Islands: Offshore, especially adjacent to southwestern coast of Busuanga, are many small islands; some are low lying, but others have steep slopes and topographically resemble Busuanga.

Movement

Existing Routes: Proposed road (1941) extends from Busuanga along southern coast (see Mindoro Island Sheet). Numerous trails (not shown on map) connect settlements with interior and northern coast.

Areas Favorable for Cross-country Movement: Foot troops and vehicles probably able to move readily; broad, open valleys especially favorable.

Ease of Cross-country Movement: Steep slopes will slow down foot troops and probably prevent movement of vehicles; can be avoided by using valley routes. Mangrove swamp is chief obstacle to movement on coasts. Footing is poor in wet weather, but dry ground gives good footing. Cultivated and cleared land on western coast permits easy movement of personnel and equipment. Forest is more extensive than in eastern Busuanga (see Mindoro Island Sheet) but, where slope and ground permit, movement is possible. Tall grass, thickets at edge of forest, and undergrowth in cultivated land are local obstacles.

Observation

Ridge crests and mountain peaks furnish observation points overlooking extensive areas in Busuanga and adjacent islands (see also Sibaltan Sheet). Visibility in cultivated and cleared land, especially on western coast, is good; in heavily forested mountains, visibility limited to short distances; limited also in mangrove swamp, undergrowth, and thickets.

Concealment

Concealment from aerial observation is poor in grassland and cleared land; many slopes are burned over and provide no concealment. In forests and coconut groves, concealment from aerial observation is good. Concealment from ground observation is good in low forest and in grassland areas where tall grass, shrubs, and trees are abundant; poor in cultivated land. Mangrove swamp affords excellent concealment from ground and aerial observation.

Cover

Existing Cover: Heavily wooded mountain slopes and bluffs on coasts provide cover. Some mining operations may have underground tunnels that will give cover.

Construction of Shelters: Soil is of variable thickness, may be less than 1 foot except in some coastal areas. Excavation may require blasting. Drainage is poor. Timber for protected shelters and rock for construction available.

EXPLANATION
Large numbers refer to terrain areas described in text.

S O U T H C H I N A S E A

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

CALAMIAN
GROUP

BUSUANGA ISLAND

A.M.S. S401

First Edition (AMS 1), 1943.
Second Edition (AMS 2), 1944.
Prepared under the direction of the Chief of Engineers, U. S. Army, by the Army Map Service (AMRS), U. S. Army, Washington, D. C., 1944.
Compiled from Sectional Aeronautical Chart, 1:600,000, USC & GS, No. 2, 1941, USC & GS Charts, 4314, 1919-4350, 1919-4714, 1936, Volumes I & V, Commission of the Census, Commonwealth of the Philippines, 1940. Intelligence Date, 1943.

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7 hrs. 56 min.
Scale 1:500,000

L.M.T. 7 hrs. 58 min. ahead G.M.T.

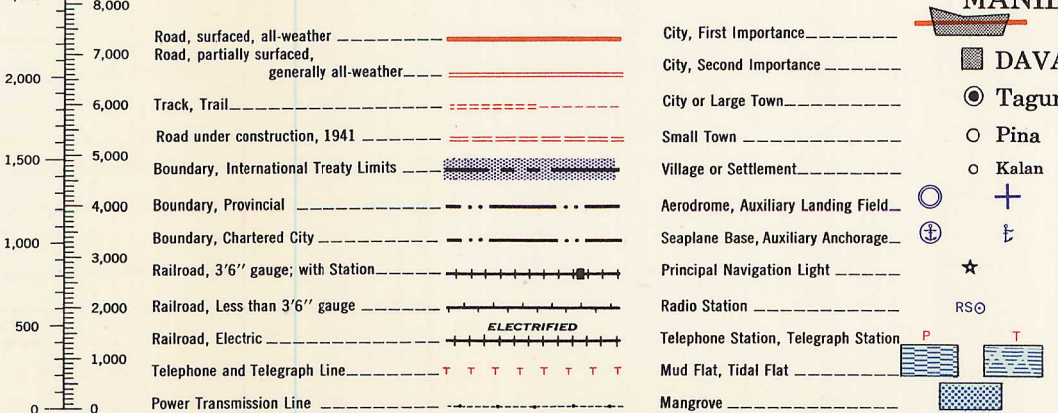
ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C. 112087

5/4488

CONVERSION GRAPH
NOT AT THE SCALE OF THE MAP
Meters
Feet



LEGEND



MANILA

DAVAO

Tagum

Pina

Kalan

Aerodrome, Auxiliary Landing Field

Seaplane Base, Auxiliary Anchorage

Principal Navigation Light

Radio Station

Telephone Station, Telegraph Station

Mud Flat, Tidal Flat

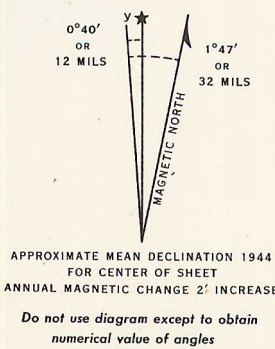
Mangrove

CONTOUR INTERVAL 500 FEET

POLYCONIC PROJECTION

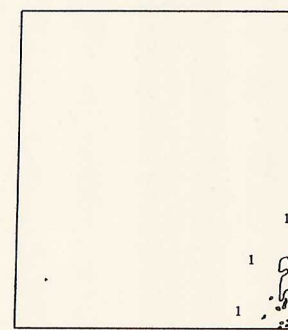
FIFTY THOUSAND YARD PHILIPPINE POLYCONIC GRID
THE LAST THREE DIGITS OF THE GRID NUMBERS ARE OMITTED

NOTE: OFFICERS USING THIS MAP WILL MARK HEREON CORRECTIONS AND ADDITIONS WHICH COME TO THEIR ATTENTION AND MAIL DIRECT TO THE CHIEF OF ENGINEERS, WASHINGTON, D. C.

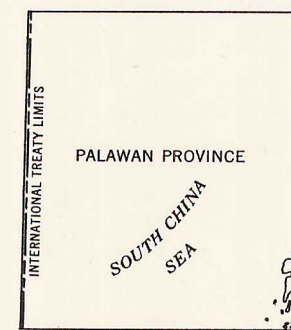


HEIGHTS IN FEET AND DEPTHS IN FATHOMS

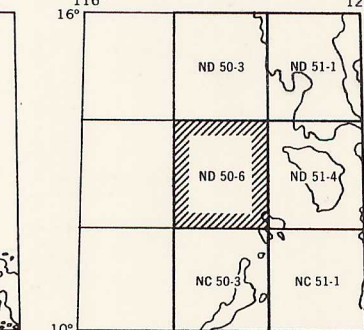
COVERAGE DIAGRAM



INDEX TO BOUNDARIES



INDEX TO ADJOINING SHEETS



1. USNAGS Charts, (Reliable survey)
2. Sectional Aeronautical Chart, 1:600,000
(Compiled map, unreliable)

Broken Shorelines Indicate Mangrove

WESTERN BUSUANGA ISLAND, PHILIPPINE ISLANDS
PALAWAN PROVINCE

N1200-E11800/200

PHILIPPINE ISLANDS 1:500,000 TERRAIN APPRECIATION

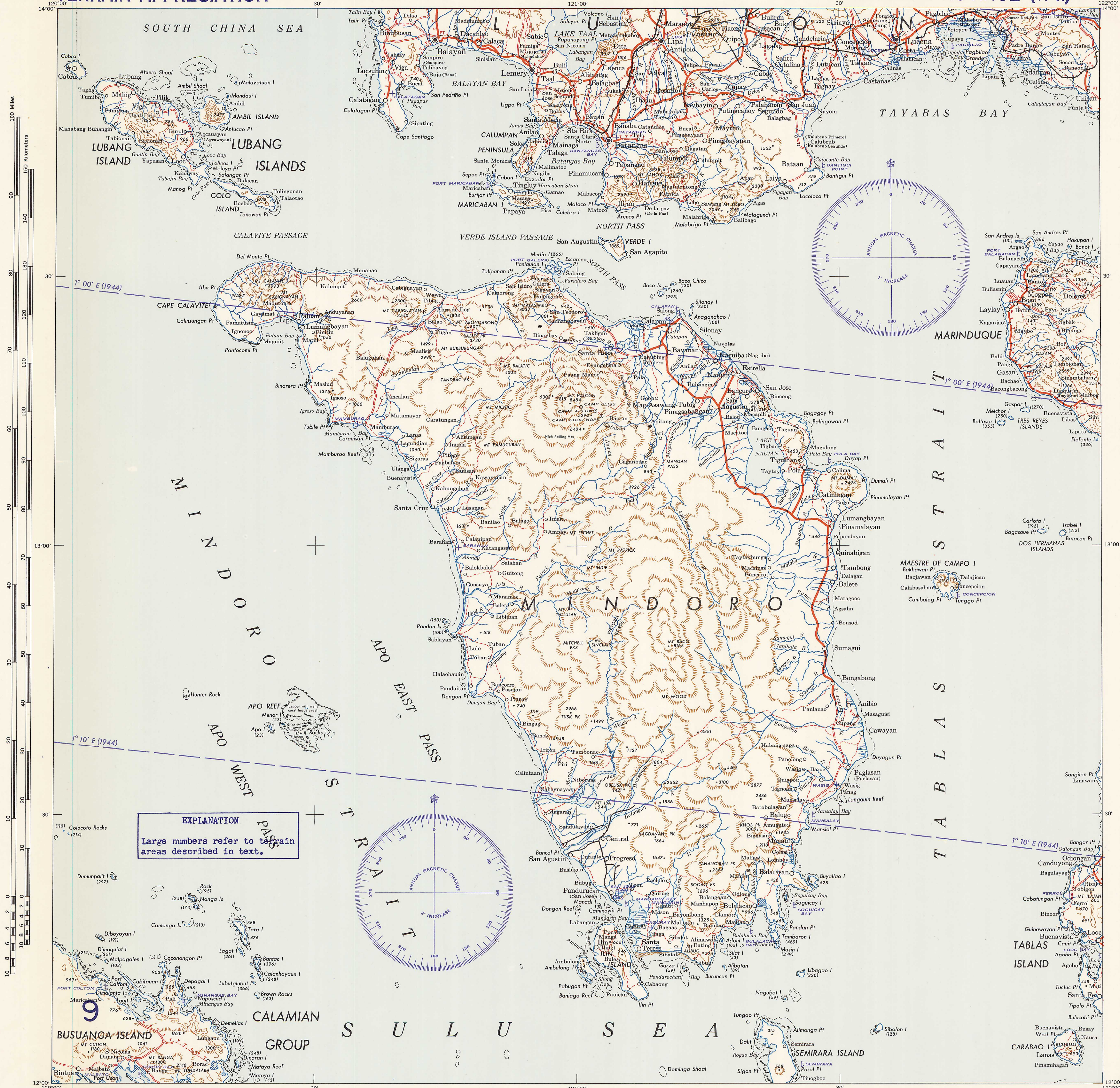
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MINDORO ISLAND

SECOND EDITION-AMS 2

ND 51-4

PALAWAN PROVINCE (P. I.)



A.M.S. 5401

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Second Edition (AMS 2) 1944.
Prepared under the direction of the Chief of Engineers, U. S. Army, by the Army Map Service (AMS), U. S. Army, Washington, D. C., 1944.
Compiled from: Luzon 1:63,360, AMS reprint 1942; and C.O.E. Phil. Dept. original 1913; Sec. Aero. Chart, 1:600,000, USC & GS, No. 2, 1941; USC & GS Chart 4214, 1933; 4218, 1941; 4305, 1939; 4314, 1919; 4338, 1914; 4339, 1912; 4340, 1939; 4351, 1916; 4410, 1915; Philippine Islands, 1:200,000, USC & GS, No. 8, 1940; No. 10, 1935; Vols. I & V, Commission of the Census, Commonwealth of the Philippines, 1940; Intelligence data, 1943; Roads from: National Road Map of the Philippines, 1:1,000,000, Standard Vacuum Oil Co., P. I., 1941; Philippine Islands, 1:200,000, USC & GS, 1935-1940; Official Road Map of the Philippines, 1:500,000, Bur. Pub. Works, Nos. 4 and 6, 1941; Tel. & Tel. from: Communication Map of the P. I., 1:400,000, Hq. Mil. Int. Phil. Dept., CW 14-3, 1931 (Corrected to 1940, AMS); Transmission Lines from: Philippine Islands, 1:1,000,000, USC & GS, No. 100, 1933.

L.M.T. 8 hrs. 02 min. ahead G.M.T.

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Scale 1:500,000

L.M.T. 8 hrs. 06 min. ahead G.M.T.

ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C. 11208B

6/448H 1944

MINDORO ISLAND, PHILIPPINE ISLANDS

N1200-E12000/200

Reliability rating: Class B

AREA 9. CALAMIAN GROUP

Topography

Relief: Busuanga Island is largest island of Calamian Group; characterized by low mountains and open valleys; some ranges, especially in east and south, have altitudes over 1,000 feet; maximum altitude is 2,140 feet (Mt. Tundalara) in southeast. Slopes of 40 to 60% are common in mountains; of 20 to 30%, in lower coastal areas and valleys.

Drainage: Streams on Busuanga Island are largely unmapped, but numerous streams probably drain from interior hills through mangrove swamps on coast.

Coastal Features: Hills and mountains approach close to north and east coasts. Bluffs and cliffs are common; low indentations between headlands are lined with mangrove swamp. On south, lowland of variable width lies in front of interior peaks; some ridges extend to coast.

Movement

Existing Routes: Road extends along part of southern coast; branch to northern coast, passing through manganese mining district in center of island. Proposed road (1941) along south coast extending to Busuanga (see Western Busuanga Island Sheet); stage of construction unknown. Numerous unmapped trails.

Areas Favorable for Cross-country Movement: Foot troops and vehicles probably able to move readily in most areas; especially in broad valleys.

Ease of Cross-country Movement: Slopes in mountains will hinder or prohibit use of vehicles, but can be avoided by using valley routes. Mangrove swamp and cliffed headlands on coasts will seriously interfere with movement, probably prevent use of vehicles. Poor footing in wet weather; ground dries slowly, but dry-weather footing is satisfactory. Extensive areas of grassland and open park-like country in central part of island and cultivated land on southern coast will facilitate movement of foot troops and vehicles; tall grass, thickets at edge of forest, and undergrowth in cultivated land are obstacles.

Observation

Peaks near southern and eastern coast will afford observation points for extensive areas in Busuanga and probably adjacent islands (see Cuyo Islands and Sibaltan Sheets). Visibility generally good, especially in cleared and cultivated land; limited to short distances in dense forest on mountains, in mangrove swamp, and in undergrowth and thickets.

Concealment

Concealment from aerial observation is poor in grassland and cleared land, especially for vehicles; generally good in forest and coconut groves; excellent in mangrove swamp. Good concealment from ground observation in forest and in grassland areas where tall grass, shrubs, and trees are abundant; excellent concealment in mangrove swamp; poor in cultivated land.

Cover

Existing Cover: Heavily wooded mountain slopes and bluffs on coasts provide cover; in central part of island, mine buildings and underground tunnels give shelter.

Construction of Shelters: Excavation may require blasting in places. Soil is of variable thickness, may be less than 1 foot, except in some coastal areas. Drainage is poor and soil dries slowly. Timber for protected shelters is readily available; rock for construction probably available in many places. Some rock from mine dumps.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY



PALAWAN PROVINCE (P.I.)

CUYO ISLANDS: AMS-S401, NC51-1

TERRAIN APPRECIATION

Reliability rating: Class B, Calamian Group and Coasts of Other Islands.
Class D, Elsewhere.

AREA 9. CALAMIAN GROUP

Topography

Relief: Culion Island consists of low hills and mountains with open inland plains; maximum relief in eastern part of island is 1,558 feet. Slopes range from 15 to 40%. Similar topography in small islands east of Culion Island and south of Busuanga Island (Uson and Apo Islands). Coron Island has extremely rugged terrain. Sharp peaks and ridges with knife-like crests occupy almost entire island. Slopes commonly over 100% and locally almost vertical; maximum altitude is 1,965 feet; some low land is indicated in northeastern part of island.

Drainage: In Culion Island streams (unmapped) drain interior mountains; plains in interior are flooded at times. Coron Island is not known to have any permanent stream channels; several lakes in interior (unmapped).

Coastal Features: Culion Island and smaller adjacent islands are generally fringed with mangrove swamp; cliffed headlands in places. At coast of Coron Island, precipitous cliffs rise several hundred feet to knife-like crests; slopes commonly over 100%, some almost vertical. Cliffs undercut in many places.

Movement

Existing Routes: Road on Culion Island from Culion Leper Colony west to Negative (see Sibaltan Sheet). Trails from Culion Leper Colony south. No routes indicated on Coron or smaller islands.

Areas Favorable for Cross-country Movement: Interior of Culion Island probably permits movement of foot troops and vehicles. Coron Island generally unsuitable for vehicles; movement of foot troops difficult.

Ease of Cross-country Movement: On Culion Island, interior plains and valleys between ridges permit free movement. Mangrove swamp and cliffs on coasts of Culion Island and smaller adjacent islands are obstacles. Steep slopes present in all parts of Coron Island are barrier to movement. Cleared and cultivated land in northeastern Culion Island and grassland on Uson Island permit easy movement; remainder of Culion Island and all other islands are covered with dense forest in which movement is possible where ground and slope permit.

Observation

In Culion Island, hills and mountaintops afford observation of surrounding area (see Sibaltan and Mindoro Island Sheets). High peaks on Coron Island coast will provide best observation in entire area. On all islands visibility in interior probably limited by heavy forest growth. On Culion Island and small islands cleared and cultivated land provides better observation. Visibility poorest in mangrove swamp and where thickets or undergrowth are abundant.

Concealment

Forest provides good concealment from aerial and ground observation. Grassland gives poor concealment from aerial observation. Adequate concealment from ground observation where grass is tall. Coconut groves offer good concealment from aerial observation; where undergrowth is present concealment from ground observation is good. Concealment excellent in mangrove swamps.

Cover

Existing Cover: Cleared and cultivated land provides no cover except near hills and mountains. Undercut cliffs on coast of Coron Island and heavily wooded mountain slopes provide good cover.

Construction of Shelters: Blasting for excavation probably necessary in many places; exposures of bedrock probably common. Soil generally thin, possibly less than 1 foot in many places. Easy excavation (soils thick), in coastal areas, except on Coron Island, where rocky coastal cliffs are common. Drainage is poor. Timber for protected shelters and rock for construction generally available.

AREA 10. CABULAUAN AND DALANGANEM ISLANDS

Topography

Relief: Small rocky islands and islets. In Cabulauan Island, maximum altitude is 775 feet; in Calandagan Island, 1,024 feet. Low hills surround peaks in Cabulauan Islands; slopes from about 30 to over 70%. Dalanganem Islands are more rugged and have very steep cliffs.

Drainage: Small streams indicated; probably few permanent stream channels. Data inadequate.

Coastal Features: Cliffs commonly face coast; some small rocky inlets; low level land in northwestern Cabulauan Island.

Movement

Existing Routes: None indicated.

Areas Favorable for Cross-country Movement: Movement of vehicles probably difficult to impossible in most places;

difficult movement for foot troops in many places.

Ease of Cross-country Movement: Steep slopes are barrier to movement in most of area. Footing generally poor in wet weather; satisfactory in dry weather. The sparse vegetation is not an obstacle.

Observation

Hilltops and ridge crests afford view over islands. Visibility good except where undergrowth is abundant.

Concealment

Concealment generally poor; where thickets are dense, may be good. In coconut groves, concealment from aerial observation is good, from ground observation generally poor.

Cover

Existing Cover: Islands generally exposed; cover may be available in coastal cliffs and possibly in interiors of Dalanganem Islands.

Construction of Shelters: Soils thin, possibly as little as 1 foot deep; blasting may be necessary for excavation. Timber and rock probably available in all islands.

AREA 11. CUYO ISLANDS

Topography

Relief: Group of small hilly islands with low, reef islets. Largest, Cuyo Island, consists of round, smooth-sloped (about 15 to 25%) 851-foot hill at north connected by narrow neck of land with main body of island, center of which rises to 600-foot hill; in south, slopes of 6 to 8% are common. Agutaya Island is main island in center of group; hills in northeast have maximum relief of 885 feet and slopes of about 20%. Northern islands (Quiniluban Group) are rugged and cliffed; slopes of 30 to 55% common; maximum relief is 1,010 feet in Quiniluban Island.

Coastal Features: Cuyo Island has narrow discontinuous mangrove swamp (not shown on map) except at extreme north and along most of eastern coast; rocky ledges, some steep, at north and at various points to south; sandy beach especially on east coast. Mangrove swamp less common on other islands in southern part of group. Agutaya Island has sandy beach in most parts. Quiniluban Group have coastal cliffs and ledges; locally beaches.

Drainage: Few streams indicated; drainage probably through gullies, no permanent stream channels. Data inadequate.

Movement

Existing Routes: Roads, mostly poor, cover most of Cuyo Island. Trail present on Agutaya Island. No other routes indicated.

Areas Favorable for Cross-country Movement: Foot troops and vehicles probably able to move readily on all islands except Quiniluban Group.

Ease of Cross-country Movement: Slopes of hills will impede or prevent use of vehicles, but can be avoided in most islands except Quiniluban Group. Wet-weather footing poor everywhere except in interior of Cuyo Island. When ground is dry, footing adequate to good. Movement obstructed by forest; easy in cultivated areas and grassland except where undergrowth is thick or grass is tall.

Observation

Observation points afforded by hilltops in all islands. Visibility generally good; poor in areas of dense undergrowth and mangrove swamp.

Concealment

In cultivated areas and grassland, concealment from aerial observation is probably poor; may be good in coconut groves. Tall grass provides adequate ground concealment; where undergrowth is present in cultivated land, ground concealment is probably good. Excellent concealment in mangrove swamps.

Cover

Existing Cover: Coastal cliffs and ledges probably give adequate cover on most islands; in general interior lacks cover areas except in more rugged Quiniluban Group.

Construction of Shelters: In interior of Cuyo Island, excavation probably easy; soil may be 10 to 30 feet deep; drains well, but becomes sticky if worked when wet; coastal soils of Cuyo Island are commonly deep (as much as 200 feet); drainage is main problem. Other islands have thin soils, as little as 1 foot deep; blasting necessary for excavation. Timber for shelters probably available; rock for construction obtainable easily.

PHILIPPINE ISLANDS 1:500,000 TERRAIN APPRECIATION

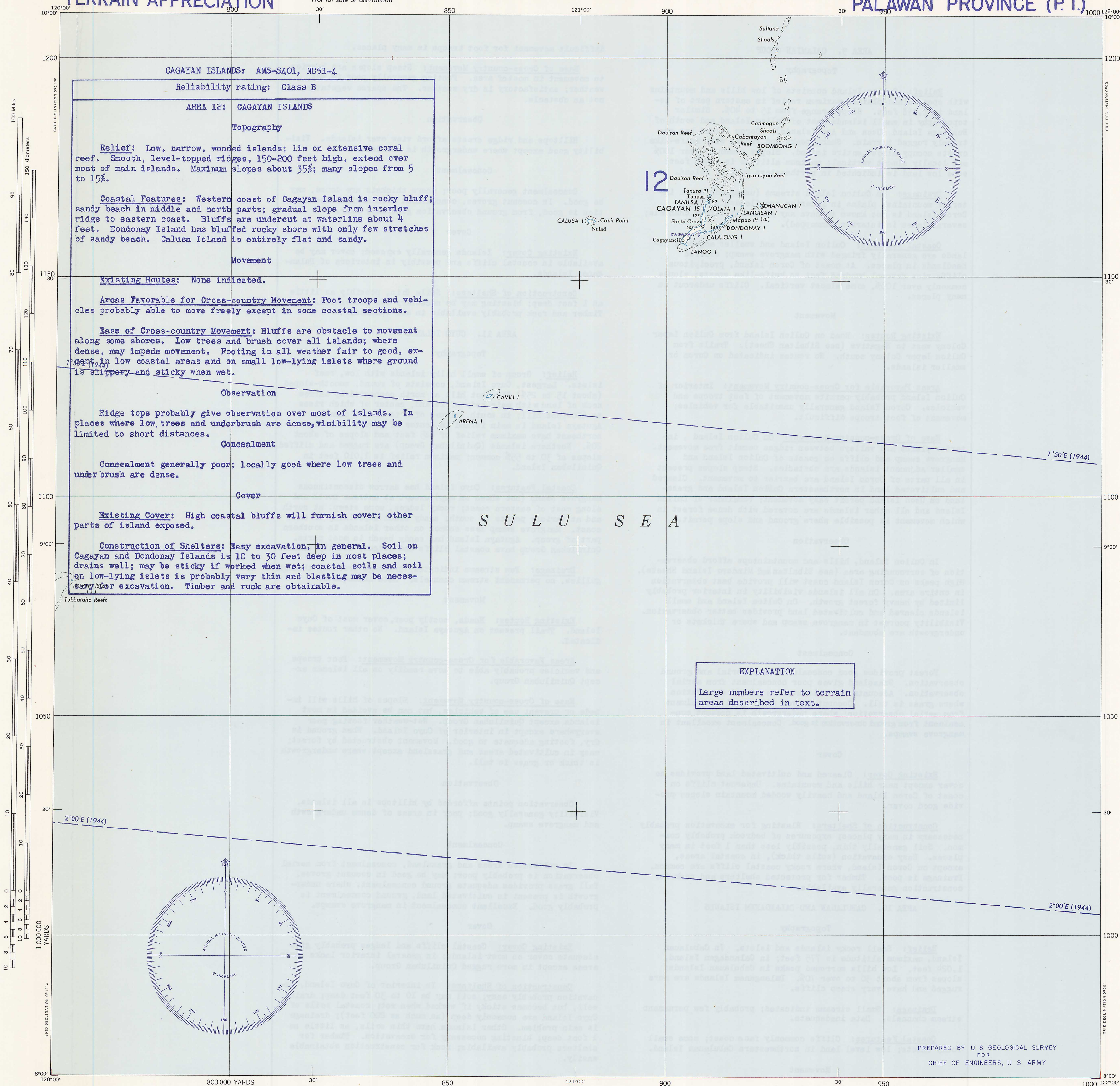
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CAGAYAN ISLANDS

SECOND EDITION-AMS 2

PALAWAN PROVINCE (P.I.)

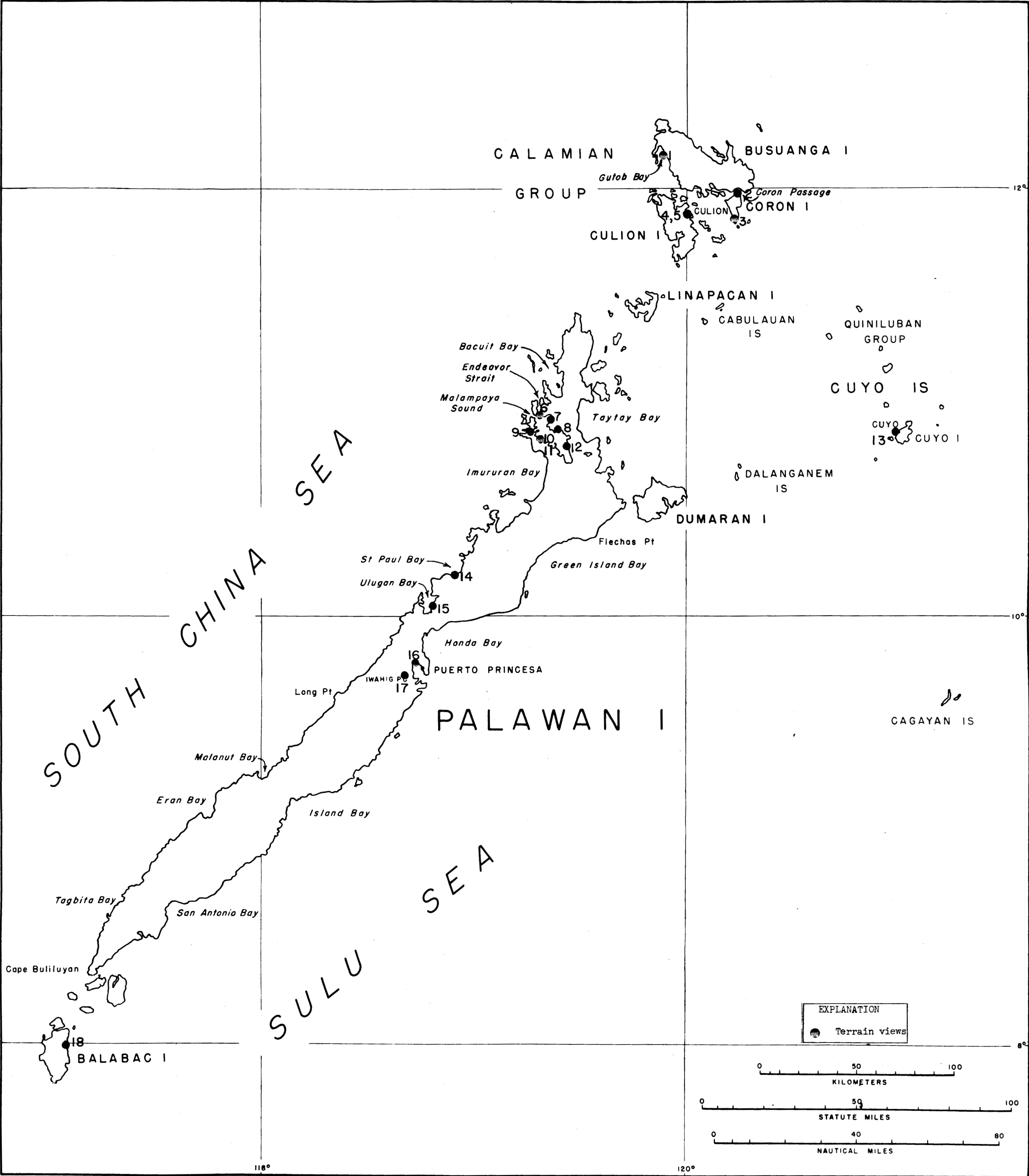
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CAGAYAN ISLANDS, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N800-E12000/200

VIEWS INDEX

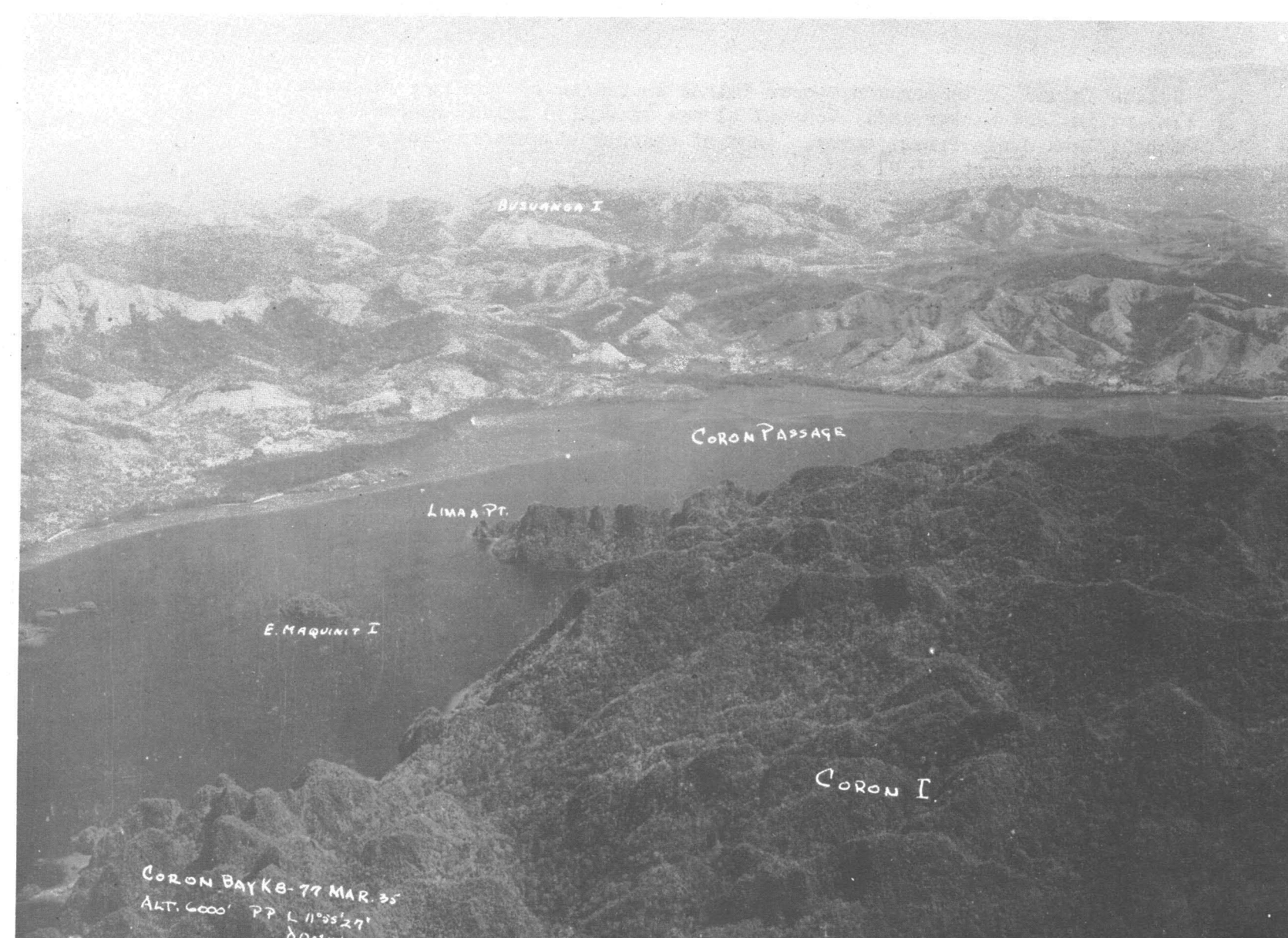
PALAWAN PROVINCE (P.I.)



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Small stream valley and coastal lowland on Gutob Bay, Busuanga Island.
Hills rise steeply above partly cleared and cultivated valley floor.
Steeper slopes largely covered with primary forest; intermediate slopes with secondary forest. (ONI 62527)



View across Coron Passage; Busuanga Island in background, Coron Island in foreground. Steep slopes, largely grass covered; lack of extensive flat areas characteristic of hilly mountainous Busuanga Island. Rugged terrain mantled by primary forest characteristic of forbidding Coron Island which has neither coastal lowlands nor flat valley bottoms. (ONI 62501)



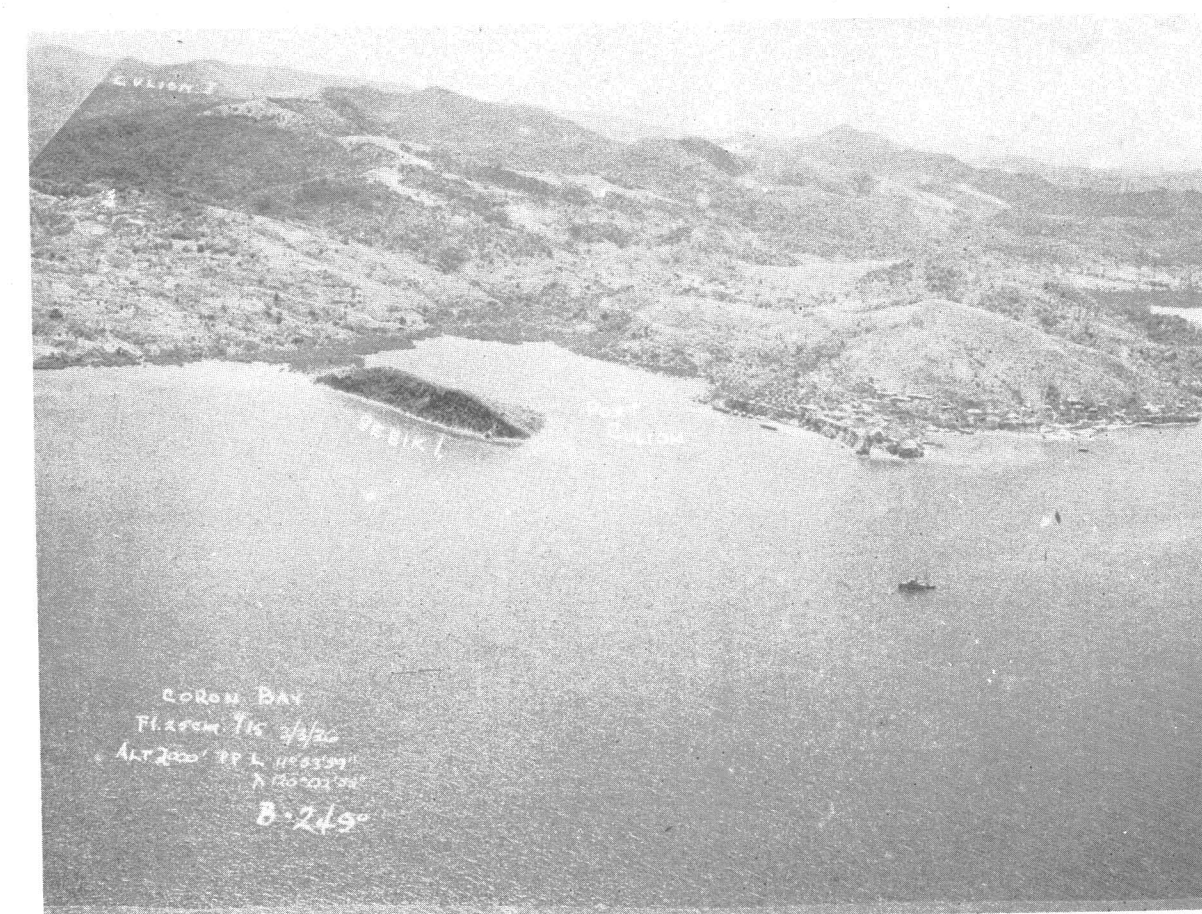
3 Southern part of Coron Island shows complete lack of coastal lowlands; cliffed shoreline. Rugged terrain with many vertical cliffs; dense primary forest covers steep slopes where there is sufficient soil. Lack of streams and stream valleys characteristic. Small interior salt water lake on right. (ONI 62425)

VIEWS 4-8

PALAWAN PROVINCE (P. I.)



4 Culion Island in foreground; Coron Island in center background; Busuanga Island in left background. Coastal slopes of Culion Island generally steep; lack dense forest cover. Lack of beaches characteristic; narrow coral reefs fringe coast. (ONI 62541)



5 Culion Island with Culion village extending along steep coast. Steep slopes, in part grassy, in part forested, and lack of coastal lowlands typical of much of island. Narrow mangrove swamps line coast to left of village. (ONI 62539)



6 View to north from Malampaya Sound (Palawan Island) along Endeavor Strait showing typical mountainous terrain of steep forested slopes. Lack of coastal lowlands characteristic. Small rocky islands with steep coastal cliffs in background. (ONI 62809)



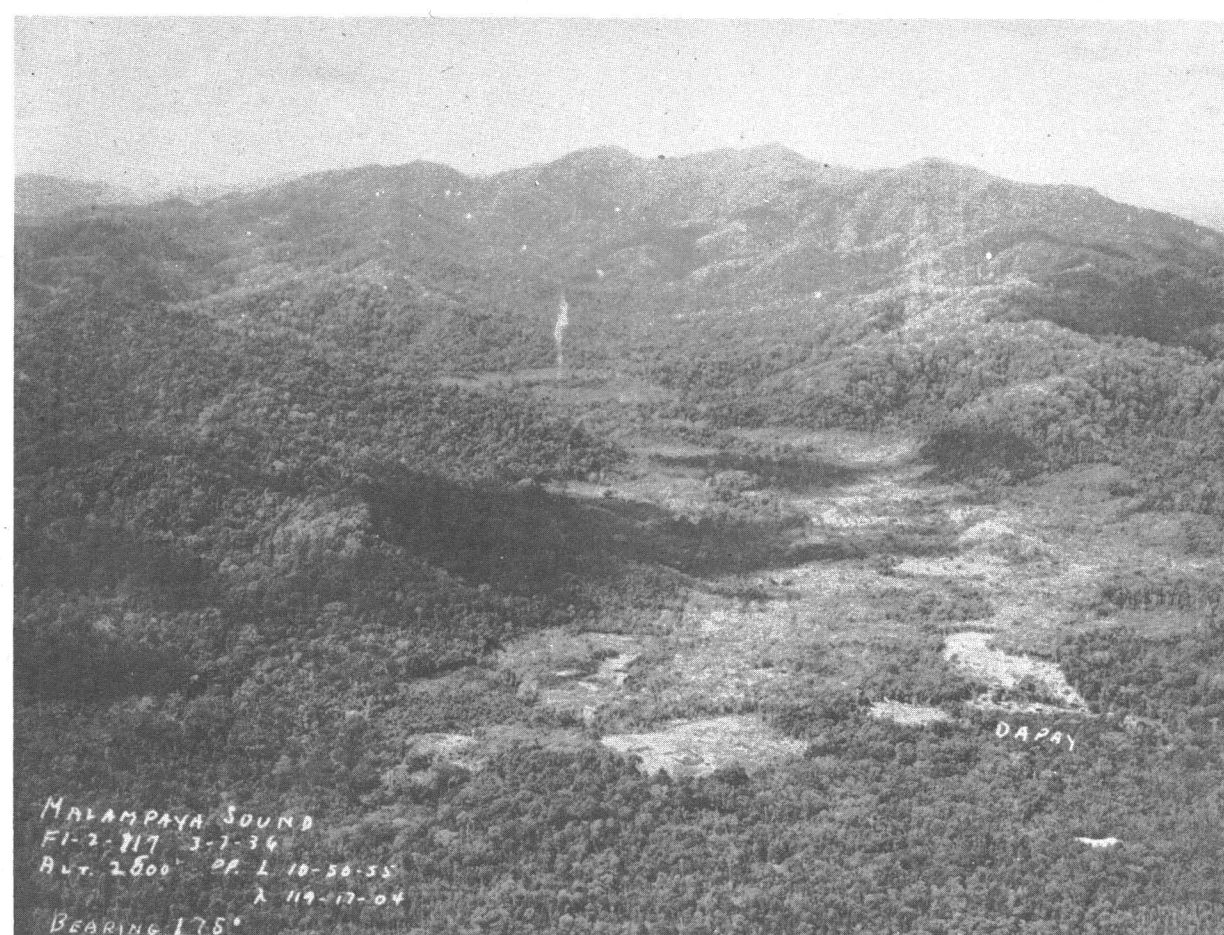
7 Small village of Binaluan (Malampaya Sound, Palawan Island) occupies narrow coastal flat at mouth of small stream. Steep forested slopes have been partially cleared; elsewhere dense primary forest forms obstacle to movement. Most settlements on Palawan Island located on small coastal lowlands; island interior generally uninhabited. (ONI 62841)



8 View to north from Inner Sound (Malampaya Sound, Palawan Island) to Bacuit Bay shows broad heavily forested valley surrounded by heavily forested mountain slopes. Small area near coast has been cleared for cultivation but is now reverting to secondary forest and grassland. Broad valleys are best routes across island but because of heavy vegetation are difficult to move through. (ONI 62831)

PALAWAN PROVINCE (P. I.)

VIEWS 9-12



9 Open valley floor at Dapay on west side of Malampaya Sound (Palawan Island) shows typical mountain terrain with steep, heavily forested slopes. Forests have been cleared in valley which has in part reverted to secondary forest. (ONI 62823)



10 View to southwest across Malampaya Sound to Mt. Capos (Palawan Island), altitude 3,350 feet; highest peak of northern Palawan. Small forested islands typical of complex coast. (ONI 75294)



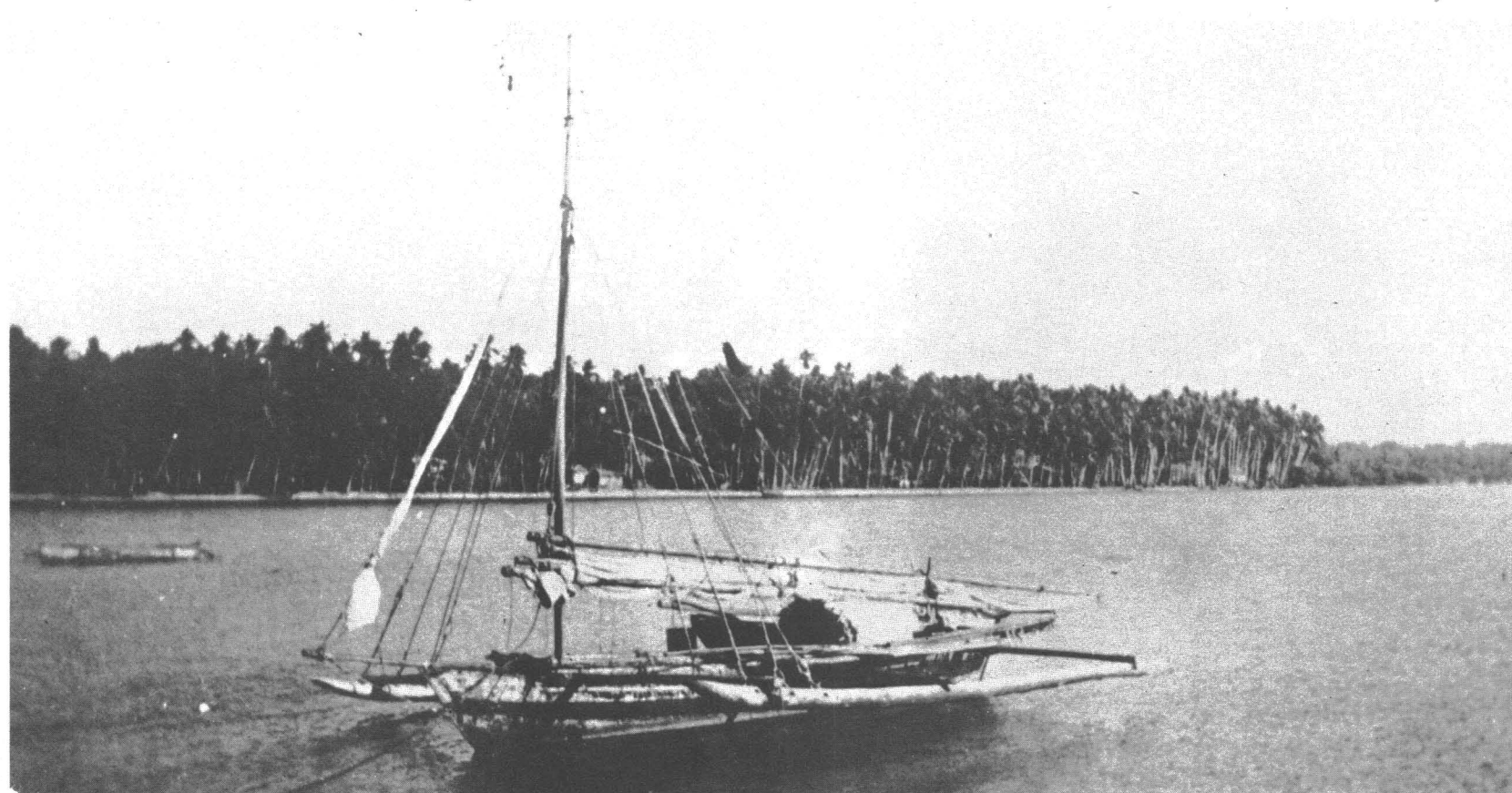
11 Characteristic view of rugged rocky shore of Palawan (Malampaya Sound). Lack of beaches and coastal lowlands characteristic. (ONI 56434)



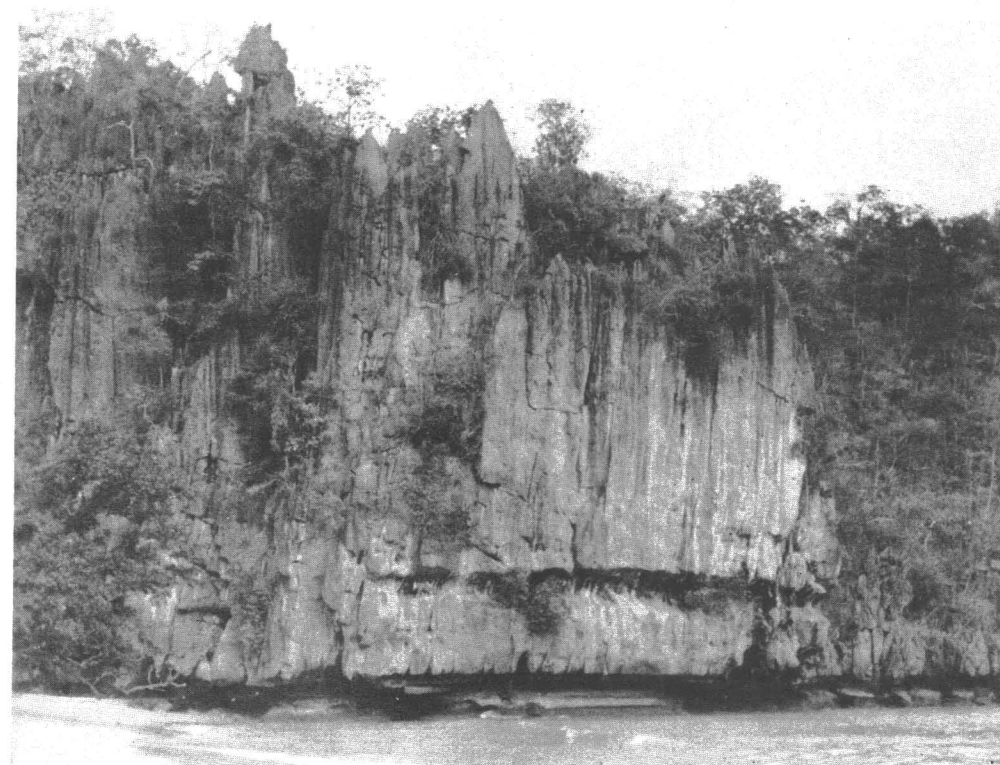
12 Palm-fringed shore of Malampaya Sound (Palawan Island) characteristic of small coastal lowlands. Sandy beaches narrow; shore fringed by coral reefs. (ONI 28906)

VIEWS 13-15

PALAWAN PROVINCE (P. I.)



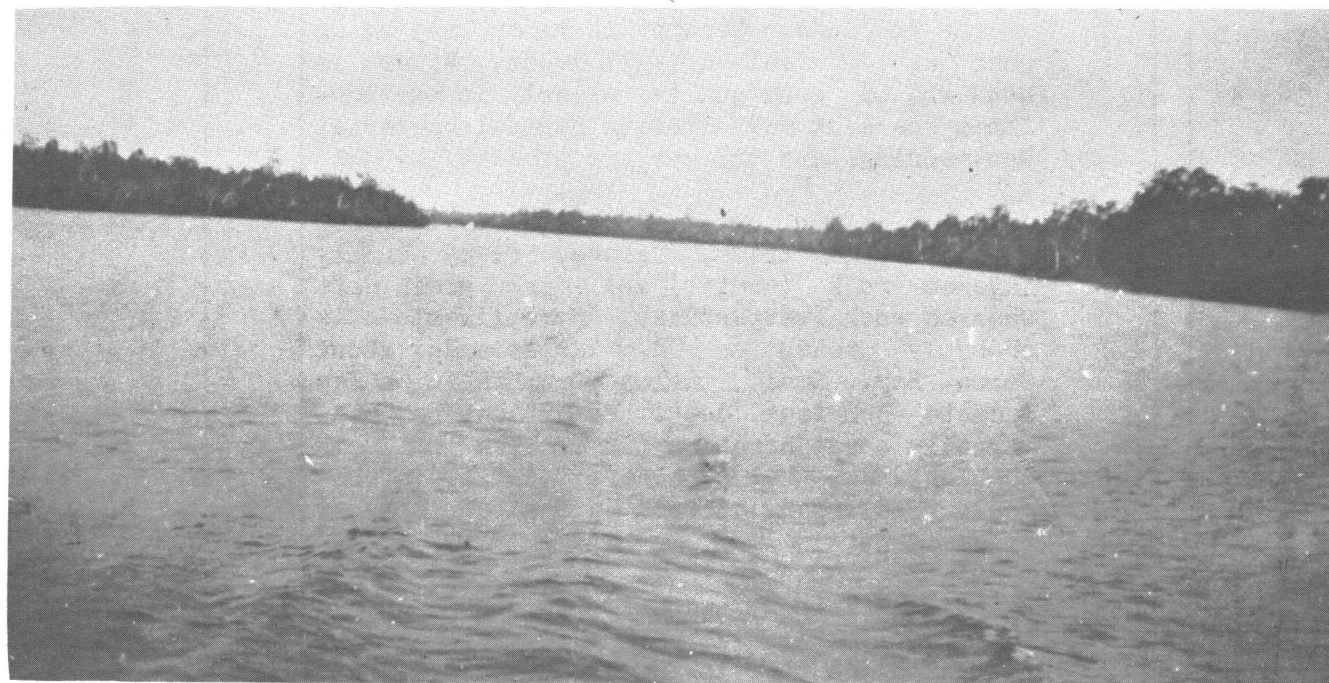
13 Coast of Cuyo Island generally low and fringed with coconut palms. Narrow sandy beaches and submerged coral reefs characteristic of these low coasts. Mangrove lines shore at right. View of shore south of Cuyo wharf. (OSS 708140)



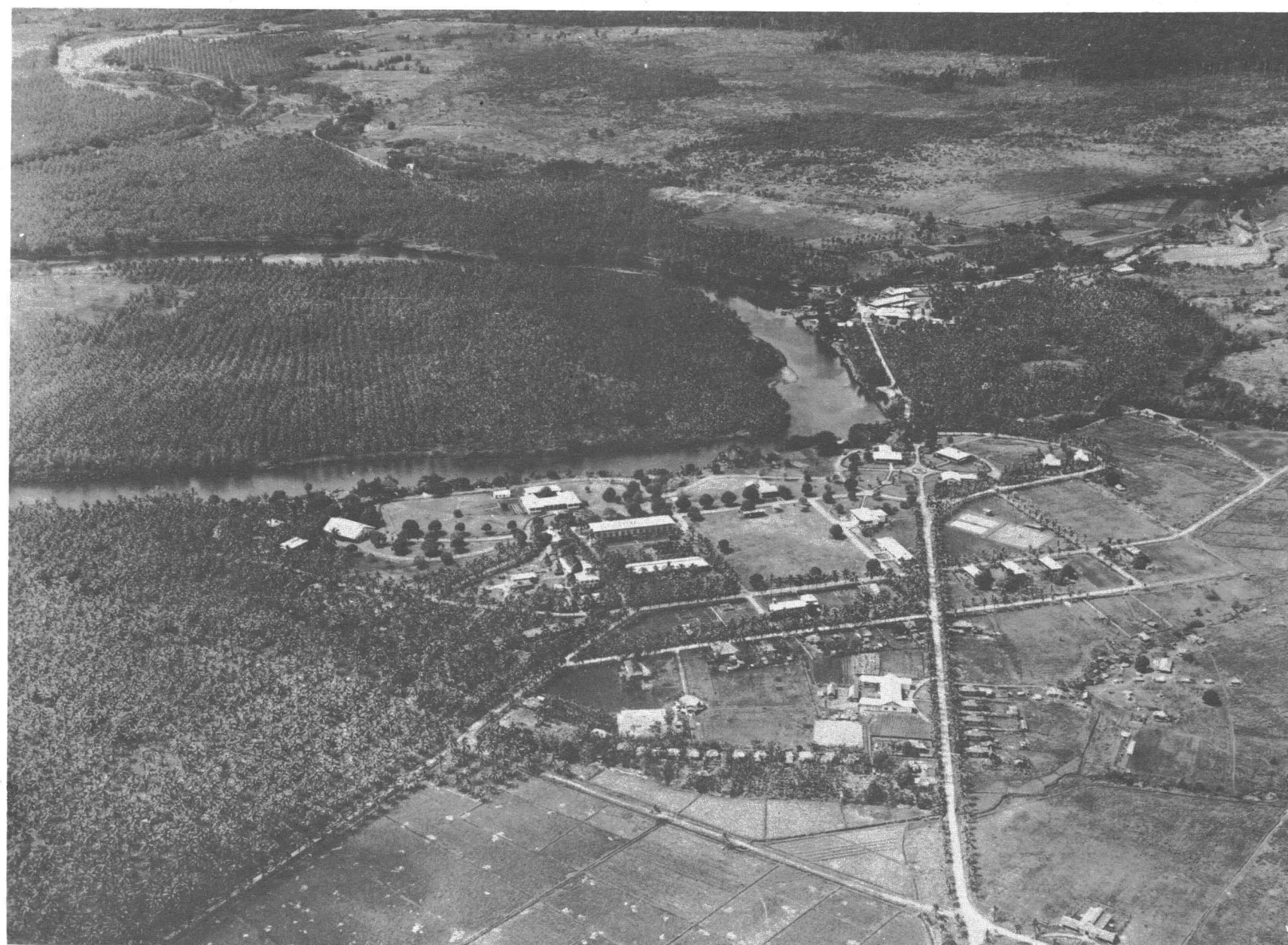
14 Limestone cliffs, undercut at base, are characteristic of Saint Paul Bay region (Palawan Island). Cliffs are notched at waterline and at different heights above present sea level. Dense primary forest developed where there is sufficient soil. View shows point of issue of underground fresh water stream. (ONI 56431)



15 Shore of Ulugan Bay (Palawan Island) similar to the steep slopes and heavily forested shores of Malampaya Sound. Lack of coastal lowlands characteristic. (OSS 95359)



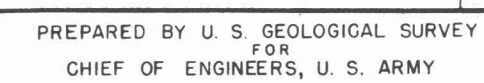
16 Low marshy coastal area around Puerto Princesa (Palawan Island) is lined by mangrove swamps. View shows broad channel of small stream near its mouth. Footing along these shores is poor; landing operations difficult. (OSS 49 578)

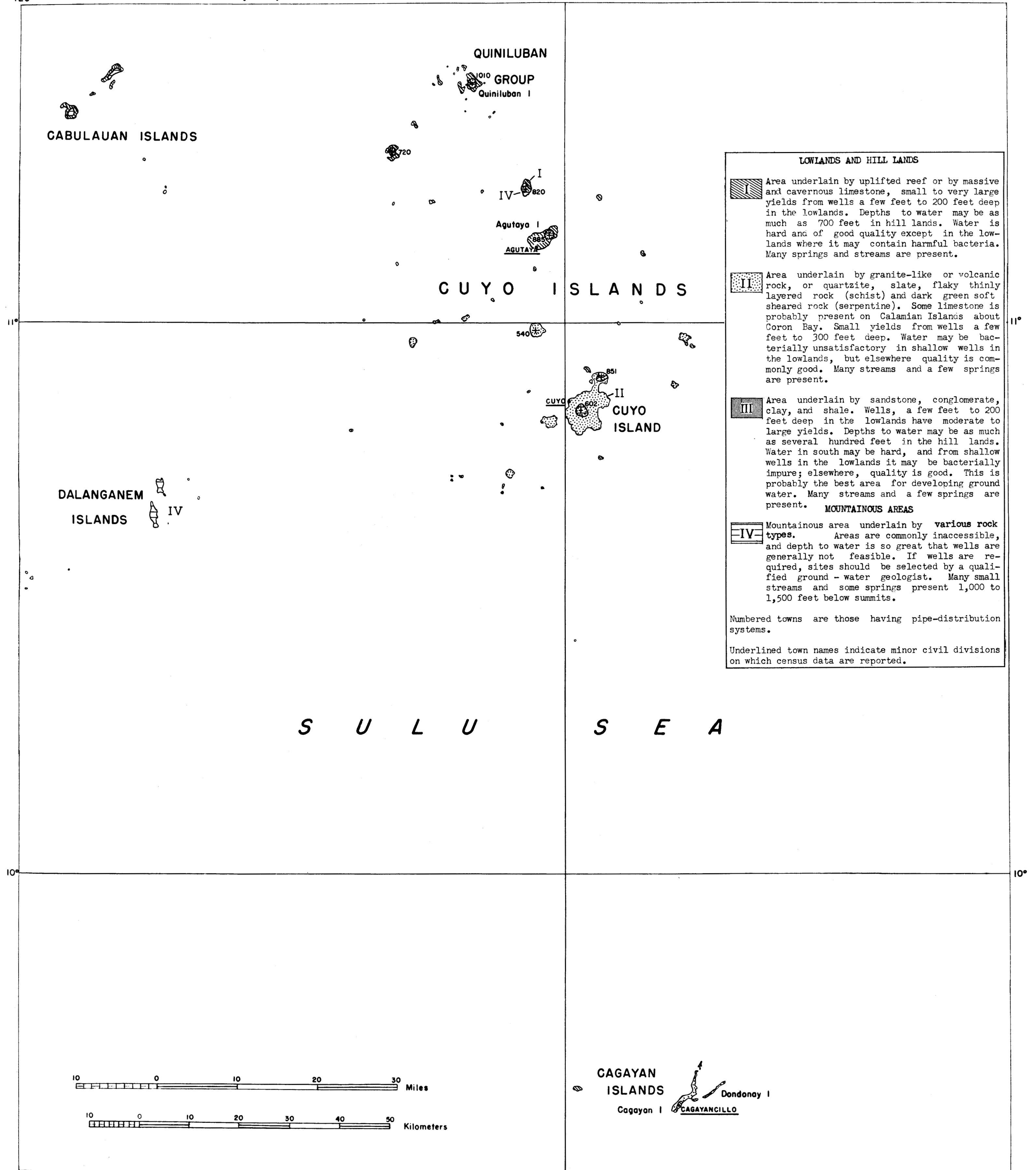


17 View of Iwahig Penal Colony on Puerto Princesa lowland. Iwahig River meanders across plain; low natural levees along banks are highest land. Coconut plantations and rice paddies comprise most of cultivated land. Road network reported best on Palawan Island. Heavy primary forest in background. (OSS 99 012)



18 View of Calandorang Bay on Balabac Island. Steep heavily forested slopes and lack of coastal lowlands and broad beaches characteristic of large parts of Balabac Island. (ONI 28589)





Reliability rating: Class D

INTRODUCTION

General Statement

Except on the islands of Palawan Province having an area less than 5 square miles, water resources are adequate for all purposes. In general, surface waters will be the most easily developed and most satisfactory sources of supply for all purposes. On the larger islands are numerous small streams and a few large ones. Most streams are perennial, but some are ephemeral. High-water stages are frequent in all streams; flood stages are reached occasionally. Water from streams in the hills and lowlands will generally require chlorination and filtration. Except in the mountains, readily accessible and easily developed watering points on streams can generally be selected. Lake Mangao near Taytay in northern Palawan Island is probably the only permanent fresh-water lake in the province.

Ground water in sufficient quantities for most purposes is generally available in the lowlands and hills. In many places where wells are not advisable, springs are present. Much of the ground water is hard, but it contains no harmful minerals. Water from shallow wells and many springs will require chlorination.

Small emergency supplies of drinking water or an acceptable substitute can be obtained from green coconuts, climbing bamboos, and certain lianas known to the natives. Rain water can be caught and stored at all seasons.

Existing water facilities are limited to a few small pipe-distribution systems, some of which deliver water unsuitable for drinking or culinary purposes without treatment. Near Aborlan on Palawan Island and Coron on Busuanga Island are a number of deep, drilled wells owned by individuals or communities. Throughout the province are numerous shallow wells. Water from shallow wells is usually contaminated.

Topography

General Statement: Palawan Province (land area about 5,700 square miles) consists of 1,169 islands, 63 of which are larger than 1 square mile. In this discussion, the islands are divided into 5 groups: (1) Palawan and adjacent islands, (2) Balabac and adjacent islands, (3) Cuyo, Quinluban, Dalanganem, and Cabuluan Islands, (4) the Calamian Islands Group, and (5) the Cagayan Islands.

Palawan and Adjacent Islands: Palawan (area about 4,555 square miles) is the largest island in the province. It is about 270 miles long and about 4 to 30 miles wide. A rugged central mountain range extends almost the entire length of the island, but is broken in a few places by hilly lowlands and plains. Coastal lowlands separated from the mountains by rolling to steep foothills reach a maximum width of 5 miles on the southeastern coast; elsewhere they are narrow or absent. Dumarang has an area of about 126 square miles. It and the smaller islands of the group are generally rolling to hilly with little level lowland. The coasts are locally precipitous and rocky; the beaches are few and small; mangrove swamp is present at many places.

Balabac and Neighboring Islands: Balabac Island has an area of about 125 square miles. In the east-central part of the island stands Balabac Peak, altitude more than 1,860 feet. Altitudes decrease to the north and south to steep rolling hills with small, narrow valleys. The hills and mountains are encircled by a narrow coastal lowland, which is widest on the west. The smaller islands of the group are low with only a few scattered rolling hills.

Calamian Group: The largest islands of the Calamian Group are Busuanga (area 344 square miles), Culion (area 150 square miles), and Coron (area 27 square miles). A few peaks rise to altitudes between 1,100 and 2,000 feet but, except for Coron, the islands are generally hilly with low rounded summits rising 250 to 700 feet above broad level valleys. Many valleys are marshes during the rainy season. Coron is very rugged throughout.

The Cuyo, Quinluban, Dalanganem, Cabuluan, and Cagayan Islands: The islands of Cuyo (area 57 square miles) and Cagayan (area 7 square miles) are the largest. The topography of all these islands is roughly similar consisting of small mountainous areas of less than 1,000 feet altitude and more extensive areas of rolling hills and level lowlands. The coasts are generally precipitous, and beaches are few and small.

Stream Characteristics

Stream channels in the level lowland valleys are as much as 150 to 200 feet in width. Gently sloping banks of alluvium are 3 to 5 feet high. In many places they are soft and marshy. Stream beds near the coast are muddy, but above the influence of high tide they are sandy and gravelly. Small rapids and falls occur within a mile of the coast on many streams. In the narrower, steeper valleys in the hills and uplands, stream channels are seldom wider than about 50 feet. The steep, 4- to 6-foot high banks are alluvium or bedrock and are generally firm. The beds are generally sandy and gravelly; small waterfalls and rapids are numerous. In the mountains, channels are narrow but generally not deep. The banks are bedrock in most places. The bedrock channels are generally mantled with cobbles and boulders; where gradients are low, they are covered by sand and gravel. Rapids and waterfalls, some several hundred feet high, are common.

Geology

Reef limestone probably underlies much of the coastal plain of southern Palawan Island, and the lowlands of Balabac, Cuyo, Cagayan, and their adjacent islands. This limestone is a soft to moderately hard, gray to white

rock; generally highly permeable but containing, in some places, relatively impermeable marly beds. It is a fair source of ground water, but many wells may be dry holes and others near the sea may strike salt water. Best opportunities for obtaining ground water are where marly beds are present. They support perched water bodies in some places and in others act to exclude sea water.

Massive and cavernous limestone underlies large areas in the uplands and hills of the province. It is moderately hard gray to buff or white rock, impermeable in mass but containing, in many places, fractures and cavities, which store and transmit water. It is a fair source of ground water but many wells may be dry holes. Yields will vary over short distances depending upon number and size of openings encountered. Badly fractured areas offer best possibilities of obtaining water.

Granite-like and volcanic rocks underlie large areas in all but the Calamian Island Group. They are hard black to light gray rocks, impermeable in mass but containing, in many places, fractures, cracks, and vesicular zones which store and transmit small amounts of water. They are a poor source of ground water. Yields will be small and variable as they depend upon size and number of openings encountered by the well. Fracture openings tend to close at depth and if water is not encountered at depths of less than 300 feet, holes should be abandoned.

Schist, slate, and serpentine (dark gray to greenish metamorphic rocks of moderate hardness), and shale occur beneath the lowlands and hills of Palawan and the Calamian Group. They are poor aquifers and will yield little or no water. However, in some localities, particularly on Dumarang Island and the Calamian Islands, they are found in conjunction with very hard, dark brown to yellow and white, fractured quartzite and conglomerate. At such places, the fractures in the quartzite and conglomerate contain small amounts of water. Perched ground-water bodies held up by impermeable shales or slates are present. Yields are small as conditions controlling the occurrence of water are similar to those in the granitic or volcanic rocks.

Soft to moderately hard, alternately bedded clays, sandstones, and conglomerates underlie areas on Palawan and Balabac Islands. The sandstones and conglomerates are generally permeable and offer the best possibilities of developing ground water in the province. Perched water bodies supported by clay beds may be found in places.

Alluvium, found in many valleys and possibly in some of the coastal lowlands, consists of heterogeneous bodies of sand, gravel, and clay. Permeability is very variable over short distances, but in general the best localities for shallow dug or driven wells and infiltration galleries are in this material.

Population

The population of Palawan Province in 1939 was about 94,000. Palawan and adjacent islands included about 47,800 people; Balabac and adjacent islands about 2,800; the Calamian Group about 21,400; Cuyo, Quinluban, Dalanganem, and Cabuluan Islands about 21,400; and the Cagayan Islands about 3,000. About 93,000 of the population are natives. Whites, principally on Palawan and the Calamian Islands, numbered 79. There are few towns; most of the population lives in scattered barrios of 30 houses or less located in the lowlands and along the coasts.

Precipitation

Palawan Province has distinct wet and dry seasons. The amount of precipitation varies somewhat from place to place. Rainfall in the dry season generally occurs as afternoon showers of small areal extent, although occasionally rain falls almost continuously for periods of a few hours to a day. During the wet season, rains are often steady and heavy over large areas; storms may last from a few hours to several days. Available rainfall data are summarized in the table at the bottom of the page. The data from Cuyo is representative of the Cuyo, Quinluban, Dalanganem, Cabuluan, and Cagayan Islands, the data from Culion is representative of the Calamian Islands, the records from Iwahig are representative of the eastern part of Palawan Island between San Antonio Bay and Fleches Point. The estimates for western Palawan are believed to be representative of the balance of Palawan Island and Balabac and adjacent islands.

WATER RESOURCES AND DEVELOPMENT

General Statement

Introduction: The accompanying table summarizes water resources of Palawan Province and outlines most feasible methods of development and the problems which must be solved. Some features apply to many areas. In order to keep the table brief, such common features are discussed under relevant headings in this general statement. References are made to them, where needed, in the areal discussions. All data given apply only to islands with areas in excess of 5 square miles.

The Smaller Islands: Information on the smaller islands is generally inadequate, and available data do not permit easy interpretation. The smaller islands generally contain no lakes, and only small ephemeral streams. Wells are subject to invasion by salt water if pumped too strongly, and, as a result yields must be kept small. Perennial springs are usually not present. Unless definite information is available, it should be assumed that potable water will be limited in amount and of poor quality. If potable water is present, the occurrence and development problems will be similar to those on nearby larger islands.

Beaches and Mangrove Swamps: Areas of beaches and mangrove swamps are too small to be shown on accompanying map. For information regarding location and areal extent of such features, see the U. S. Coast Pilot, Philippine Islands, Part II: Palawan, Mindanao, and Sulu Archipelago, and the coastal charts of the U. S. Coast and Geodetic Survey. These publications also give information in regard to known watering places along the coast.

Supplemental Water Sources: Small supplies of water or an acceptable substitute are available from sources other than ground or surface water. Coconut palms grow on nearly all beaches, in large cultivated plots in lowlands, and in smaller cultivated groves in the hills. The milk of the green coconut is a palatable substitute for drinking water. Climbing bamboos grow in open glades in the forest from sea level to high in the mountains. The segments between the nodes contain small amounts of water. Certain water-bearing lianas, known to the natives, have a distribution similar to the bamboos, but are also found in the deep forest. A two-foot length of liana contains as much as a pint of palatable water.

Rain water can be caught from trees (see Figure 1) or on tarpaulins during all seasons. It is the only local source of supply in mangrove swamps, on many of the smaller islands and beaches, and on high bare mountain peaks. If men are isolated for any length of time in such areas, it will be necessary either to transport water to them or to set up distilling plants to treat sea water. Sea water is recommended for distillation rather than swamp water as certain earthy tastes and odors found in the latter pass over the still with the water.

Accessibility: The accessibility of the various areas to foot or vehicular traffic is indicated in the column on occurrence of surface water. In most instances reference should be made to the terrain sheets for data and specific localities.

Recommended Sources of Water Supply: These columns of the table list what are probably the most feasible sources of water for various types of operational and occupational phases. The several sources listed under each category are alternatives given in order of decreasing desirability and importance. Selection of sources and relative desirability were based on supplies needed for one division. Length of tenure, water requirements per man, reliability and quality of supply, ease of development, and availability of equipment were considered in the recommendations.

Several terms used in the table are more fully defined as follows:

Imported: Two days' supply to be carried by each man; or arrangements made to truck or otherwise deliver water to established watering points.

Rain Water: Rain water caught from trees, on tarpaulins, or other catching surfaces.

Cisterns: Tanks for storage of water diverted from ephemeral streams, or gathered from collecting grounds or other surfaces. Ordinarily such structures can be filled only during the rainy season.

Construction Materials Available Locally: The extensive forests of the province contain numerous trees which are excellent for curbing, shoring, timbering, and temporary foundations. It is reported that, unless treated, all wood in contact with the soil will require replacement at least once a year. Clays suitable for dam cores and impervious membranes are widespread in the areas underlain by limestone, serpentine, clay, shale, and volcanic rocks. Relatively permeable, easily compacted earth for use in dams and similar structures, is most abundant in areas underlain by granite. Sand and gravel suitable for concrete aggregate occur in most stream channels and on some beaches. Rock suitable for riprap, masonry, and other construction purposes is abundant in most parts of the province.

Equipment and Materials Needed: The following list gives only the most essential and desirable equipment and supplies needed for the development of water supplies:

General: Chlorination, Filtration, and Distillation Units; 5 gpm 2-man pack filters if available; carpenter's tools; hand excavating tools; explosives for excavating; pipe for pipe line; cement; lumber and timber for cribbing, forms, and temporary foundations (See Construction Materials Available Locally).

Surface-water Development: Heavy-duty screens and trash racks; centrifugal pumps with suction-line fittings; pontoons.

Ground-water Development: Drilling rigs; extra drilling tools; fishing tools; perforating tools; driving rigs; drive pipe; drive shoes; screens; casing; high- and low-capacity, high-lift turbine pumps with necessary fittings; high-lift cylinder pumps with necessary rods, drop pipe; pitcher pumps.

Ground-water Development

Ground Water in Alluvium: Ground water is present at relatively shallow depths in alluvium at or near perennial and ephemeral stream channels and possibly at places in the coastal lowlands. The amount of water present varies with the volume of alluvial material and the size of the drainage basin or contributing area.

The alluvium consists of heterogeneously dispersed and intermixed lenses and channels of clay, sand, gravel, and larger rocks. In the lowlands, the material is fairly fine-grained and well-graded; in the hill lands, it is coarse and poorly sorted. Yields of wells will range from quite small to large over short distances, depending upon permeability which varies with degree of sorting, grading, and coarseness of material.

The quality of the water will be similar to that in the streams traversing the alluvium except that it will be clear and silt-free because of natural filtration.

In the lowlands, where stream valleys and channels are relatively broad, driven wells spaced on 20- to 25-foot centers along a line crossing the stream channel can be put down in shallow or ephemeral streams where the surface of the underflow is less than 15 feet below the bed of the stream. If possible, wells should be driven to the base of the alluvium. Because of buried boulders, logs, and other large objects, it may be impossible to drive wells in some places. By moving the well site a short distance the pipe can usually be sunk easily. Screens will be essential on such wells; wells can be connected through a manifold to one centrifugal pump. Well heads and manifold must be protected against swift high water and flood flows which are laden with heavy debris. Pumping plants can be located at altitudes above such dangers.

Dug or driven wells can also be put down in alluvium outside stream channels. Sites near streams are best but even at such sites yields will be less than from wells in the stream channels. Excavation will be easy but driving may be difficult to impossible because of buried obstacles similar to those beneath stream channels. Curbing or screens will be required.

If culvert or other large-diameter pipe is available (see Figure 4), it can be installed beneath stream channels. The collecting well can be located beneath high ground. Such installations will be safe from interruptions due to high water or floods. When pipe is not available, wooden culvert may be constructed from locally available material, or open ditches shored with native timber can be constructed along banks of streams at sites above flood levels.

Salt-water Contamination: The estimated distance from the coast within which there is danger of salt-water contamination of wells due to overpumping is indicated for each area in the table. Even beyond the limits given, it is advisable to make periodic checks of the chloride content of wells penetrating below sea level. For data on control, see Diagrams A to D, Figure 5.

Spacing of Wells: Recommendations in each area are directed toward avoiding possible contamination of wells by salt water and toward keeping interference between wells reasonably low. Experience may indicate a more desirable spacing. Well spacings should be measured approximately along a contour and under no circumstances should more than one well be drilled on or near a line normal to the contours.

Depths of Wells: Recommended depths of wells are directed entirely against possible contamination of wells by salt water. In some areas, unique conditions present locally applicable limits, which are mentioned in the discussion of the area. In all other areas the following limits are applicable: in lowlands, within 500 feet of coast, 1 foot below sea level; 500 feet to 1/2 mile from coast, 1 to 3 feet below sea level; beyond 1/2 mile, depth unlimited.

In hill lands, within 500 feet of the coast, 1 foot below sea level; 500 feet to 1/4 mile from coast, 1 to 3 feet below sea level; beyond 1/4 mile, depths unlimited. In country where depths are unlimited, it will be advisable to make periodic checks of water from wells within 1 mile of coast, to detect evidence of salt-water encroachment.

In some areas, maximum depths are given, below which it is probable that openings in rocks will be so small and infrequent in occurrence that only a little water will be present, and it will be yielded to wells slowly or not at all.

Depth to Water: The depths to water given in the various areas are general estimates of distance to water table if measured from lower parts of the land surface, such as beneath valley floors or lower slopes of hills. In general, depth increases with increasing altitudes.

Development of Springs: Springs can be improved by tunneling and ditching to permit unimpeded and concentrated flow of water (see Figure 2). Excavating will ordinarily require explosives. Tunnels in most localities must be timbered.

If flows are small, storage basins can be constructed near spring outlets. Basins may require sealing with concrete or puddled clay to reduce seepage losses. Ditches to intercept and divert surface run-off from spring outlets and storage basins should be dug. Several acres above spring outlets should be restricted. No attempt should be made to develop ephemeral springs and use of them is not recommended.

Some springs, particularly those with large fluctuations in flow may require chlorination and at times filtration.

RAINFALL IN INCHES IN PALAWAN PROVINCE					
Station	Aver. Annual	Rainy Season		Dry Season	
		Months	Seasonal Rainfall	Months	Seasonal Rainfall
Cuyo	87.0	May-Nov.	82.3	Dec.-Apr.	4.7
Culion	126.1	May-Nov.	118.6	Dec.-Apr.	7.5
Iwahig	79.9	May-Dec.	71.2	Jan.-Apr.	8.7
W. Palawan (estimated)	110-115	May-Oct.	93-94	Nov.-Apr.	16-22

(continued)

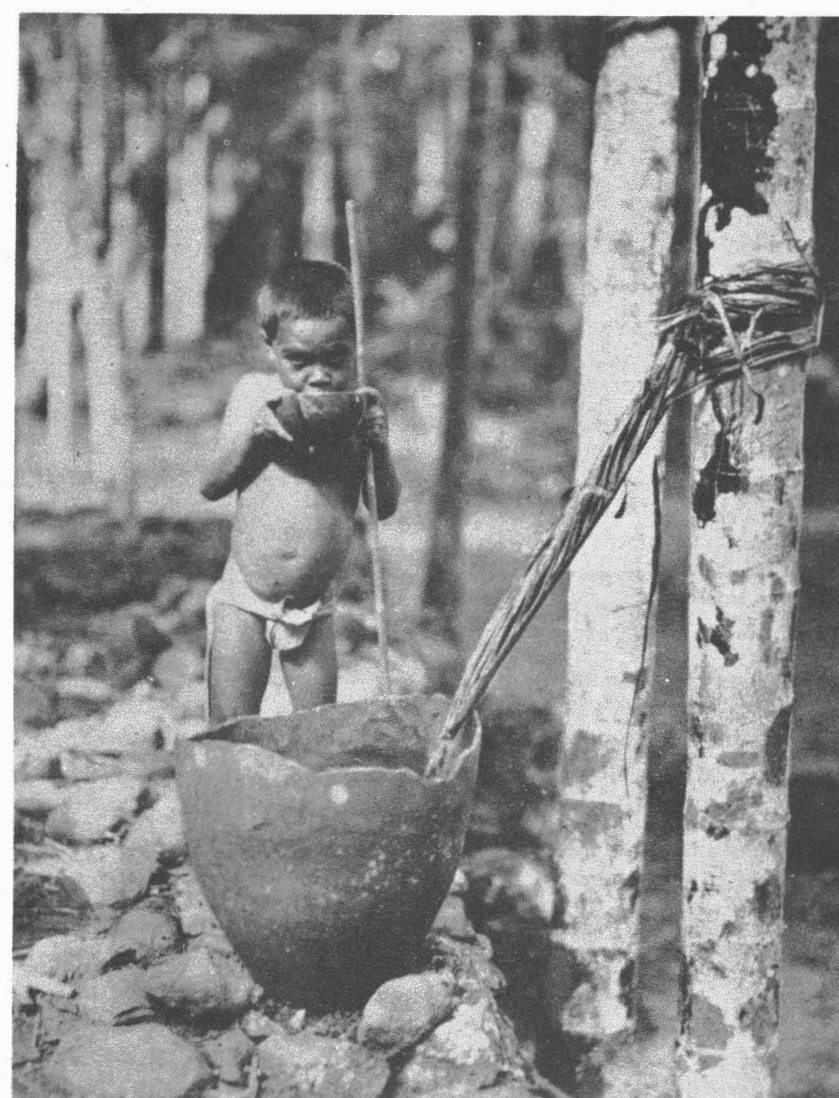
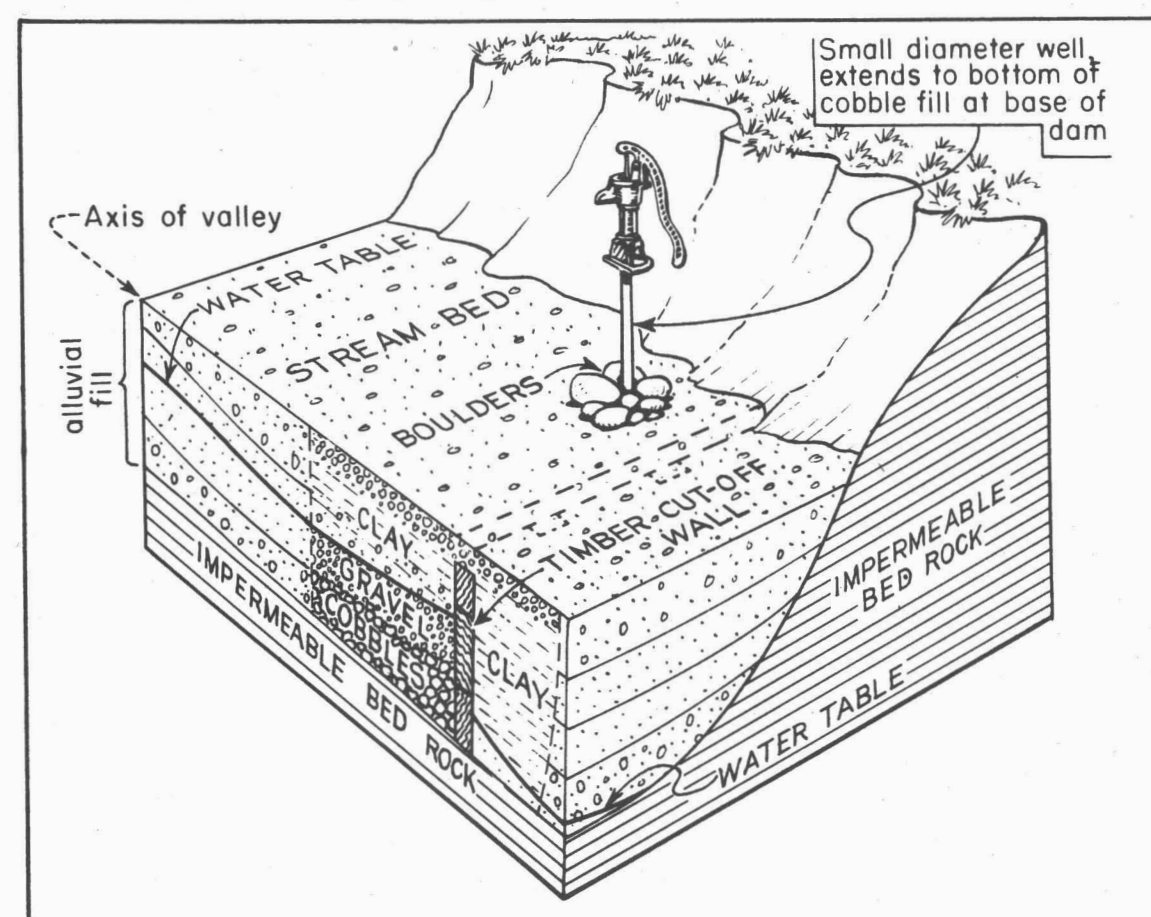


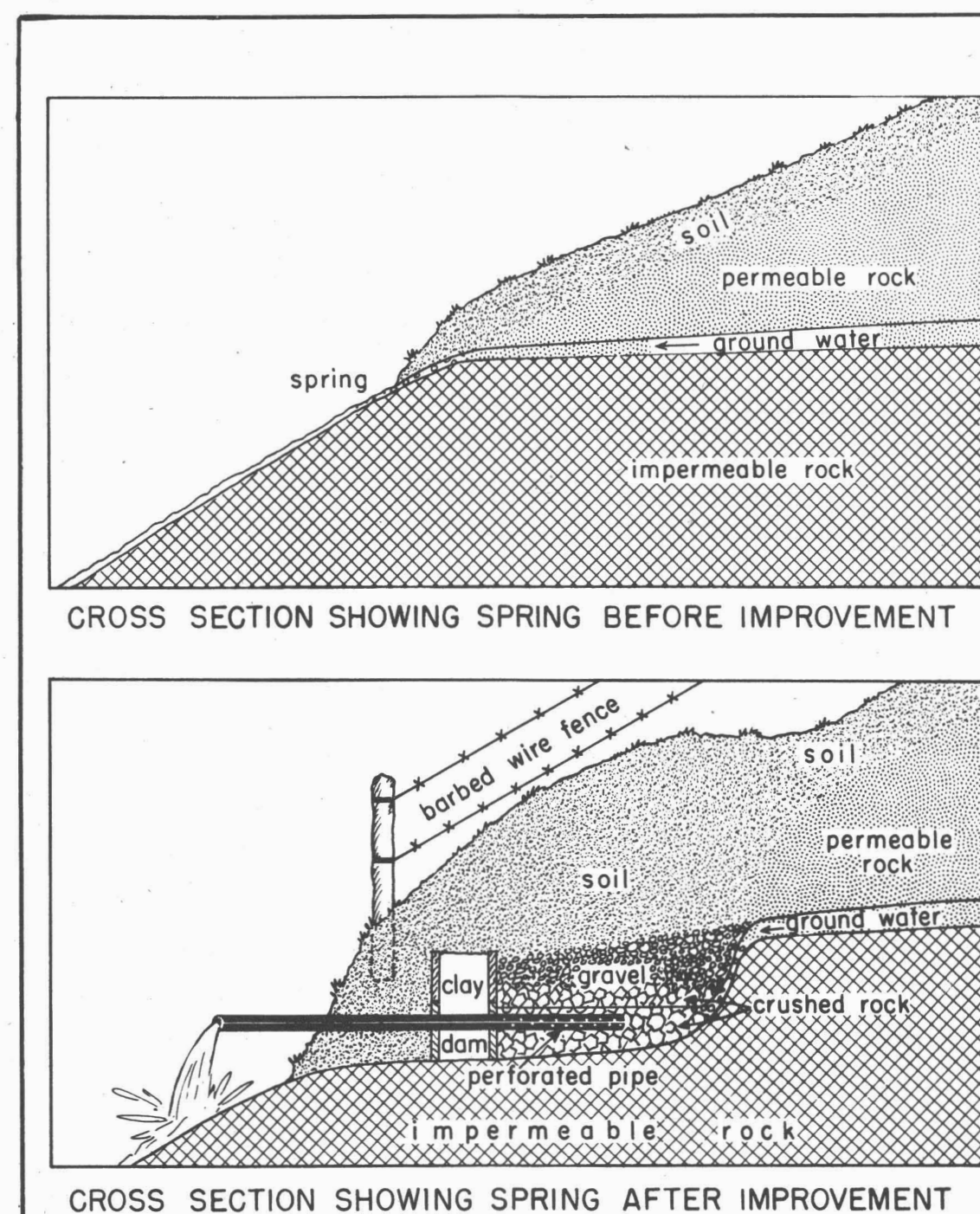
FIGURE 1. Collecting rain water from trees, coco-nut palms, etc. Palm leaves, twisted ratan or cogon grass, rope, metal collars, etc. are attached to trunk to intercept and divert water.

FIGURE 3. GROUND WATER DAM



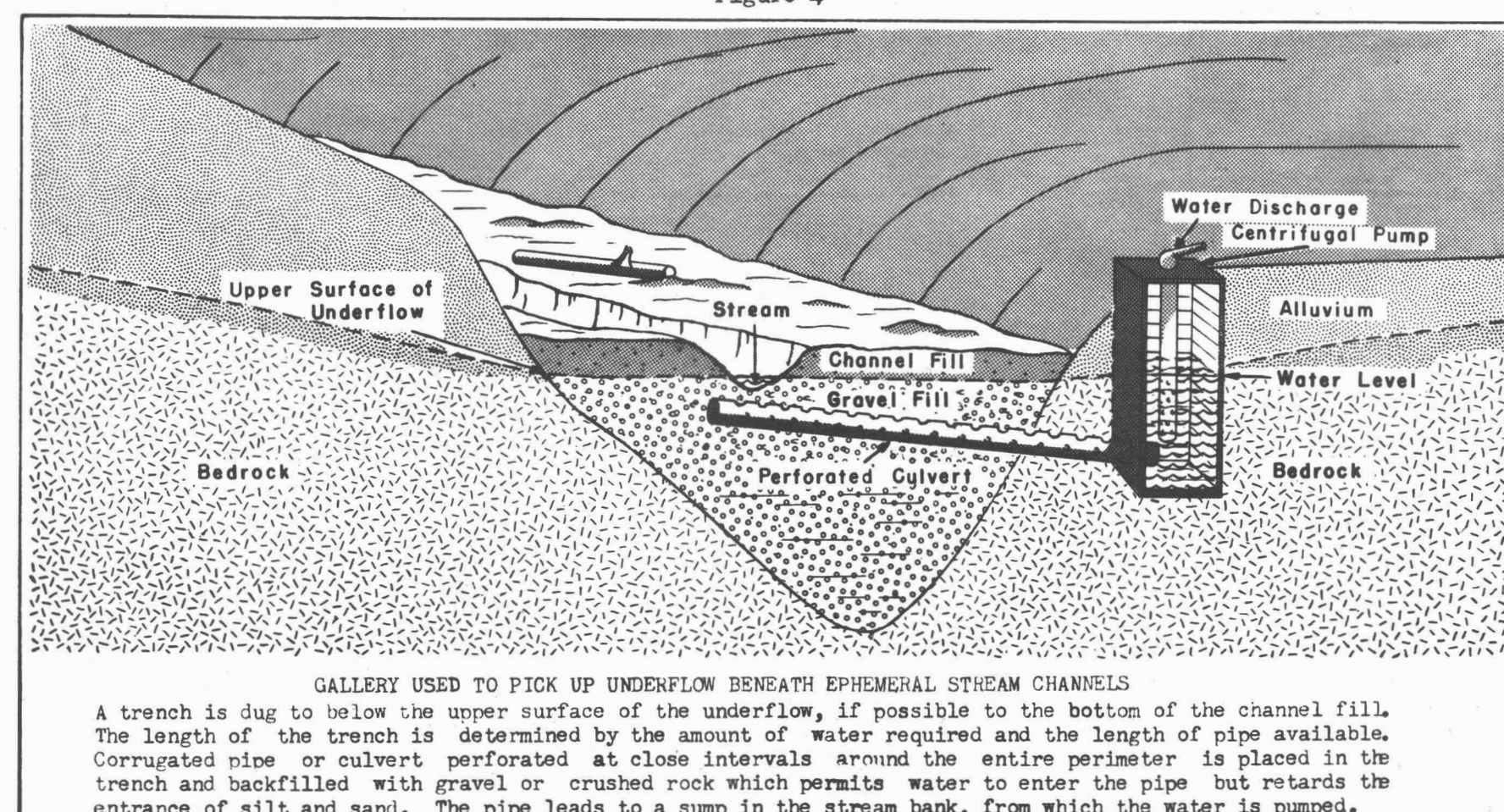
Cross section showing simple method of obtaining filtered water from the alluvial fill in the channel of an intermittent stream. Site is selected where stream flows in fairly narrow channel cut through impermeable rock. Alluvial fill is excavated to bedrock entirely across valley. Timber cut-off wall, sized rock, and clay are emplaced as indicated in diagram. Water can be pumped by small hand pump connected with 2-inch pipe perforated at lower end. Pump can be placed at side of valley and protected from floods by boulders. The quantity of water obtainable in this manner is limited to the amount of ground water flowing through the alluvial fill; probably not more than a few thousand gallons per day for small streams. However the water, unlike water from the stream itself, is naturally filtered and always available.

FIGURE 2.



Diagrams showing simple method of improving spring to avoid contamination and increase useable flow. Equipment required includes pipe, tools, wood or concrete for dam, and fencing. Dam must be watertight. It can be made of concrete or of two wooden bulkheads with a tamped clay fill. Excavation behind dam is filled with layers of crushed rock and gravel. Pipe must be large enough to accomodate increases in yield of spring. Ditches for diverting surface drainage and fences are used to protect restricted zone above spring from contamination. Restricted zone should be at least 100 feet long.

Figure 4



GALLERY USED TO PICK UP UNDERFLOW BENEATH EPHEMERAL STREAM CHANNELS
A trench is dug to below the upper surface of the underflow, if possible to the bottom of the channel fill. The length of the trench is determined by the amount of water required and the length of pipe available. Corrugated pipe or culvert perforated at close intervals around the entire perimeter is placed in the trench and backfilled with gravel or crushed rock which permits water to enter the pipe but retards the entrance of silt and sand. The pipe leads to a sump in the stream bank, from which the water is pumped.

FIGURE 5. OCCURRENCE AND DEVELOPMENT OF GROUND WATER SUPPLY IN COASTAL AREAS AND ON SMALL ISLANDS

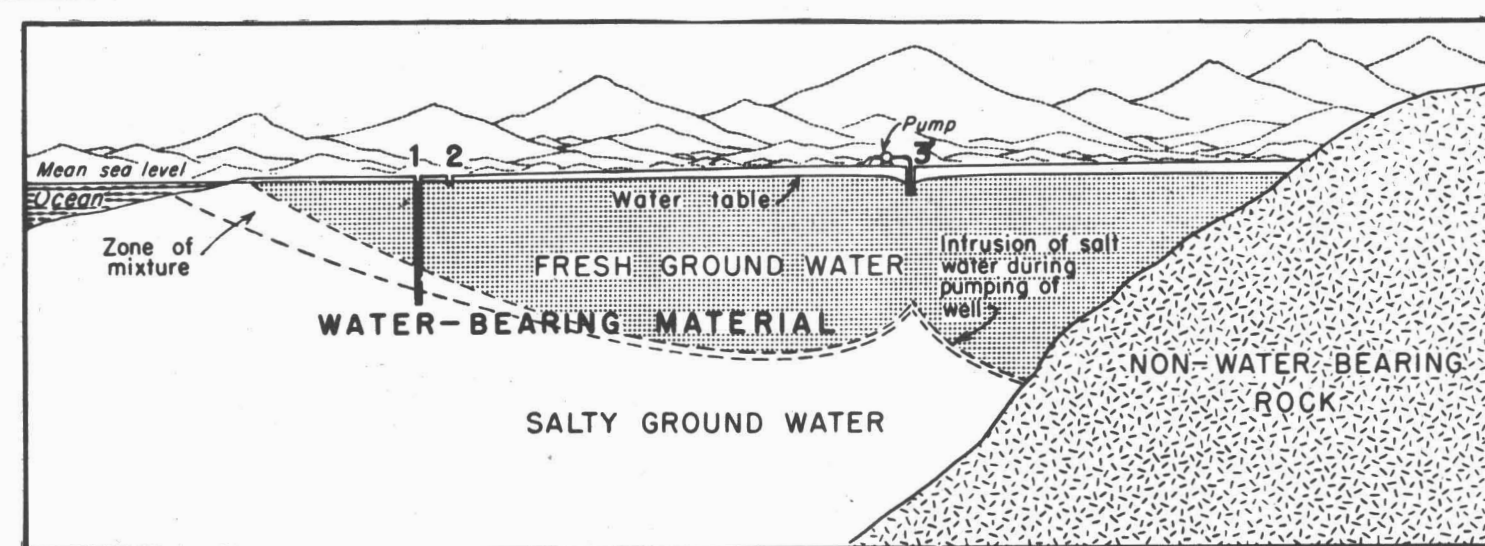


DIAGRAM A

Occurrence of ground water along a sea coast underlain by permeable material. A deep well near the shore (well 1) will penetrate zone of mixture and salt water zone, although small supplies of fresh water can be obtained from shallow wells (wells 2 and 3). Well 3 shows conditions during pumping. Vertical scale about twice the horizontal scale.

The following statements refer chiefly to areas where the rocks have more or less uniform permeability. Where permeable and impermeable rocks alternate, giving rise to artesian conditions the occurrence of ground water is more complex and the problems involved are not considered here. In such areas developments of water supply should be made upon recommendations of a competent ground-water geologist after field study.

Occurrences of Fresh Ground Water: Fresh ground water, generally found slightly above sea level in most coastal areas, is derived from and replenished by rainfall and runoff. A body of fresh water, because of its lower density, floats upon underlying salt water. (See Diagram A). The depth to salt water is roughly a function of the height of the water table above mean sea level and the density of the sea water. Theoretically the fresh water extends about 40 feet below sea level for each foot that it rises above sea level; that is, if the water table is one foot above sea level, the salt-water surface will be about 40 feet below sea level and the fresh water layer will be about 41 feet thick. Actually the fresh-water layer is always thinner because the fresh and salt water become mixed near the surfaces of contact, owing to diffusion and tidal fluctuations. The amount of mixing increases rapidly as the tidal fluctuations increase. The zone of mixing is thickest near the shore and thins inland. It is thicker in very permeable materials such as cavernous limestone and thinner in less permeable materials such as sand.

The quality and quantity of ground water available in coastal areas depend upon many factors. Some of the most important are:

(1) Recharge to water-bearing formations. The accumulation of a large body of fresh water is favored by a high evenly distributed rainfall over a large catchment and contributing areas. The recharge from rains is augmented by seepage losses from streams traversing alluvial plains and coastal areas. In areas of light rainfall, or during periods of prolonged drought, the fresh ground-water layer is likely to be thin or absent. After heavy rainfall the ground water freshens, and during dry periods it becomes salty.

(2) Permeability of water-bearing formations. The fresh-water layer in highly permeable material is relatively thin; it increases in thickness as the rocks become more impermeable. Moderately permeable rocks are more likely to

have the most easily exploited ground-water layer. Coastal areas underlain by reef limestone are bordered between high- and low-tide levels, at many places by a layer of nearly impermeable cemented sand (beach rock) which tends to exclude sea water and retard the seaward movement of fresh water. This barrier, as well as those presented by mud and ooze overlying the front of deltas and filling mangrove swamps, promotes the accumulation of a thick fresh-water layer.

(3) Width of the coastal area. It is not possible to state the minimum width of a coastal lowland from which potable ground water can be obtained but in general the wider the coastal area the greater is the likelihood of its containing potable ground water. Large tidal fluctuations on coastal areas underlain by permeable rocks cause a thick and extensive zone of mixing between fresh and salt water. If recharge is not great in such areas, particularly if the coastal lowlands are narrow, potable ground water may not be present. Under less extreme conditions the ground water may be brackish; however, water with salt concentrations as high as 1,500 parts per million is still palatable and may be beneficial, as the salt compensates for that lost from the body through perspiration.

Selection of Well Sites and Other Collecting Works: On narrow coastal areas wells should be located within the landward quarter of the lowland but not too close to the interior uplands. Where water-bearing materials are very permeable the distance from the shore should bear about a 10:1 ratio to the depth of the well; a well 100 feet below sea level should be at least 1,000 feet from shore. However if the material is sand or other less permeable material the ratio may be reduced to 6 to 1. Especially favorable locations are on stream deltas where the material is sandy or on coastal areas behind beach rock or mangrove swamp.

Vegetation indicates in many places the quality of shallow ground water. Coconut palms grow only where the ground water is fresh, taro where it is fresh or slightly brackish, and nipa palm and mangrove only where it is brackish to salty.

Wells and other collecting works should be located on the landward side, and as great a distance as possible from latrines, garbage dumps, burial grounds, native villages, and other possible sources of contamination.

Construction of Wells: On narrow coastal plains wells should not be extended far below sea level. On broader low-

lands wells more than 1/2 mile from the shore need not be limited in depth but should be checked periodically for evidence of salt-water contamination.

Dug wells are generally more satisfactory than drilled wells or drive points on coastal areas where depth to water is not too great. They provide a larger storage capacity in the well and drawdowns are somewhat lower for the same yields. Drilled wells are more easily constructed in hard materials where the water table is at considerable depth. Drive points can be used in unconsolidated materials when cobbles or larger rocks, tree trunks, and other buried materials are not present.

Where the fresh-water lens is thin it is advisable to obtain water from ditches or pits dug to about 1 foot below sea level, or where ditches are not practical, from galleries (See Diagram D). Open pits and ditches should not be pumped, but water should be dipped or skimmed from the surface.

When large supplies are required and there is sufficient room, several infiltration galleries, dug wells, driven wells, or ditches can be spaced on about 200-foot centers along a line parallel to the shore. Ditches and infiltration galleries should have their long axes parallel to the shore.

Pumping: Excessive pumping draws salt water into wells (See Diagram B). To minimize this danger pumps should be regulated so that water levels will not be lowered below sea level. Measurement of the water level, and titration of the water to determine chloride content after each day's pumping will aid materially in establishing the safe pumping rate for each well. If chloride content shows a progressive increase from day to day, pumping rates should be reduced to 1/2 that of the previous day until such time as tests indicate a constant or decreasing chloride content. On some narrow coastal plains it may be necessary to limit pumping to periods of low tide.

If water supplies are planned for large installations in areas subject to salt-water contamination, storage should be provided to carry over droughts and periods of especially high tides when pumping rates may have to be reduced.

If wells become salty as a result of overpumping they can sometimes be freshened by allowing them to rest, especially, during rainy periods. On resumption of pumping withdrawals should be limited to 1/2 the previous rate and tests made as described above.

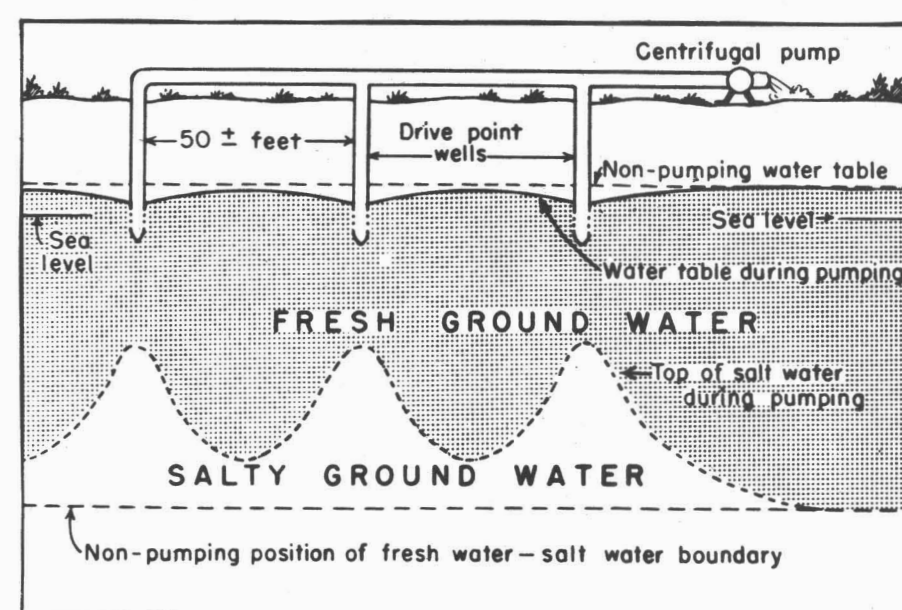


DIAGRAM B

Battery of driven wells (drive points) to spread pumping and decrease draw-down, thereby minimizing danger of salt-water contamination. Perforations must be below water level so that suction will not be broken during pumping. Wells should be about 50 feet apart and should not extend more than a foot or two below sea level. Diagram is not to scale. Zone of mixture not differentiated.

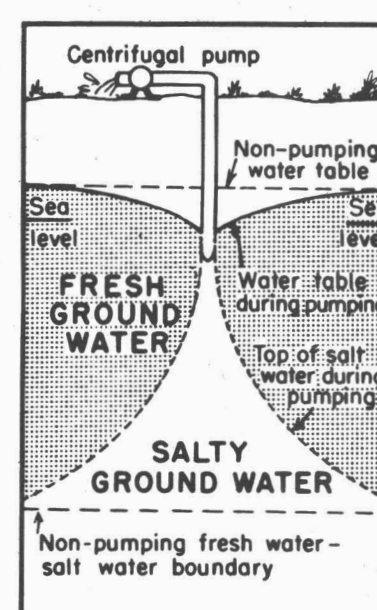


DIAGRAM C

Showing contamination of a well owing to excessive pumping. If well is too deep, contamination is more likely to occur than if well is shallow. Wells that have become contaminated may freshen if allowed to rest. Diagram not to scale.

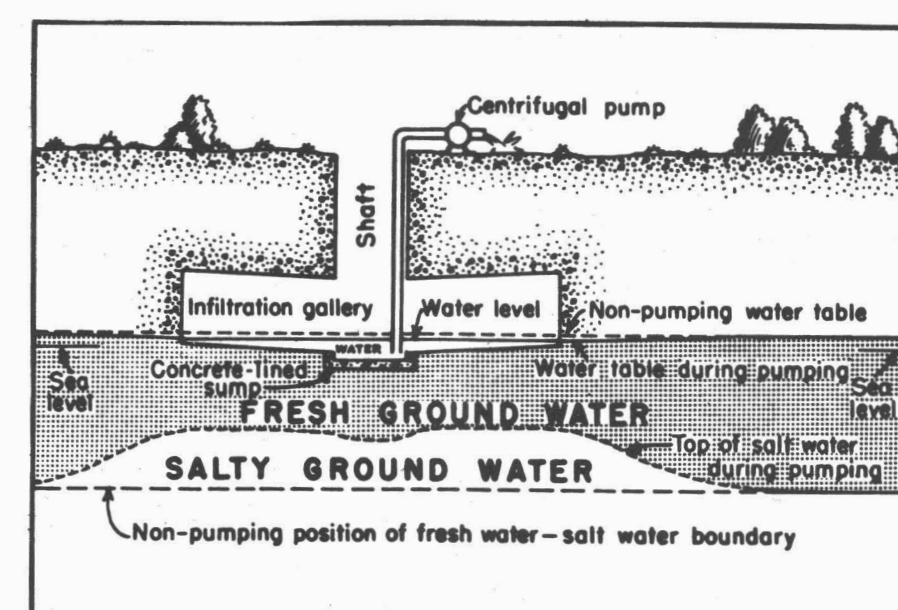


DIAGRAM D

Infiltration gallery used to skim fresh water from top of salt water where fresh-water zone is thin. For equivalent pumpage, rise in salt water is much less than when small-diameter wells are used. Shaft is sunk about 2 feet below sea level and bottom is lined with impermeable material to form a sump. Galleries are driven from near bottom of shaft parallel to shore and with a slight grade so that water will flow to sump. Lowest part of gallery should not be more than a few inches below sea level. If galleries are in caving material, adequate timbering must be provided. Diagram is not to scale.

PALAWAN PROVINCE (P. I.)

WATER SUPPLY

Reliability rating: Class D							
Map Area	Surface Water		Ground Water			Recommended Sources of Water Supply (See Introduction)	
	Occurrence ^{a/}	Development	Well Water		Springs		
			Occurrence	Development	Occurrence (See Introduction for Development)		
BEACHES ON ALL ISLANDS Underlain by quartz, coral, or black sand, gravel, and shingle. (See Introduction).	Brackish or salty water fills most streams except at low tide, during high water or flood stages. Water is generally turbid, may have a high silt content and probably contains harmful organisms.	Intake should be easily movable or protected against swift high-water flows, they should be protected with heavy screens and trash racks. Pumping plants should be on high ground or else easily moved out of flood danger. On larger streams, where overhanging forest growth gives concealment, intakes and pumping plants can be mounted on securely anchored pontoons. Chlorination and filtration will be required. No permanent water points are recommended because of uncertainty of supply.	A thin layer of fresh water which increases in thickness inland floats upon a salt-water body. Water may be brackish near the shore but quality improves inland; only small supplies can be obtained unless beach is very wide. On wide beaches fairly large amounts may be developed with infiltration galleries. Water may contain harmful bacteria.	Shallow pits dug to sea level will provide emergency supplies. Pits should be cribbed against caving or dug with sufficient side slope to prevent sloughing. Pumps are not recommended and water should be dipped or skimmed from surface to avoid salt-water contamination. Where beaches are wide, driven wells and infiltration galleries (see Fig. 5D) will generally yield reliable supplies for small personnel units. Driving and excavating should be easy. Wells and galleries should be spaced on a minimum of 200-foot centers and located as far from shore as possible. Water may require chlorination.	Fresh-water springs may occur at or slightly below high-tide level. Outlet may be under water at high tide, and initial flow on ebbing tide may be brackish or salty. Quality is unknown, but harmful bacteria may be present. Because of location and character, springs are not easily developed. Water may require sterilization.	Combat, Overnight Bivouac, and Similar Operations: Shallow dug wells, imported plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Infiltration galleries, shallow dug wells, imported.	
MANGROVE SWAMPS ON ALL ISLANDS Underlain by heavy clay and mud. (See Introduction).	Lakes and streams contain brackish or salty water with deep coloration. Water is not potable and is not amenable to any treatment but distillation.	Distillation of swamp or sea water. Sea water will probably be a more desirable source as swamp water contains certain tastes and odors which pass through the still with the water.	No potable ground water is available.	Not possible.	None.	Combat, Overnight Bivouac, and Similar Operations: Imported, rain water. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Imported distilling units.	
I LOWLANDS AND HIGHER HILL LANDS Underlain by reef limestone on the east coast south of Panagtaran Point and elsewhere by massive and cavernous limestone.	Lowlands: Many small streams; some of which are dry during much of dry season crossing lowlands. At 10- or 15-mile intervals are larger streams with base flows of 20 cfs or more. Combined base flow of streams emptying into Puerto Princesa estimated to be sufficient for 200,000 men. All streams occasionally reach flood stages. Water may be brackish as much as 1 1/2 miles from the coast. Upstream, it is hard but contains no objectionable minerals; it is often turbid and has a high content of decomposed organic matter. During high-water stages, streams carry large loads of silt and heavy debris. Banks are low, in some places marshy, and at others heavily vegetated. (See Terrain Sheet for data on specific areas). Hilly Areas: Many streams with base flows of 5 cfs or less flow through hilly areas. Stream flows fluctuate considerably. Some streams have short surface courses as they flow into sink holes and follow subterranean channels. Water is hard but contains no harmful minerals. Streams generally clear and possibly bacterially safe except during high water when silt and debris loads are large. Banks generally less than 6 feet high and firm; may be heavily vegetated. Area easily accessible to foot traffic but may be difficult to impassable for wheeled vehicles in some sections. (See Terrain Sheet for data on specific areas).	Lowlands: Intakes should be located above limit of salt-water incursion at high tide. Sites above small falls and rapids which, in many streams, are within 1 1/2 miles of the coast are safe from salt water. Intakes should be protected against heavy debris carried by stream during high water or flood stage. Intakes should be installed to operate at widely fluctuating water levels and should be equipped with heavy trash racks and screens. Pumping plants should be easily movable or located on high ground above flood levels. In larger streams, where overhanging forests offer adequate concealment, pumping plants and intakes can be mounted on securely anchored pontoons. Water will generally require filtration and chlorination. Hilly Areas: Development is similar to that in the lowlands with the following additions: Plunge pools beneath water falls can be improved with small expenditures of material and labor to store small amounts of water and to better pumping conditions. Sites are present for small dams, constructed of locally available material. Dams should have large well-protected spillways. Reservoir storage capacity may be large. Reservoir sites may be highly permeable and should be examined carefully before dams are built. Small permeable areas can be sealed with clay blankets protected by riprap. Both materials are abundant on islands. If pipe is available water from reservoirs may be delivered under gravity pressure to sites on the lowlands. Reservoirs will act as natural settling basins to remove much silt. Because of heavy forest, combined with soft ground in the lowlands, and rough topography in the hill land, roads may have to be constructed to watering points.	Fresh water is present a few feet to 200 feet below the surface in the lowlands and between 150 and 800 feet in the hills. Yields will range from a few gallons to several hundred gallons per minute with the possibility of some dry holes. Except for hardness water is of good quality, however, in the vicinity of Puerto Princesa it is reported to be heavily polluted and to have an objectionable fishy smell and taste. There is danger of salt-water contamination in wells within 1/2 mile of the coast on the lowlands and 1/4 mile in the hill lands. Underflow is probably present in stream channels.	Below altitudes of 30 feet, in parts of the area underlain by reef limestone, dug wells and infiltration galleries (see Fig. 5D) are practical. Wells should be spaced on 150-foot centers as a minimum. Explosives will be needed for excavating. Curbing and timbering will be necessary. Centrifugal pumps can be used. Where water table is more than 15 feet below the ground surface centrifugal pumps can be set in pits to depths within the suction lift of the pumps. Elsewhere in the area, drilled wells are recommended. Wells should be spaced on 100-foot centers but greater spacing is desirable particularly within 1/2 mile of the coast. In massive limestone, badly fractured areas offer the best opportunities of obtaining water. Hard coral heads in reef limestone, and open fractures and cavities in massive and cavernous limestone may cause difficulties in drilling and tend to deflect the holes. Possibilities of loading tools are great, and fishing and extra drilling tools should be available. Shooting may improve some wells in massive and cavernous limestone but should never be done to wells in reef limestone. Screens will not be needed. Casing may be required in upper 20 feet of hole. High-lift turbine or cylinder pumps will be needed. Water from wells in the lowlands may require chlorination. For data on development of underflow, control of salt-water contamination, and recommended depths of wells see Introduction.	Few springs occur in the lowlands, except near the foot of the hills. In the hills they are common. Some may have base flows of several hundred gallons per minute. Flows of some springs fluctuate considerably, other springs are ephemeral. Water is hard but otherwise generally of good quality. However, after heavy rains some springs are silty and possibly contaminated.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources, rain water. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, infiltration galleries, driven well in alluvium. Permanent Camp or Hospital: Drilled wells, streams, pipe lines.	
	II LOWLANDS AND HIGHER HILL LANDS Underlain by granitic, volcanic, and metamorphic rocks.	Lake Manguao: Situated in low, hilly country south of Taytay is the only lake on Palawan Island. It contains an estimated minimum storage of 1,340,000 gallons, the area varies from 2 to 9 square miles. Average low-water depth is about 20 feet. Outlet is underground through vesicular and columnar volcanic rock at south-east end of lake. Water contains no objectionable minerals but it probably has a brownish color, and a large content of decomposed organic matter. Banks are probably marshy and at places heavily vegetated. Lowlands: Many small streams some of which are dry during much of the dry season. At 10- or 15-mile intervals are larger streams with base flows of about 20 cfs. All streams are subject to frequent high-water and occasional flood stage. Water is brackish as much as 1 1/2 miles from the coast but upstream it is palatable. It is often turbid, has a high content of decomposed organic matter, and during high water carries large loads of silt and heavy debris. Banks are low, in some places heavily vegetated and commonly marshy. Hill Lands: Many small streams with base flows up to 5 cfs. Stream flows fluctuate considerably. Water is clear and of good quality except during high-water stages when silt and heavy debris loads will be large. Banks are generally low, heavily vegetated, and in many places marshy. Ordinarily area is easily accessible to foot traffic, but marshes and heavy forest may block vehicles in some sections. (See Terrain Sheet for data on movement in specific areas).	At Lake Manguao, intakes should be capable of operating under fluctuating water levels; should be protected against moderate wave action, and should be equipped with screens and trash racks. Pumping plants should be easily movable or located at sites above high-water level. Mounting of intakes and pumps on pontoons would be advantageous, but conditions for concealment are probably unsatisfactory. Water will require chlorination and at times filtration. Approaches for vehicles and foundations for installations will be required because of swampy ground. Development of watering places on streams will be similar to Area I above. Small dam sites are less common than in Area I but those present are probably more desirable from the standpoint of permeability of reservoir sites. In some places road for wheeled vehicles may have to be constructed to watering points.	Fresh water is present a few feet to 200 feet below the surface in the lowlands and between 150 and 600 feet in the hills. Yields will generally be less than 25 gpm, and in areas underlain by serpentine they may be too small to warrant drilling. Little or no water is available below depths of 300 feet in areas underlain by granitic rock. Small amounts of water may be present at shallow depths at the base of weathered material overlying granite. Quality of water is good but it may have a high iron content. Wells within 1/2 mile of the sea on the lowlands and 1/4 mile on the hill lands are in danger of salt-water contamination. Underflow is probably present even in areas unsuitable for deep well development. See Introduction regarding occurrences.	Wells should not be drilled at places underlain by soft dark green sheared rock (serpentine). In country underlain by granite-like or volcanic rocks, holes should be abandoned if no water is found at depths less than 300 feet. Where gentle slopes are underlain by deeply weathered granite, dug wells and infiltration galleries (see Fig. 5D) 20 to 30 feet deep are practical. Such facilities should have minimum spacing of 100-foot centers. Large residual boulders preclude the use of driven wells and may obstruct excavating to such an extent that explosives will be required. Excavations must be curbed or timbered. Elsewhere drilled wells are recommended. Badly fractured granite or volcanic rock offers the best possibilities of obtaining water. Wells should be spaced on 150-foot centers near the coast but can be 25 to 50 feet closer together inland. Rock is very hard and drilling may be slow. Dipping fractures and contacts and brecciated rock may deflect holes or cause tools to stick. Tools may be lost; fishing and extra drilling tools should be available. Shooting may improve some wells but should never be used in rocks containing clayey or shaly material. Screens will not be needed but casing may be necessary in upper 20 feet of weathered granite and through clay and shale beds. Low capacity, high-lift turbine or cylinder pumps needed. Water from wells in the lowland may require chlorination. For data on development of underflow, control of salt-water contamination and recommended depths of wells, see Introduction.	Few springs occur in the lowlands except near the foot of the hills. In the hills they are not uncommon. Flows are generally small and some spring flows are subject to slight fluctuations. A few springs are ephemeral. Quality of water is usually good.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, seepage galleries, or driven wells in alluvium. Permanent Camp or Hospital: Streams, driven wells, seepage and infiltration galleries.
	III LOWLANDS AND HILL LANDS Underlain by beds of sandstone, shale, or clay, and conglomerate	Occurrence and characteristics of streams and stream waters are similar to those found in Area II above. Area is heavily forested and in many places marshy. Generally easily accessible to foot traffic but some localities difficult to impassable for wheeled vehicles. See Terrain Sheet for data on specific area	Development problems on streams are similar to those found in Area II above. and between 150 and 800 feet ground water may be found at shallower depths in many places. Yields will generally be good, some wells possibly yielding several hundred gallons per minute. Quality of water is commonly good but in the south between Malant and Island bays it will be hard. Wells on the lowlands within 1/2 mile of the sea and in the hill lands within 1/4 mile are in danger of salt-water contamination. Underflow is probably present in or near stream channels (see Introduction for further data on occurrence).	The general water table is a few feet to 200 feet below the surface in the lowlands, in the hill lands. Perched ground water may be found at shallower depths in many places. Yields will generally be good, some wells possibly yielding several hundred gallons per minute. Quality of water is commonly good but in the south between Malant and Island bays it will be hard. Wells on the lowlands within 1/2 mile of the sea and in the hill lands within 1/4 mile are in danger of salt-water contamination. Underflow is probably present in or near stream channels (see Introduction for further data on occurrence).	At altitudes below 40 feet driven or dug wells, or infiltration galleries (see Fig. 5D) can be used. Infiltration galleries will be more satisfactory within 500 feet of the shore. Galleries should be spaced on 200-foot centers. Excavating should not be difficult. Timbering will be required. Farther inland below 40-foot altitude, and at higher altitudes where perched water table is present at shallow depths, dug or driven wells will be more satisfactory. Excavating will be easy to difficult and explosives may be needed. Driving may be obstructed by hard layers or boulders in loose material. Wells should be spaced on 100 to 125-foot centers. Driven wells must be screened and dug wells curbed. Centrifugal pumps can be used in areas where water table is more than 15 feet below the ground surface, centrifugal pumps can be set in pits to depths within the suction lift of the pumps. Drilled wells are recommended for most of the area. Wells should be spaced on 75- to 100-foot centers. Drilling will generally be easy. Wells must be cased for full depths and equipped with screens. Perforating tools should be available for use on wells penetrating more than one aquifer. High-lift turbine or cylinder pumps will be needed. Water from shallow wells may require chlorination. (For data on development of underflow, control of salt-water contamination, and recommended depths of wells, see Introduction.)	Springs are not numerous in the lowlands. They probably occur most frequently near the foot of the hills. In the hill lands springs are common. Seeped areas amenable to development are marked by strips of scrub growth and low trees on otherwise cogen grass-covered hillsides. Yields of springs and seeps are small (1/2 to 10 gpm). Quality of water is good but in the south in the vicinity of Malant and Island bays it will be hard.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, infiltration galleries, dug wells. Permanent Camp or Hospital: Drilled wells, streams, pipe lines, seepage galleries.

^{a/}cfs = cubic feet per second

(continued)

WATER SUPPLY

PALAWAN PROVINCE (P.I.)

Reliability rating: Class D							
Map Area		Surface Water		Ground Water			Recommended Sources of Water Supply (See Introduction)
		Occurrence ^{a/}	Development	Occurrence	Well Water Development	Springs Occurrence (See Introduction for Development)	
PALAWAN AND ADJACENT ISLANDS (cont.)	IV MOUNTAINOUS AREAS Underlying rock undifferentiated	1,000 to 1,500 feet below the summits small streams with base flows of 1/3 to 3 cfs are numerous. Stream flows fluctuate greatly and some streams are ephemeral. In limestone mountains, streams may have short surface courses as they flow into fracture zones, and sink holes, and follow underground channels. Quality of water is excellent but it will be hard in limestone areas. Streams are generally clear. Channels may be difficult to approach because of steep high banks and heavy undergrowth. Area impassable for vehicles and in places difficult for foot traffic.	Small dams to form storage basins and increase depth of water to permit easier pumping are advisable. Dams may be constructed of locally available material and should be readily replaceable in event of washouts. Plunge pools beneath falls are natural basins which can be enlarged in some cases to have considerable storage capacity. Area is inaccessible to large or heavy equipment and elaborate facilities are impractical. The new type 5-gpm, 2-man pack filter will produce adequate treatment. Water in streams and plunge pools is sufficient for small combat forces without development. Standing water should be filtered and chlorinated.	Water is at excessive depths and vehicular movement is difficult to impossible, so wells are not generally feasible. Small deposits of sand and gravel in stretches of low gradient in ephemeral stream channels may contain small amounts of water of excellent quality. An underground stream issues from St. Paul's Mountain (alt. 3,370 feet); navigable from there to the sea. The stream flows several hundred cubic feet per second of clear, hard water. It is reported, however, to have an objectionable fishy taste and odor.	If wells are required, location of well sites and type of well sunk should be selected by a ground-water geologist. Shallow hand-dug pits are the only practical method of obtaining water from sand and gravel in stream channels. Quantity of water present is too small to warrant pump installations.	Springs are not uncommon. Flows will range from less than a gallon to possibly a hundred gallons per minute. Some springs have fluctuating flows and others are ephemeral. Quality of water is excellent. Access to springs may be difficult because of locations in deep narrow canyons. Normal flow of springs is sufficient for small personnel units operating in the mountains. Treatment will probably be unnecessary.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs.
	I COASTAL LOWLANDS OF BALABAC ISLAND AND THE LOW ISLANDS TO THE NORTH All underlain by reef limestone. Hilly upland of Balabac Island underlain by massive and cavernous limestone.	In the lowlands of Balabac Island, and on the low reef-limestone islands to the north, streams have base flows of less than 5 cfs. All streams have frequent high water and occasional flood stages. Streams on Balabac Islands probably carry much silt and heavy debris during such flows. Water is probably brackish 1/2 mile or more from the coast during high tide. Upstream the water is fresh but hard and may have a high content of decayed organic matter primarily vegetative in origin. Banks are low, marshy, and heavily vegetated in most places. Lowlands are usually easily accessible to foot traffic and in most places to wheeled vehicles. In the hill land, located principally on Balabac Island, streams are few. Base flows are probably no more than 1 or 2 second foot. Some streams are ephemeral. A portion of the streams may have short surface courses because they flow into sink holes, etc. to follow underground channels. Water is hard but otherwise of good quality. Hill lands are quite rugged and heavily forested. They are generally impassable to wheeled vehicles.	In the lowlands intakes should be located above the limit of salt-water incursion at high tide, should be equipped with screens and trash racks, and on Balabac Island should be protected against swift high-water and flood flows laden with heavy debris and silt. Pumps should be located on high ground, or should be easily movable. Streams are probably too small to permit use of ponton mounts for intakes and pumps. Perennial streams should be selected for watering points. Water will generally require chlorination and filtration. The hill lands, except at low altitudes, are inaccessible to large or heavy equipment, and installation of major facilities is generally impractical. Water in plunge pools, streams, etc. is sufficient for small combat groups without development. Standing water should be filtered and chlorinated. The 5-gpm, 2-man pack filter will treat sufficient water for most purposes. If larger watering plants are required, they should be installed at plunge pools or at sites where small dams can be constructed to improve pumping conditions and to provide some storage capacity. Storage capacity of some plunge pools can be increased with only small expenditures of time and material. Dams can be constructed of locally available material. They should be readily replaceable if washed out. Pumping plants and intakes should be easily movable, or protected against high water. Screens and trash racks are recommended. Large dam and reservoir sites may occur in easily accessible places. Reservoir sites should be examined carefully before dam construction, as some may be too permeable to be useable. Small permeable zones may be sealed with concrete or puddled clay, protected with riprap. Large spillways will be essential. Reservoirs will act as settling basins to remove silt and will provide carry-over storage on small or ephemeral streams. If pipe is available, water may be delivered to lowland points under gravity pressure.	The water table is generally from a few feet to 40 feet below the surface on the low islands to the north, and in the lowlands of Balabac Island from a few feet to 200 feet. In the hills it is between 150 and 800 feet. Yields of wells will vary over short distances from a few gallons to several hundred gallons per minute. Water is hard and in the lowlands may contain harmful bacteria. All wells on the low islands to the north, and those within 1/2 mile of the coast on Balabac Island, are in danger of salt-water contamination. On Balabac Island, underflow is probably present in or near stream channels. (See Introduction for more data on occurrence of ground water.)	At altitudes below 40 feet, dug wells and infiltration galleries (see Fig. 5D) will be most desirable. Facilities should be spaced on 200-foot centers. Explosives will be needed in excavating; curbing or timbering will be essential. At higher altitudes, drilled wells are recommended. Wells should be spaced on 100-foot centers. Rock is soft to moderately hard, but coral heads in reef limestone, and cavities and dipping fractures in massive and cavernous limestone may cause difficulties. Straight holes may be difficult to drill, and loss of tools may occur. Fishing and extra drilling tools should be available. Shooting may improve some wells but should never be attempted in reef limestone. Casing may be needed in upper 30 feet of hole but screens will not be required. High-lift centrifugal and cylinder pumps will be necessary. Water from wells in the lowlands may require chlorination. (For data on development of underflow and control of salt-water contamination, see Introduction.) On the low islands to the north, depths of wells should not exceed 1 foot below sea level within 1/4 mile of the coast or more than 2 feet elsewhere.	Springs may occur near the foot of the hills and in the hill lands of Balabac Island. Some springs may have large flows; some may have fluctuating flows; and others may be ephemeral. Some springs, particularly the fluctuating and ephemeral ones, may carry silt and yield contaminated water.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, infiltration galleries on small islands, and lowlands. Permanent Camp or Hospital: Drilled wells, streams, seepage galleries.
	III LOWLANDS Underlain by sandstone, clay, and conglomerate, limited to Balabac Island	Same as lowland portion of Area I above. However, water is softer. Most of area is cleared and it is generally accessible to all forms of traffic.	Same as Area I above. many places. Yields will generally be good with some wells yielding several hundred gallons per minute. Quality of water is good but may contain bacteria. Wells within 1/2 mile of the coast are in danger of salt-water contamination. Underflow is probably present at shallow depths in alluvium in or near stream channels. (See Introduction for more data on occurrence of ground water in alluvium.)	The general water table is a few feet to 200 feet below the surface. Perched ground water may be found at shallower depths in	At altitudes of less than 40 feet, dug wells or seepage galleries (see Fig. 4) will be most satisfactory. They should be spaced on 150- to 200-foot centers. Explosives may be needed in excavating. Wells or galleries must be curbed or timbered. Where water table is more than 15 feet below the ground surface, centrifugal pumps can be set in pits to depths within the suction lift of the pumps. Centrifugal pumps will serve. At high altitudes drilled wells will be best. Wells should be spaced on 100- to 150-foot centers. Drilling will be easy, wells will require casing throughout full depth and screens. Perforating tools should be available for wells penetrating more than 1 aquifer. High-lift turbine or cylinder pumps will be needed. Water will require chlorination. (For data on development of underflow, control of salt-water contamination and depths of wells, see Introduction.)	Springs are probably present near the foot of the hills. Yields will be small. Quality of water will be good.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, dug or driven wells. Permanent Camp or Hospital: Drilled wells, streams, pipe lines.
	IV MOUNTAINS Underlain by undifferentiated rocks	Limited quantities of fresh water available from streams with small flows. Many streams are ephemeral. Quality of water is good. Area rugged, heavily forested and difficult to penetrate even by foot troops.	Inaccessibility of the area precludes the necessity of major developments. Sufficient water for small combat units may be obtained from perennial streams. Standing water should be filtered and chlorinated.	Depth to ground water is so excessive and area is so inaccessible that well development is impractical. Small deposits of sand and gravel in stretches of low gradient in ephemeral streams may contain small amounts of good water at shallow depths.	Wells are generally not feasible because of depth to water and inaccessibility of the area. If they are needed, location of well sites and type of pump should be selected by a ground-water geologist. Shallow hand-dug pits are the only practical method of obtaining water from sand or gravel deposits in stream channels. Quantity of water present is too small to warrant pump installations.	Springs are probably present, but flows will be small. Quality of water will be good.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, shallow pits, plant sources.

^{a/} cfs = cubic feet per second

(continued)

Reliability rating: Class D							
Map Area		Surface Water		Ground Water			Recommended Sources of Water Supply (See Introduction)
		Occurrence ^{a/}	Development	Occurrence	Well Water Development	Springs Occurrence (See Introduction for Development)	
C A L A M I A N G R O U P	I LOWLAND AND HILL LANDS Underlain by massive and cavernous limestone. (Reported to be present on islands but exact location unknown, probably present about Coron Bay.)	Many small lakes are reported in the lowlands of the islands, but data regarding exact locations are lacking. Information indicates lakes may be ephemeral ponds and marshes which dry during the dry season. Water is probably turbid and heavily contaminated. Shores are marshy. The islands contain numerous small streams. The combined base flows of the Bintuan and Dipuyoy Rivers and adjacent streams in southwest Busuanga Island is estimated to be about 1,380,000 gallons per day. Quantities available in other parts of the group are probably of like magnitude. All streams have frequent high water and occasional flood stages. A few streams in the hills are ephemeral. Some streams in the hill lands may have short surface courses, because they flow into sink holes, and follow underground channels. Water will be brackish 1/4 to 1/2 mile from the coast during high tide, but upstream the water, although hard, contains no objectionable minerals. Water is turbid and has a high content of dissolved and suspended organic matter of primarily vegetative origin. During high-water flows, streams carry large loads of silt and heavy debris. On the lowlands, stream banks are low, frequently marshy and at places overgrown with impenetrable bamboo thickets. In the hills some streams with narrow steep-sided valleys may be difficult to reach. Away from the streams the area is in general easily accessible to both foot troops and mechanized units.	Establishment of watering points on ephemeral lakes is not recommended because of heavy load on treatment equipment and unreliability of supply. If perennial lakes are present, development problems are similar to those at Lake Mangas(see Palawan and Adjacent Islands: Area II), but a smaller quantity of water will be available. On streams, intakes should be located above the limits of salt-water incursion at high tide; should be protected against swift high water flows laden with heavy debris and silt, and should be equipped with heavy screens and trash racks. Pumping plants should be located at sites above flood-stage levels or easily moved out of danger. On some streams in the lowlands, intakes and pumps can be mounted on securely anchored pontoons. Water is generally present in sufficient quantities to make storage unnecessary. Small storage basins, however, can be developed by plugging sink holes and enlarging plunge pools. Larger dams and reservoir sites are probably also present in the hills. Reservoir sites should be carefully examined for permeability. (See Balabac and Adjacent Islands: Area I for development data.) Water will require filtration and chlorination. Roads and pump foundations will be necessary at many sites because of marshy ground.	The general water table in the lowlands lies a few feet to 200 feet below the surface, and in the hills between at a depth of 150 and 800 feet. Yields of wells will vary over short distances from a few gallons to several hundred gallons per minute. Water is hard but of good quality, although water from some wells in the lowlands may be contaminated. Wells in the lowlands within 1/2 mile of the sea and in the hill lands within 1/4 mile are in danger of salt-water contamination. Underflow is probably present in or near most stream channels. (For more data on occurrence of ground water in alluvium, see Introduction.)	Drilled wells are recommended because the rock is too hard for driven or dug wells. Wells can be spaced on 100-foot centers but greater spacing is desirable, particularly within 1/2 mile of the coast. Badly fractured areas offer the best opportunities of obtaining water. Dipping fractures and cavities in limestone may cause difficulties in drilling and act to deflect the holes. Tools may be lost; fishing and extra drilling tools should be available. Shooting may improve some holes. Screens will not be needed but casing may be required in upper 20 feet of hole. High-lift turbine or cylinder pumps will be needed except at altitudes below 25 to 30 feet where centrifugal pumps will generally serve. Water from wells in the lowlands may require chlorination. (For data on development of underflow, control of salt-water contamination and recommended depths of wells, see Introduction.)	Springs are possibly present in the lowlands near the foot of the hills. They are numerous in the hill lands. Flows may be large. Some springs may have fluctuating flows and some may be ephemeral. Water is hard. Quality is good in some respects, but some springs may be silty and possibly contaminated after heavy rains.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, infiltration galleries. Permanent Camp or Hospital: Drilled wells, streams
	II LOWLAND AND HILL LAND Underlain by granite-like or volcanic rock, or quartzite, shale and conglomerate	Same as Area I above, with the exceptions that water is less hard, and short surface courses are not present because of underground drainage.	Same as Area I above, with the exception that although dam and reservoir sites will be less numerous, those present will probably be more satisfactory. in the hill lands. In parts of the area underlain by quartzite and shale, perched ground-water bodies of considerable size occur at shallower depths in many places. Yields of wells will seldom exceed 25 gpm. In portions of the area underlain by granite-like and volcanic rocks, yields will be unimportant from depths greater than 300 feet. Quality of water is generally good but some wells on the lowlands may contain harmful organisms. Wells within 1/2 mile of the coast on the lowlands and 1/4 mile of the coast on the hill lands are in danger of salt-water contamination. Underflow is probably present. (For more data on occurrence of ground water in alluvium, see Introduction.)	General water table lies at depths from a few feet to 200 feet below the surface in the lowlands and up to 700 feet below the surface	Drilled wells are recommended because rock is generally too hard for dug or driven wells. Wells should be spaced on 200-foot centers within 500 feet of the shore and on 100- to 150-foot centers elsewhere. Badly fractured areas offer the best possibilities of obtaining water. Rock is hard with dipping contacts and fractures. Drilling will be difficult, and crooked holes and loss of tools should be anticipated. Fishing and extra drill tools should be available, also perforating tools for use in case more than one aquifer is encountered. Shooting may improve some wells but should not be tried in shaley or clayey aquifers. Casing may be needed in upper 20 to 30 feet of hole and through clay or shale beds. Screens will not be necessary. Low-capacity high-lift turbine or cylinder pumps will be required on wells above altitudes of 30 feet. Centrifugal pumps will serve at lower altitudes. Water from shallow sources may require chlorination. (For data on development of underflow, control of salt-water contamination, and depths of wells, see Introduction.)	A few small springs occur in the lowlands near the foot of the hills. They are slightly more numerous in the hills. Quality of water is good, but in some places harmful organisms may be present. Seeped areas are marked by strips of heavy scrub and tree growth on sides of grass-covered hills (cogon grass). Such areas probably mark the contact where fractured quartzites overlie shales. Clearing to reduce transpiration losses and digging of collecting ditches along the contact will develop small flows of water, some of which may require sterilization. Storage facilities and protective measures are the same as for spring development.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs, plant sources. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Streams, drilled wells. Permanent Camp or Hospital: Drilled wells, streams.
	IV MOUNTAINOUS AREAS Underlying rock undifferentiated	A number of small lakes are present on Coron Island. Reports vary in regard to the freshness or saltiness of the water. Natives are reported to bring water to Coron Island from Busuanga Island. Limestone areas have few streams as most drainage is underground. Elsewhere streams with base flows 1 or 2 second-feet are fairly numerous. Flows fluctuate somewhat and some streams are probably ephemeral. Area is in places easily accessible, in places almost inaccessible even by foot troops. (See Terrain Sheets for data on movement in specific areas.)	Lakes are in inaccessible areas and are not potable. Without development, streams will supply sufficient water for combat units. Standing water in pools should be chlorinated and filtered.	Inaccessibility of the area and excessive depths to water make wells generally impractical. Small deposits of sand and gravel in stretches of low gradient in ephemeral stream channels may contain small amounts of good water.	If wells are required, well sites and type of equipment should be selected by a qualified ground-water geologist. Shallow hand-dug pits will serve in obtaining water from sand and gravel in stream channels. Quantity of water present is too small to warrant pump installations.	Same as Area II above except that springs may be difficult to reach because of location in deep steep-walled canyons and valleys.	Combat, Overnight Bivouac, and Similar Operations: Streams, springs.
CUYO, CABULUAN, QUINILUBAN, AND DALANGANEM ISLANDS	I CABULUAN, QUINILUBAN, DALANGANEM and CUYO ISLANDS. Lowlands underlain by reef limestone and hills underlain by massive and cavernous limestone.	Area contains only a few small ephemeral stream channels. When flowing, water in channels is probably turbid, silty and bacterially contaminated. Underground drainage may be present in the hill lands. Plunge pools may hold small amounts of water of questionable quality between flows. Area is easily accessible to both foot traffic and wheeled vehicles. Rain water stored in tanks or cisterns is reported to be the major source of supply on the islands. Reservoirs will act as natural settling basins to remove silt, but all water will require sterilization. If pipe is available, water may be delivered from reservoirs to lowland sites under gravity pressure.	In the lowlands, reservoirs and dam sites are lacking. Occasionally flows in stream channels may be diverted into cisterns for storage. Water has high silt content, and cisterns will require frequent clearing. All water will require chlorination which can be done in the cisterns. In the hill lands suitable sites for dams and small reservoirs are probably present. Plunge pools may form storage basins which can be enlarged with small expenditures of time and material. Materials for clay-core, earth, or rock dams are plentiful. Reservoir sites may be permeable, but where permeability is not too great it may be sealed with puddled clay or concrete blankets.	Water table is a few feet to 200 feet below the surface in the lowlands and from 150 to 600 feet in the hill lands. In the lowlands salt water probably underlies a relatively thin layer of fresh water and yields must be kept low to avoid contamination. Water is hard and possibly bacterially unsatisfactory. In the hill lands, salt water is a problem only within 1/4 mile of the coast when wells penetrate below sea level. Inland, yields may be large and quality of water is good except for hardness. Small amounts of underflow may be present at shallow depths in alluvium in the stream channels.	Dug wells or infiltration galleries (see Fig. 5D) are feasible at altitudes below 30 or 35 feet. Wells and galleries should be spaced on at least 100-foot centers. Depths should be limited to a few inches below sea level. Explosives will be needed in excavating wells and galleries must be cased or timbered. At higher altitudes drilled wells are recommended. Wells should be spaced on 50-foot or longer centers. Badly fractured areas in massive and cavernous limestones offer the best possibilities of obtaining water. Hard coral heads in relatively soft reef limestone, and dipping fractures and cavities in harder massive and cavernous limestone may deflect holes and cause loss of tools. Fishing and extra drilling tools should be available. Shooting may improve some wells but should never be done in reef limestone. Screens will not be needed and only one or two lengths of casing will be required in any well. High-lift turbine or cylinder pumps will be needed. Water from wells in the lowlands may require chlorination. All wells penetrating below sea level should be checked periodically for evidence of salt-water encroachment. (For data on development of underflow, control of salt-water contamination, and depth of wells, see Introduction.)	Springs are few in number, and flows are small. Some are probably ephemeral. Quality of water is questionable. Development will probably not increase yields materially. Total yields are probably utilized entirely by native inhabitants. For use by combat troops, halozone or chlorine treatment is recommended.	Combat, Overnight Bivouac, and Similar Operations: Imported, plant sources, native wells or cisterns, distilling plants. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Cisterns, infiltration galleries. Permanent Camp or Hospital: Drilled wells, cisterns.

^{a/}cfs = cubic feet per second

WATER SUPPLY

PALAWAN PROVINCE (P. I.)

Reliability rating: Class D							
Map Area		Surface Water		Ground Water			Recommended Sources of Water Supply (See Introduction)
				Well Water		Springs	
		Occurrence ^{a/}	Development	Occurrence	Development	Occurrence (See Introduction for Development)	
CUYO, CABULUAN, QUINILUBAN, AND DALANGEM ISLANDS (cont.)	II LOWLANDS AND HILL LANDS Underlain by volcanic rocks	Same as Area I above but under-ground drainage is not a factor in the hill lands.	Same as Area I above except that fewer dam and reservoir sites will be present. They will generally be more satisfactory, however, from the standpoint of permeability.	General water table is a few feet to 200 feet below the surface in the lowlands and from 150 to 600 feet beneath the hill lands. In the lowlands salt water probably underlies a relatively thin layer of fresh water and yields must be kept low to avoid salt-water contamination. Water is possibly bacterially unsatisfactory. In the hill lands salt water must be guarded against only in wells which penetrate below sea level within 1/4 mile of the coast. Yields will generally be small but quality should be good. Small amounts of underflow may be present at shallow depths in alluvium in stream channels.	Drilled wells are recommended at all altitudes. Wells should be spaced on 200-foot centers within 500 feet of the coast and on 100-foot centers inland. Badly fractured or vesicular areas offer the best possibilities of obtaining water. Rock is hard and drilling will be slow. Dipping fractures may cause difficulties in drilling. Fishing and extra drilling tools should be available. Shooting may improve some wells. Screens will not be needed and only one or two lengths of casing will be needed in any well. High-lift turbine or cylinder pumps will be needed. Water from wells in the lowlands may require chlorination. All wells penetrating below sea level should be checked periodically for evidence of salt-water contamination. (For data on development of underflow, control of salt-water contamination, and depth of wells, see Introduction.)	Same as Area I above.	Combat, Overnight Bivouac, and Similar Operations: Imported, plant sources, native wells and cisterns, distilling units. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Cisterns, distilling units. Permanent Camp or Hospital: Drilled wells, cisterns.
	IV MOUNTAINOUS AREA Underlain by undifferentiated rocks	Area contains only a few small ephemeral stream channels. Run-off is relatively clear and may be bacterially safe. Standing water in plunge pools, however, between flows is of questionable quality. Area is easily to difficultly accessible to foot traffic.	Development of watering points at streams generally impractical because of inaccessibility, remoteness, and uncertainty of supplies. Supplies for small combat groups can be obtained from pools and treated with 5-gpm two-man pack filters and lister bag chlorination.	Depths to water and difficult drilling conditions discourage well development. Small sand and gravel beds in stream channels may contain good water in sufficient quantities to supply a small personnel unit for a few days.	If wells are necessary, sites and equipment should be selected by a qualified ground-water geologist. Water in sand and gravel in stream channels may be obtained with shallow hand-dug pits. Quantity present does not warrant installation of pumps.	Same as Area I above.	Combat, Overnight Bivouac, and Similar Operations: Imported, springs, plant sources.
C A C A Y A N I S L A N D S	I Underlain by coral limestone	No streams are reported on the islands. Area is easily accessible to foot traffic and in most places to wheeled vehicles.	No large development possible. Run-off during rains may be diverted from gullies into cisterns, or collecting ditches may be dug to lead run-off from hills into cisterns. Excavating will require explosives. Must be plastered with concrete to control seepage losses. Catchment areas should be restricted. Water will require filtration and chlorination. Cisterns will need frequent cleaning.	Ground water is present from a few feet to 200 feet below the surface. Yields must be kept small because of danger of salt-water contamination in all parts of the area. Water is probably hard but chemically unobjectionable. Water at shallow depths may be bacterially unsatisfactory. There is a group of small water holes near the west end of town. vesicular, fissured, or fractured, drilling can continue. Fishing and extra drilling tools should be available. Shooting may improve some wells in volcanic rock but should never be done in reef limestone. Casing may be required in upper 10 or 15 feet of hole. Screens are not essential. High-lift turbine or cylinder pumps will be needed. Water may require chlorination. All pumping must be controlled to avoid salt-water contamination, and chloride content of water should be checked daily. (See Introduction for data on control of salt-water contamination.)	Dug wells or infiltration galleries (see Fig. 5D) are feasible at altitudes below 30 feet. Wells or galleries should be spaced on at least 100-foot centers and dug to only a few inches below sea level regardless of location. Explosives will be required in excavating. Wells or galleries must be curbed or timbered. Centrifugal pumps can be used. At higher altitudes drilled wells are recommended. Depths should be limited to less than 1 foot below sea level. Wells should be spaced on 100-foot centers. Rock is generally soft but hard coral heads may cause difficulty in drilling and in places hard volcanic rock may be encountered. If massive unfractured volcanic rock is reached before water, drilling should be stopped. If volcanic rock is	Same as Area I on the Cuyo, Quiniluban, Dalangem, and Cabuluan Islands.	Combat, Overnight Bivouac, and Similar Operations: Imported, plant sources, native cisterns or wells, distilling units. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Infiltration galleries, cisterns, imported. Permanent Camp or Hospital: Drilled wells, infiltration galleries, cisterns.
	II HILL LAND Underlain by volcanic rock	Same as Area I above.	Same as Area I above.	Water table between 150 and 750 feet depth. Yields of wells will be small and from depths greater than 250 to 300 feet will not warrant drilling. Quality of water is probably good.	Drilled wells are recommended. Depths should be limited to 1 or 2 feet below sea level. Spacing of wells should be at least 100 feet. Rock is hard, and drilling will be slow. Badly fractured or vesicular rocks are the best locations of obtaining water. Dipping fractures will tend to deflect holes. Fishing and extra drilling tools should be available. Shooting may improve some wells. One or two lengths of casing may be needed in some wells, but screens will not be necessary. High-lift, low-capacity turbine or cylinder pumps will be needed. All pumping must be controlled to avoid salt-water encroachment, and chloride content of water should be checked after each day's pumping. (See Introduction for data on controlling salt-water contamination.)	Same as Area I on the Cuyo, Quiniluban, Dalangem, and Cabaluan Islands.	Combat, Overnight Bivouac, and Similar Operations: Imported, plant sources, native cisterns or wells. Rest Bivouac, Temporary Camp, Field Hospital, Semi-permanent Camp: Imported cisterns. Permanent Camp or Hospital: Drilled wells, cisterns.

^{a/cfs} = cubic feet per second

PALAWAN PROVINCE (P. I.)

WATER FACILITIES

WATER SUPPLY

Reliability rating: Class B

INTRODUCTION

Palawan Province has ample water supplies except on the smaller islands. The water resources, however, are practically undeveloped, and most of the population depends for its supply upon rain-water cisterns, shallow unsanitary wells, streams, and springs. The inhabitants of many of the smaller islands depend

entirely upon rain water or water diverted from ephemeral streams stored in cisterns. The following tables summarize the available data on water-distribution systems in the province, the quality of water, and the Philippine census data of 1939 on sources of water supply of reporting families in the different minor civil divisions.

Piped Water-Distribution Systems in Palawan Province ^{a/}						
Island or Town	Number of Families Served	Capacity (Gallons per day)	Sources of Supply	Quality of Water	Type of System	Remarks
1. Aborlan, Palawan Island	16	---	Deep wells. (probably 200 feet)	Good	Pumping plant	
2. Bacuit, Palawan Island	53	---	Mountain streams	Excellent	Gravity system	Base supply available in dry season.
3. Binaluan, Palawan Island	--	11,520	" "	"	" "	" " " " " "
4. Iwahig, Palawan Island	--	---	Mountain streams and deep wells	"	" "	2 wells 400 to 410 feet deep, capacity of each about 25 gpm. Brownish color, slightly alkaline.
5. Puerto Princesa, Palawan Island	71	28,800	Shallow wells	Very poor, not used for drinking.	Pumping plant	Estimated 500,000-gallon total rain-water storage capacity in numerous small privately owned cisterns. Water-distribution system obtaining water from Iwahig River with sufficient capacity for 100,000 men authorized, but present status unknown.
6. Taytay, Palawan Island	10	---	---	--	---	
7. Balabac Island	36	---	Stream	Questionable	Gravity system	
8. Coron, Busuanga Island	110	20,160	Deep wells	Good	Pumping plant	
9. Salvacion, Busuanga Island	--	---	Mountain stream or spring	"	Gravity system	
10. Port Zeb Peters, Busuanga Island	--	15,000	Spring	"	" "	
11. Uson Island Wharf, (exact location unknown)	--	---	Mountain stream	"	" "	
12. Culion, Culion Island	1,244	144,000	Mountain streams and wells	"	Gravity and pumping plant	

a/ In 1931, gravity systems had been planned for Concepcion, Oton, (not on map) and Bintuan to serve 600, 330, and 1,000 people, respectively. Pumping systems to serve 800 people at Cuyo, and an unknown number at Bacons (not on map) were also under consideration. A rain-water tank to serve 1,000 people was under consideration at Cagayancillo. The status of these projects in 1944 is unknown.

Sources of Water Supply by Number of Families Reporting in Palawan Province, Philippine Islands, 1939 ^{a/}					
Island Group and Minor Civil Division	Pipe-Distribution Systems	Artesian Wells ^{b/}	Surface Wells ^{c/}	Rain Water or Lakes	Streams and Springs
Palawan and Adjacent Islands:	150	28	3,940	6,190	1,351
Aborlan	16	28	351	952	113
Bacuit	53	--	307	131	55
Brooke Point	--	--	1,049	4,305	529
Puerto Princesa	71	--	1,085	639	469
Taytay	10	--	624	163	82
Dumaran	--	--	524	---	103
Balabac and Adjacent Islands	36	--	470	8	83
Calamian Group	1,354	9	2,387	326	217
Culion (town)	1,244	--	560	7	106
Coron (town)	110	9	1,827	319	111
Cuyo Islands	--	--	3,979	---	223
Agutay (town)	--	--	740	---	34
Cuyo (town)	--	--	3,239	---	189
Cagayan Islands	--	--	590	---	12
TOTAL	1,540	37	11,366	6,524	1,886

a/ From Census of the Philippines, 1939.

b/ In the Philippines any drilled well is called an artesian well; in this province the wells probably are not artesian in character.

c/ Shallow hand-dug pits or wells.

Water Analyses of Some Water Supplies in Palawan Province (parts per million unless otherwise specified)										
	Palawan Island			Dug Well at Puerto Princesa	Mountain Stream	Culion Island				Uson Island Spring at Coal Dock
	Underground River at Mt. St. Paul	Wells at Iwahig Penal Colony				Spring (Location unknown) <u>a/</u>	Balala Springs (Location unknown)			
		1	2				1	2	3	
Depth of Wells in Feet	NR ^{b/}	435	425	4	NR	NR	NR	NR	NR	NR
Yield, gpm	NR	25	25	NR	NR	NR	NR	NR	NR	NR
Color of Water	None	Light Brown	Light Brown	None	None ^{c/}	None	None	None	None	Light Brown
Odor of Water	Fishy	None	None	Fishy	None	None	None	None	None	None
Reaction	NR	Neutral	Alkaline	NR	Neutral	NR	Neutral	Acid	Alkaline	Neutral
Total Solids	8,688	28.0	412	554	47.0	NR	28.8	28.6	79.0	56.8
Mineral Solids	8,674	NR	NR	539	41.4	NR	24.2	22.8	67.2	NR
Loss on Ignition	14	NR	NR	15	5.6	NR	4.6	5.8	11.8	NR
Fe ₂ O ₃ and Al ₂ O ₃	3.7	NR	1.7	2.4	NR	Trace	NR	NR	NR	NR
Ca	140	NR	25	179.9	NR	736.2	NR	NR	NR	NR
Mg	310	NR	80	28.8	NR	1,015	NR	NR	NR	NR
Na	NR	NR	NR	NR	NR	10,603	NR	NR	NR	NR
Cl	5,559	T	11.5	51.9	2.02	18,615	3.9	7.8	2.8	60.3
SiO ₂	23.7	NR	50.5	61.7	NR	Trace	NR	NR	NR	NR
SO ₄	620	NR	1.7	19.7	NR	2,505	NR	NR	NR	NR
B. Coli per cc	NR	NR	NR	Excessive	NR	NR	NR	NR	NR	Excessive

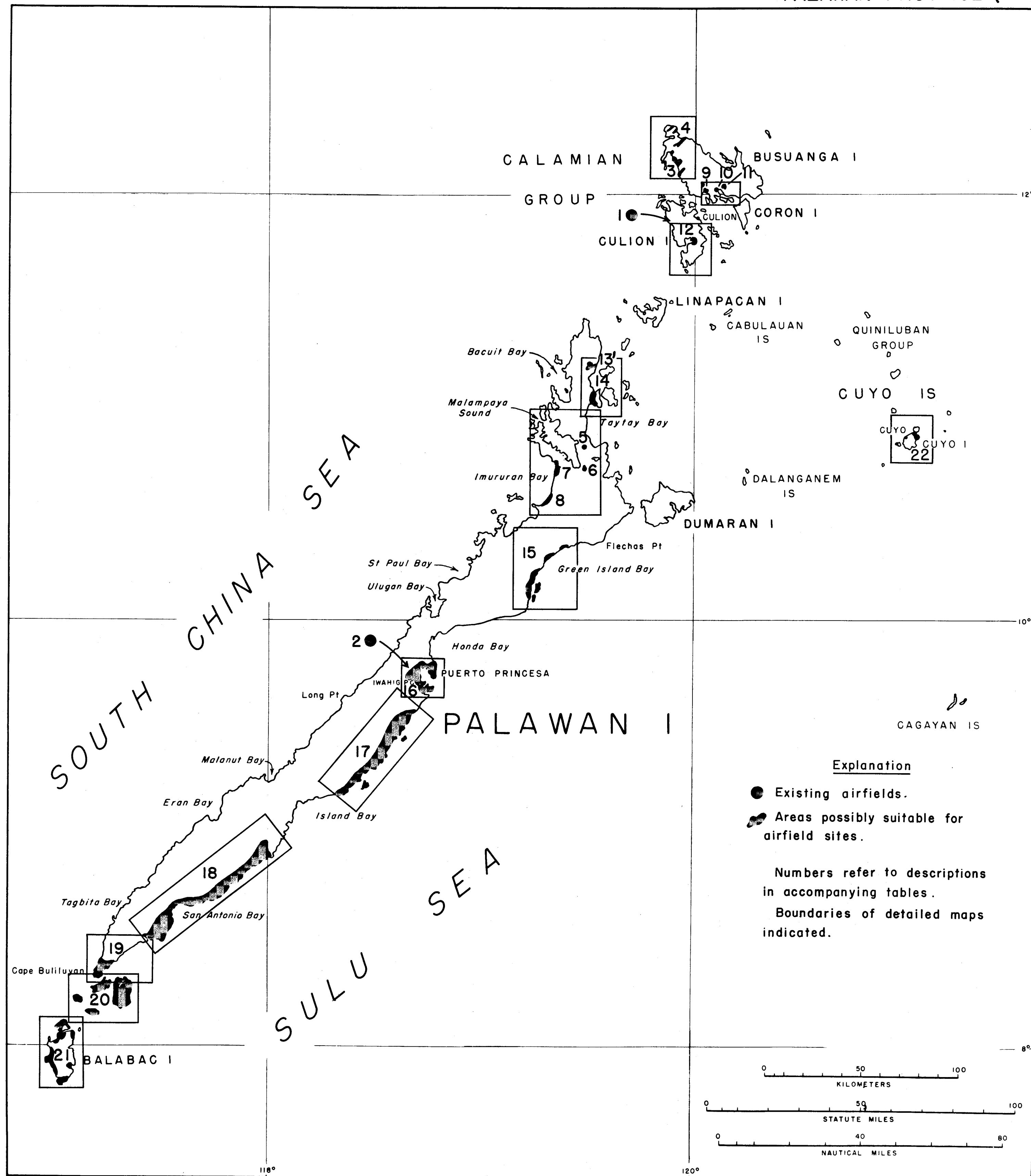
a/ About the composition of sea water. A number of salt springs are reported on the island.

b/ NR - Not reported.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

INDEX - AIRFIELD CONSTRUCTION

PALAWAN PROVINCE (P. I.)



Reliability rating: Class D

INTRODUCTION

The elongate, hilly to mountainous island of Palawan and the adjacent Calamian and Balabac island groups have not been mapped topographically in detail, and large areas are relatively unexplored and unknown. The coastline of the islands has been surveyed, and in part coastal terrain has been indicated by generalized 100-foot contour lines with spot elevations given for prominent hills and mountains (see U. S. C. & G. S. Charts). Topography of the interior is not known, and aerial photographs are available only for small parts of the area (Calamian Islands and Malampaya Sound-Palawan Island).

Because of the meager terrain information, areas indicated as possibly suitable for airfields can be considered only as worthy of further investigation. Many small areas suitable for emergency landing strips may have been omitted because of lack of detailed data. For large sections of the western coast of Palawan, the character of the terrain is not known; aerial reconnaissance in those regions may reveal sites suitable for airfields. Where the most detailed maps have a contour interval of 100 feet, little attempt is made to indicate grades or possible lengths of runways. Aerial reconnaissance, supplemented by field observations where possible, is advisable for accurate determination of size of possible airfields and detailed construction problems.

Only two airfields, Culion and Iwahig, are reported to have been in use in Palawan Province at the time of the Japanese invasion. The Iwahig airfield at Puerto Princesa has been

reported enlarged by the Japanese for use as a heavy-bomber airfield. Data on the existing airfields have been gathered from reports by ONI, MID, and Air Staff Intelligence.

Some areas designated as possible sites are listed in ONI 93, pt 2, as suitable for emergency landings or, with a minimum of preparation, small fighter fields. Sites suitable for enlargement to accommodate heavy aircraft will require extensive improvement. Each possible site described in the following table is accompanied by a map modified from the U. S. C. & G. S. charts and, where available, by a view.

In general, all areas suitable for airfield sites are coastal lowlands. Those north of the Puerto Princesa areas are small and poorly suited to use by heavy aircraft. From the Puerto Princesa area south, the lowlands along the east coast of Palawan, the southern tip of the island (Cape Buliluyan) and the adjacent islands, such as Bugsuk, are more suitable for the development of airfields which might accommodate heaviest aircraft. In general, airfield sites on Palawan are poor when compared to those of Mindanao some 200 miles to the southeast.

Data on soil conditions and construction materials locally available have been derived from the Soils and Geology Tables. For general descriptions, see Terrain Appreciation and Water Supply Tables.

1. CULION AIRFIELD

Location, Suitability, Accessibility: Reported lat 11°51' N, long 119°56' E, near village of Negative (not on map), about 10 miles SW of Culion on provincial road (probably passable in all but wettest weather). Exact location, character of local terrain and approaches not known. Altitude 165 feet.

Grading, Dispersal Areas, Hard Standings: Landing strip (NE-SW, 300 x 1,680 ft.) on grassy gently sloping surface. Extent of level land, suitability for extension, and other possible runway orientations not known. Grading probably will require only ordinary graders and dozers. May be ample room for scattered dispersal areas and hard standings.

Foundation, Drainage: Soil is friable sandy clay; generally well drained but may be soft and plastic during rainy season. Soil structure may be destroyed if worked when wet; will result in muddy plastic clay. Bearing strength moderate. Runways for use of heavy aircraft must have base course and subgrades developed by addition of coarse fractions and mechanical stabilization. Side collection channels along runway may reduce water table under paved runways sufficiently to avoid use of subdrains. Run-off from adjacent hills may require canalization to divert flood water from runways. Addition of coral-reef limestone to sandy clay will provide excellent base when mechanically stabilized. Crushed and stabilized reef limestone will provide excellent surfacing.

Clearing, Grubbing: Little clearing or grubbing necessary unless runway is extended; can be accomplished by graders or dozers.

Construction Materials Available: Character of bedrock in hills adjacent to site not known. Island reported underlain largely by sandstone, in part highly indurated. Overburden commonly thin on sandstone; for quarrying sandstone will require blasting and power tools. Limited local supplies of sand and gravel in stream channels. Quartz and limy sand on beaches readily available. Coral reefs fringe exposed coasts; reef rock is best construction material available. Adjacent forested hills will supply good construction timber.

Water Supply: No data on surface water at site. Shallow dug or driven wells at site will provide potable water for personnel.



Culion Airfield; view to west. (USAAF,CFL, 21211 A. C.)

2. IWAHIG (PUERTO PRINCESA) AIRFIELD

Location, Suitability, Accessibility: Lat 9°44' N, long 118°40' E, near Iwahig Penal Colony; about 5 miles west of Puerto Princesa. Site on broad coastal lowland suitable for enlargement to accommodate heaviest aircraft with orientation of runways in any direction. Accessible by road from Puerto Princesa throughout year; about 1 1/2 miles from low mangrove-lined coast. Aerial photographs show airfield on south side of Iwahig Penal Colony on all-weather (?) road. Altitude about 22 feet. Airfield reported improved by Japanese since occupation; new Japanese airfield reported to NW but exact location not known. See also Area 16.

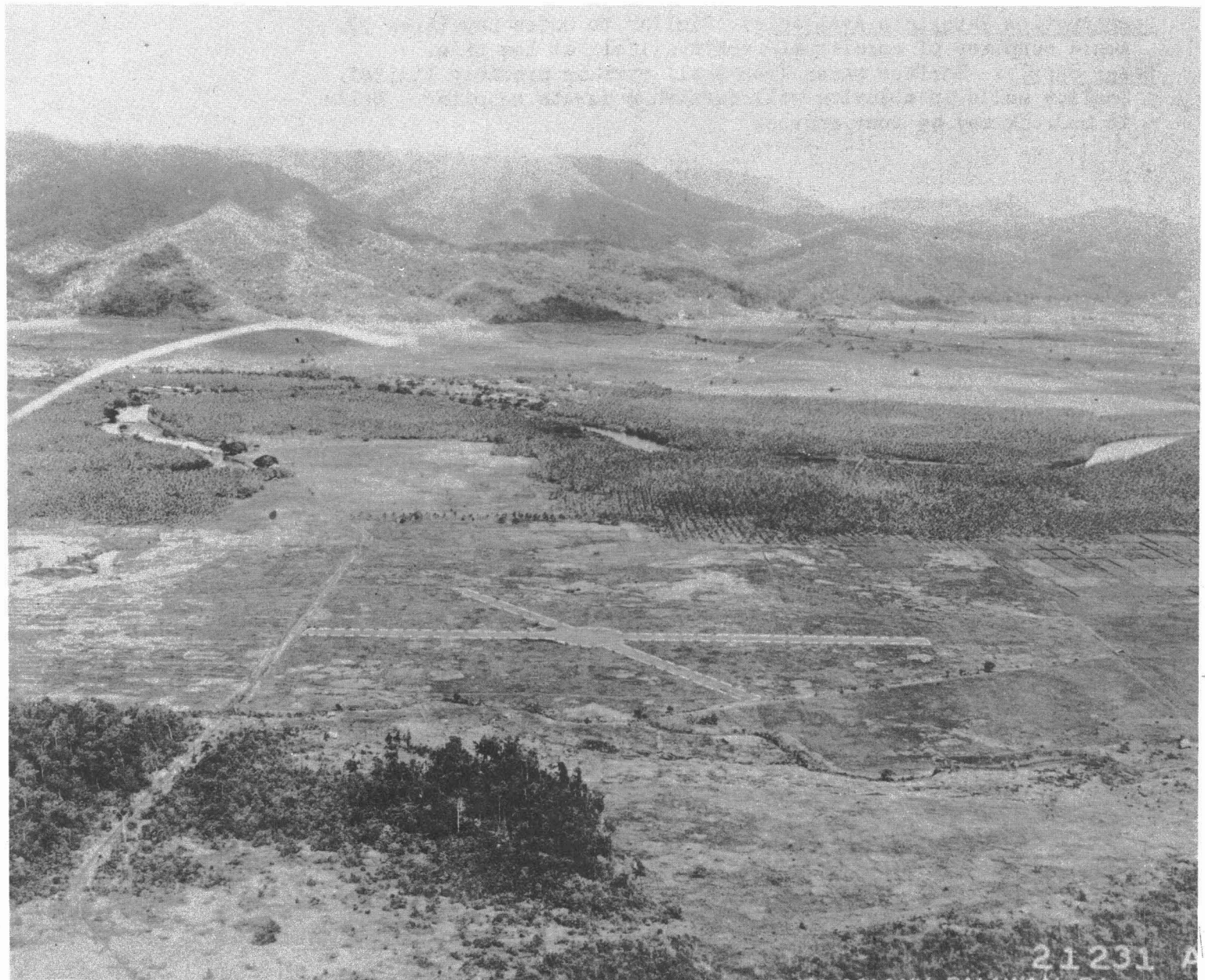
Grading, Dispersal Areas, Hard Standings: Two level sodded runways (E-W, 165 x 1,980 feet and NW-SE, 132 x 990 feet) can be extended in all directions. Exact character of adjacent hilly terrain not known, but present approach angle reported 40/1 in 5 miles. Other adjacent sites suitable for extended runways of different orientations. Little grading required; ordinary graders and dozers can be used. Ample room for dispersal areas and hard standings.

Foundation, Drainage: Sodded clay-loam runways reported soft in wet weather. Drainage generally poor; area possibly flooded following severe rains. Plastic clay-loam soil may be waterlogged after heavy rains. Near hills and Iwahig River, soil may be sandy or gravelly. Soil has moderate bearing strength; is not adapted to mechanical stabilization without addition of coarse fractions and suitable drainage. Runways for heavy aircraft may require raised and drained subgrades with stabilized base course. Surfacing or pavement of stabilized coral-reef limestone desirable. Side collection channels along runway desirable for removal of surface run-off and as an outlet for subdrains. Low natural levees along river may be of sufficient height to protect runways from ordinary high water.

Clearing, Grubbing: Vegetation low; can be cleared by ordinary graders and dozers.

Construction Materials Available: Hills adjacent to lowland have thin sandy soil mantle on dark granite-like (gabbro) or soft dark green sheared (serpentine) rock. Some coral limestone may crop out along base of hills; is best construction material available. Large areas of reef limestone exposed at low tide on nearby shores. Sand available on beach; may be largely limy. Sand and gravel readily available in Iwahig River channel. Timber from adjacent forested hills suitable for construction.

Water Supply: Surface supply from Iwahig River more suitable than brackish ground water from driven wells.



Iwahig Airfield; view to north. (USAAF,CFL, 21231 A.C.)

AIRFIELD CONSTRUCTION

PALAWAN PROVINCE (P.I.)

Reliability rating: Class D

3. GUTOB BAY

Location, Suitability, Accessibility: West coast of Busuanga Island, approximate location lat $12^{\circ}10' N$, long $119^{\circ}53' E$. Areas suitable for airfields on coastal lowlands and stream valleys near villages of Busuanga and Salvacion; reported to be largest and most level area in Calamian Group. Accessible only by water except for small trail at north leading from village of Calauit on east coast. Sites can be located near sandy beaches. Village of Busuanga connected by trail and third-class road or track with Bintuan and Malbato (see Map Area 10).

Grading, Dispersal Areas, Hard Standings: Low coastal terraces, probably upraised coral reefs, may require runways oriented parallel to shore; little grading necessary. In valleys leading from coast, moderate amounts of grading will be necessary for development of flight strips because of low stream terraces and gentle slopes from valley walls. Level tracts suitable for development of dispersal areas and hard standings of limited extent.

Foundation, Drainage: Sandy clay alluvium in coastal areas reported to be well drained throughout year; bearing strength probably high. In stream valleys sandy clay may be in part lateritic and friable; drains readily, but if worked when wet, soil structure will be destroyed and a plastic clay will result. Some gravel may be mixed with soil on alluvial slopes at base of hills. Runways in coastal areas may not need subdrains, but side collection channels will be necessary to remove surface run-off from paved runways. In stream valleys small tributary streams must be diverted to prevent flow across runways during periods of heavy rain. Soil suitable for mechanical stabilization with addition of coarse fractions. Pavement of stabilized coral-reef rock desirable for runways to be used by heavy aircraft.

Clearing, Grubbing: Large parts of area grassy, will require no clearing. Some coconut plantations and low-forest growth can be cleared by dozers. A small amount of blasting and cutting may be necessary.

Construction Materials Available: Bedrock of hills adjacent to site not known; island reported underlain largely by sandstone, in part hard. Coastal terraces may be underlain by upraised coral reefs; reef rock may be in part suitable for working with hand tools. Sand and gravel available in stream channels and on beaches; some coral reef fringes shore and is available for quarrying at low tide. Coral-reef rock is best construction material for use on airfields. May require drilling and blasting. For quarrying hard sandstone, blasting and power tools required; construction quality fair to poor. Adjacent hills may provide abundant supplies of timber suitable for construction.

Water Supply: Busuanga River will furnish ample supplies of fresh water. Shallow wells in coastal and valley alluvium will provide additional supplies.

4. CALAUIT AREA

Location, Suitability, Accessibility: Northwest part of Busuanga Island; approximately lat $12^{\circ}18' N$, long $119^{\circ}56' E$. Three broad low tracts of relatively level land trending NE.; separated by hilly ridges with altitudes to more than 600 feet. Area may be suitable for airfields accommodating heaviest aircraft, but all runways must be oriented NE. Areas accessible from reef-fringed shores; some mangrove swamps. Footpath follows shore south of Calauit; branch trail to west coast at Buluang.

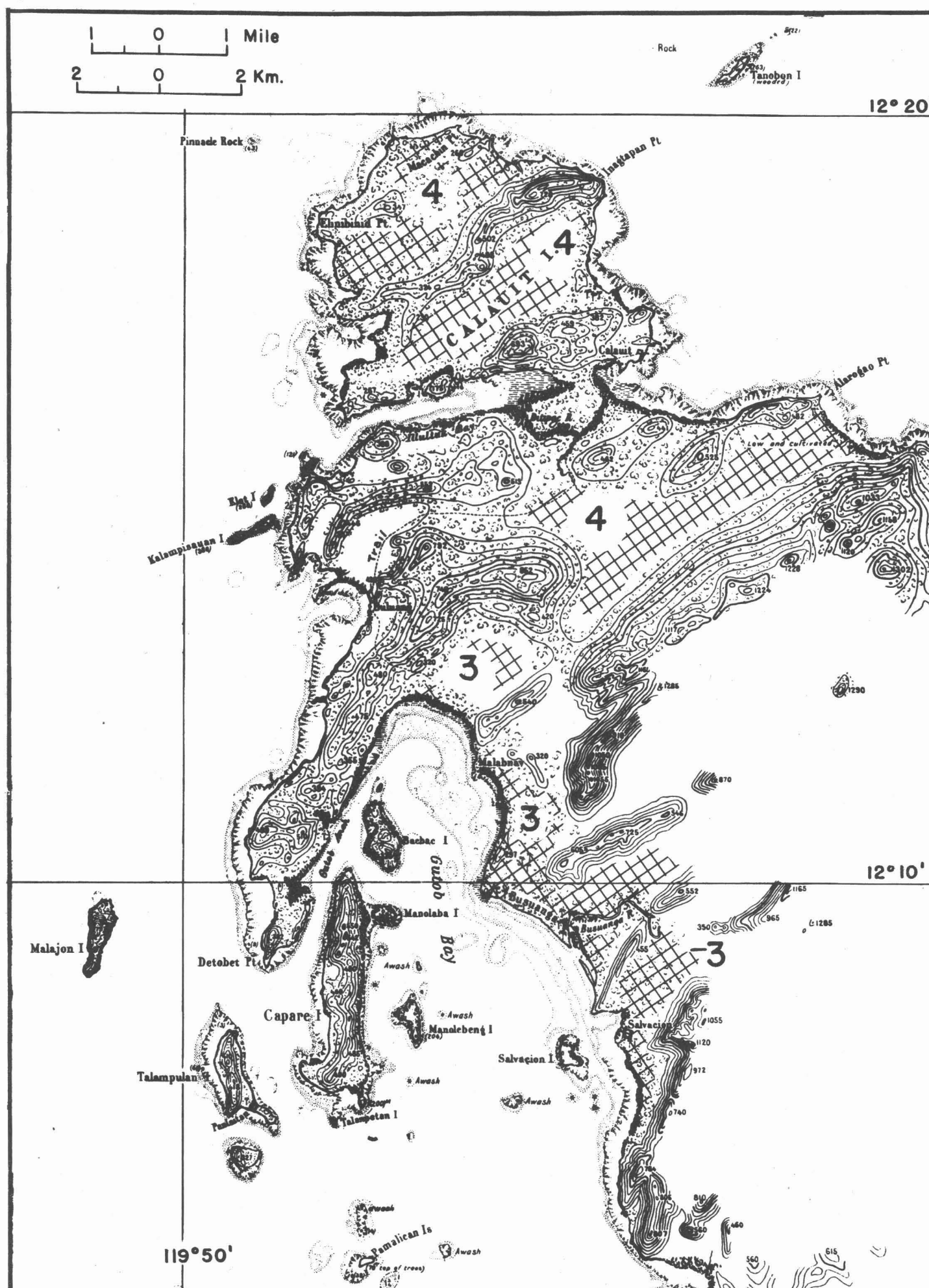
Grading, Dispersal Areas, Hard Standings: General detailed character of terrain not known; ground may be somewhat rolling and in part may require moderate grading; elsewhere necessity of grading may be negligible. Little blasting necessary; valley floors probably mantled by relatively thick alluvium. Room for dispersal areas and hard standings limited, but concealment provided by primary forest.

Foundation, Drainage: Foundation and drainage conditions similar to those of Gutob Bay (Area 3).

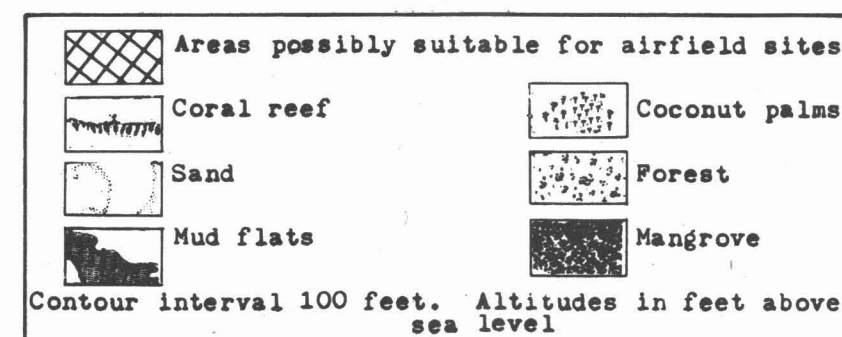
Clearing, Grubbing: Parts of area have been cultivated; some secondary forest. Valley floors and hill slopes generally covered by primary forest. Clearing of secondary growth can generally be accomplished by graders and dozers; primary forest will necessitate use of power tools and blasting. Heavy equipment necessary for grubbing of tree stumps.

Construction Materials Available: Similar to Gutob Bay (Area 3). Ample supplies of coral-reef rock available at low tide.

Water Supply: Surface water from small streams probably limited. Shallow wells in alluvium will furnish moderate supplies. Wells in bedrock may be poor source.



Source: U. S. C. and G. S. no. 4314



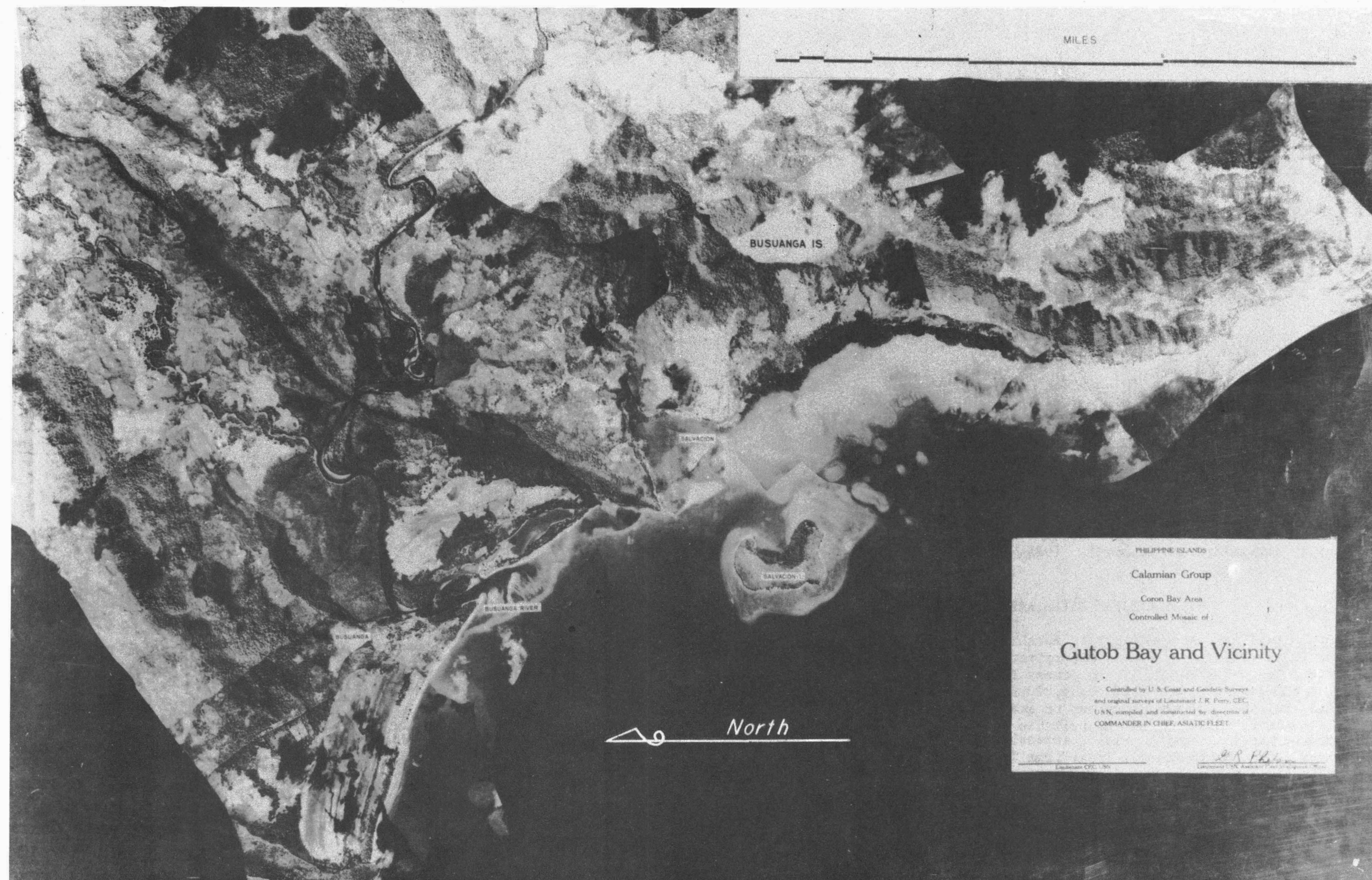
Coastal terrain at mouth of Busuanga River. (ONI 62529)



Gutob Bay region north from Salvacion. (ONI 62525)

(continued)

Reliability rating: Class D



5. TAYTAY TRAIL

Location, Suitability, Accessibility: Taytay Trail between village of Taytay and Inner Sound of Malampaya Sound (Palawan Island); approximate lat 10°49' N, long 119°29' E. Site on cleared valley floor about mid-way across island; dimensions 1,000 by 6,000 feet. Accessible from Taytay on east coast by partially surfaced all-weather road and from Malampaya Sound by trail probably suitable for jeeps during dry season; muddy when wet. Site surrounded by low hills; details of terrain adjacent to site not known. Site suitable for emergency landings and fighter plane field; probably not suitable for heavy aircraft. Airstrip, 1,500 by 3,200 feet, unreported since 1938.

Grading, Dispersal Areas, Hard Standings: Site generally level, will require minimum grading. SW. part reported most level but under water during rainy season. Runways may require raised subgrades. With considerable grading, site may be extended to east and west. Areas for dispersal and hard standings limited but may be most advantageously placed to south of field and concealed in dense forest.

Foundation, Drainage: Soils generally friable sandy loam with good bearing strength; dry readily when drained. Plastic mud developed if soil is worked when wet. Soil thickness moderate; in part soil may be underlain by sandy gravelly alluvium of Malapajo River which swings to south of site. Site in part covered by rice paddies. Drainage necessary, especially in SW. part which may be flooded during rainy season. Drainage ditches to river will carry away surface run-off, but subdrains will be necessary to reduce water table at site. When drained, soil probably suitable for mechanical stabilization.

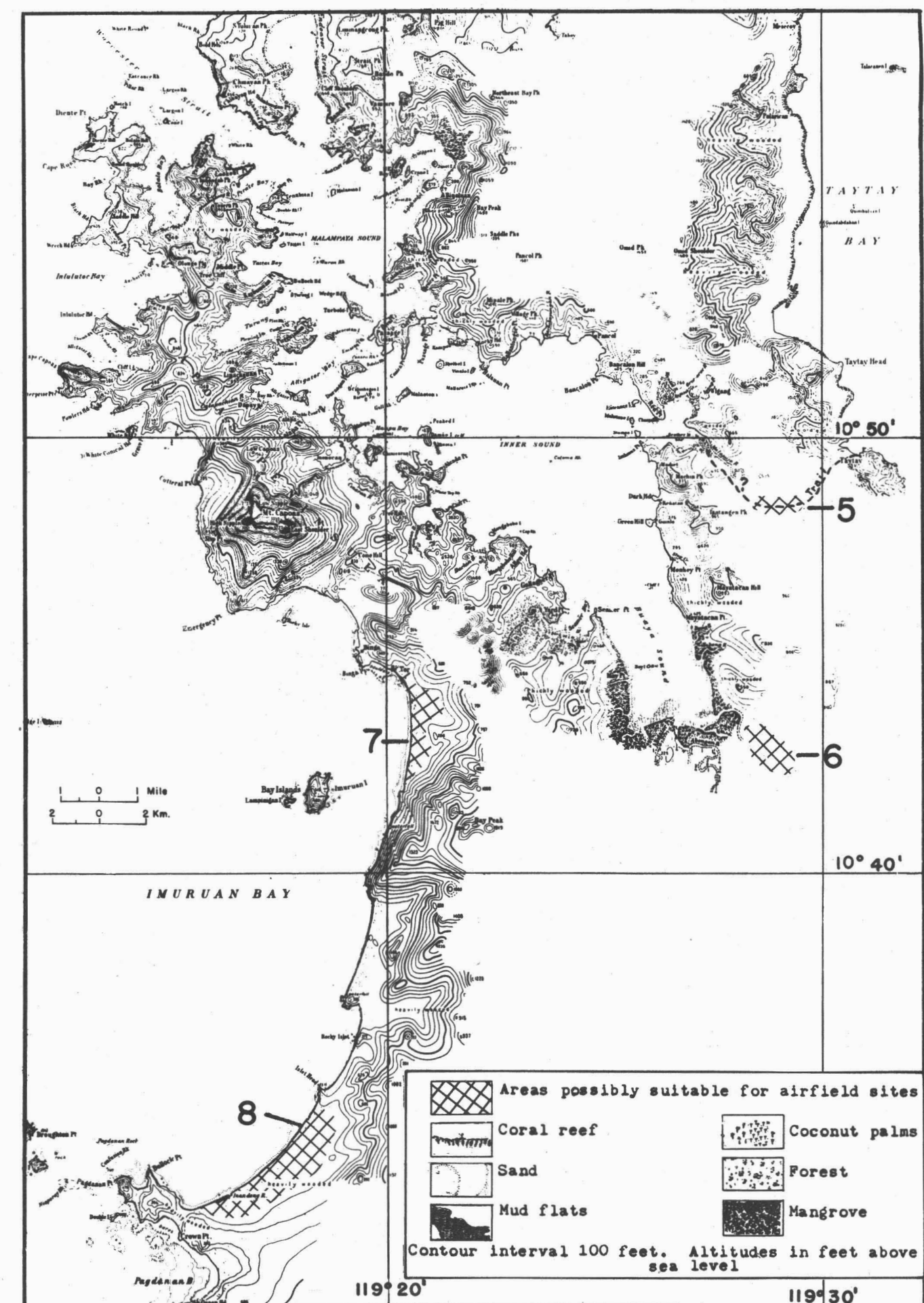
Clearing, Grubbing: Little clearing necessary for utilization by small aircraft but moderate clearing of primary forest necessary for extension of airfield. Some power tools and blasting necessary for rapid clearing of larger trees; ordinary graders and dozers will remove smaller brush and low trees.

Construction Materials Available: Bedrock reported to be sandstone and shale; may be in part hard and brittle; will require blasting and power tools for quarrying. Some sand and gravel may be available in stream bed near site. Coral rock obtainable from fringing reefs near Taytay; is best construction material for airfields. Abundant local supply of timber for construction.

Water Supply: Moderate amounts of surface water may be available in stream near site. During periods of unusually dry weather stream may fail. Shallow wells at site may provide suitable auxiliary supply.



Taytay Trail from Taytay to Inner Sound, Malampaya Sound; view to west. (ONI 29863)



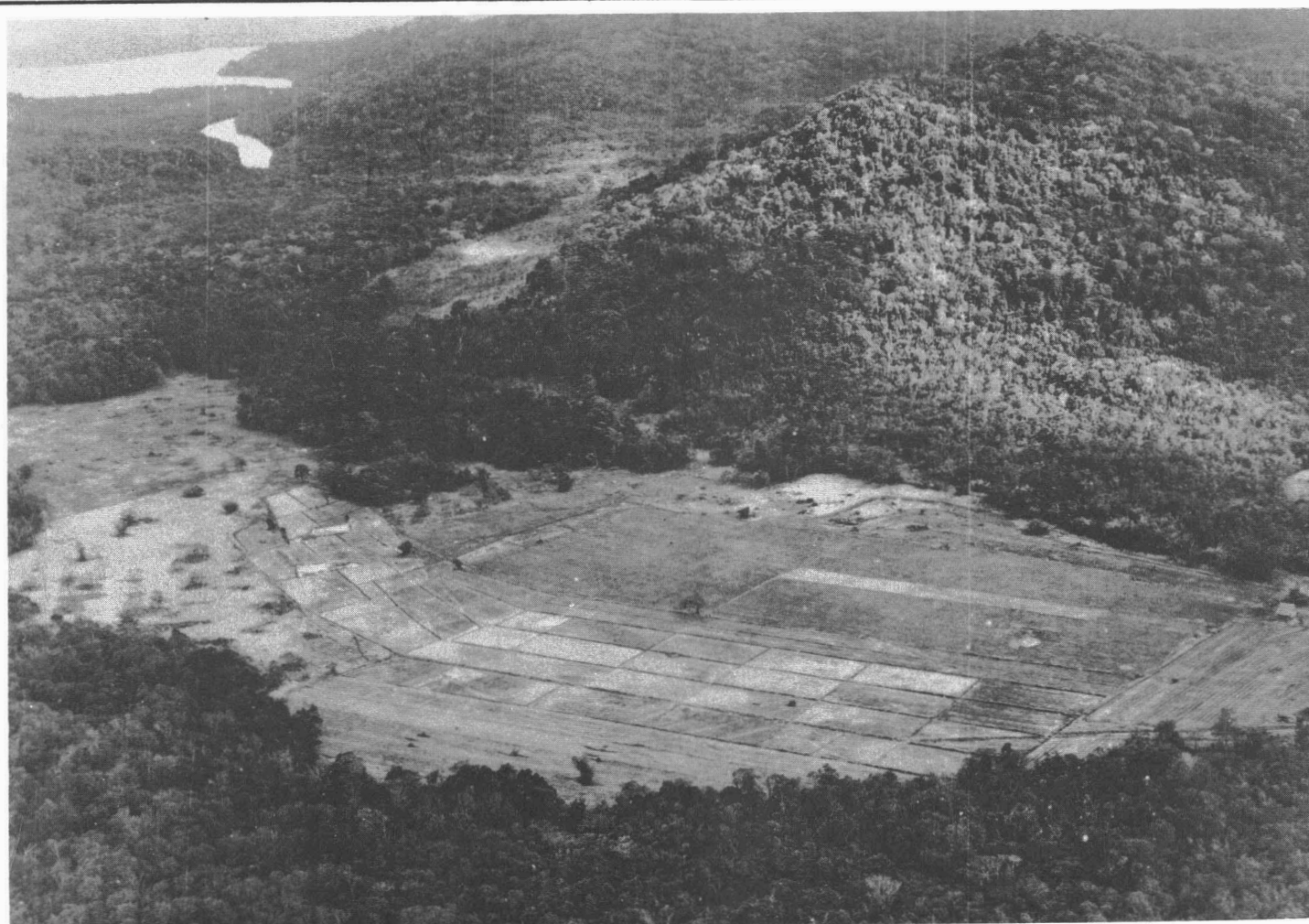
Source: U. S. C. and G. S. no. 4316

(continued)

AIRFIELD CONSTRUCTION

PALAWAN PROVINCE (P. I.)

Reliability rating: Class D



Taytay airfield; view to north. (USAAF, CFL, 21192 A.C.)

6. KALABIKAY RIVER AREA

Location, Suitability, Accessibility: Kalabikay River Valley at head of Buaya (Malampaya) Sound; approximate location lat $10^{\circ}43' N$, long $119^{\circ}29' E$. Three grassy fields (2,700 by 4,300, 1,800 by 4,000, and 1,200 by 3,000 feet) reported nearly treeless, suitable for emergency use or small fighter field with slight leveling. Site may not be suitable for enlargement to accommodate heavy aircraft. Fields accessible from head of Malampaya Sound (Buaya Sound). Trail from Taytay on east coast (see Site 5) to Malampaya Sound. Movement along shore from west end of trail to site difficult due to poor footing and vegetation.

Grading, Dispersal Areas, Hard Standings: Gently sloping grassy fields can be leveled by graders and dozers. Exact nature of terrain and possibilities for expansion of site not known. Area for dispersal and hard standings probably limited.

Foundation, Drainage: Sandy clay soil, slippery when wet. Drainage and reduction of water table necessary before addition of coarser fraction for soil stabilization. Soil probably semi-plastic alluvial clay; bearing strength and drying rate moderate. During rainy periods, lower parts of fields may be flooded by Kalabikay River. Airfield may require protection from flooding and canalization of small streams draining adjacent hills.

Clearing, Grubbing: Little grubbing reported necessary on grassy fields.

Construction Materials Available: Bedrock of adjacent hills reported to be sandstone and shale; may be hard and brittle. Will require blasting and power tools for quarrying. Some sand and gravel may be available in stream bed adjacent to site and on beaches near mouth of Kalabikay River. Ample local supplies of timber suitable for construction.

Water Supply: Ample supply of fresh water available in Kalabikay River. Shallow wells at site will furnish auxiliary supply; should not be overpumped if near coast because of danger of salt water encroachment.

7. BINGA POINT

Location, Suitability, Accessibility: Shore of Imuruan Bay south of Binga Point; approximate location lat $10^{\circ}43' N$, long $119^{\circ}21' E$. Small coastal lowland between sandy beach and hilly ridge of Capoes Peninsula. Maximum dimensions about 2 by 3 miles. Gently sloping surface can be utilized for runway parallel to shore suitable for emergency landings or airfield for lighter aircraft; approach glide angles too great for heavy aircraft.

Grading, Dispersal Areas, Hard Standings: Runway parallel to shore will require moderate grading by dozers and graders. Inner margin of flat land has steeper slopes not suitable for runways because of steep approach angles and irregular surface. Ample room for dispersal areas and hard standings; can be concealed in dense forest.

Foundation, Drainage: Sandy clay loam soil, probably friable at highest altitudes; in part plastic sandy clay near shore. Bearing strength good to poor; drainage moderately good. Soil suitable for mechanical stabilization only after addition of coarse fractions. Water table high near shore; runways if paved will require subdrains and side collection channels to handle surface run-off.

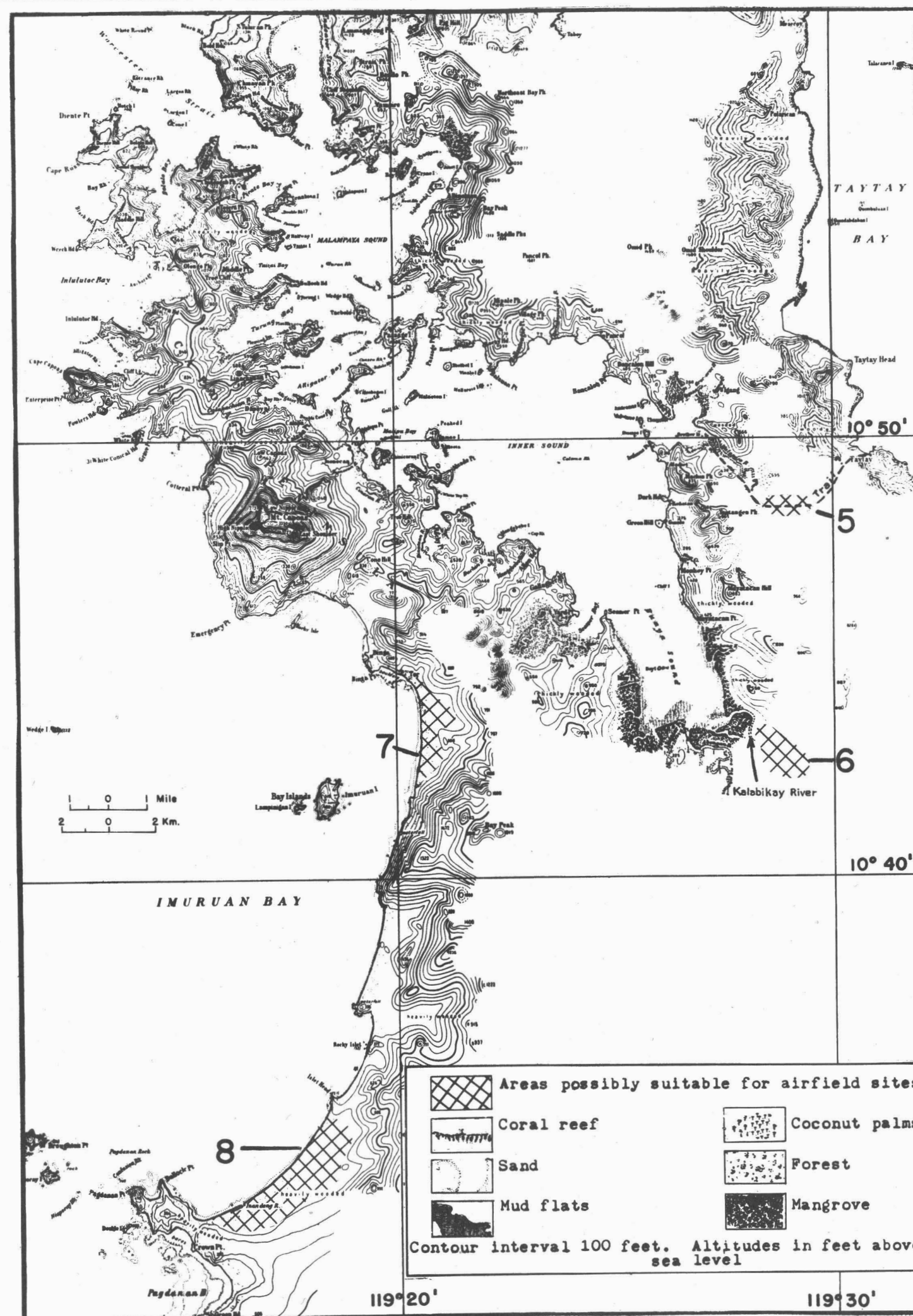
Clearing, Grubbing: Dense forest vegetation covers large part of site; will require removal by blasting and power tools. Small areas of grassland and low scrub can be cleared with ordinary graders and dozers. Larger stumps will require blasting and grubbing.

Construction Materials Available: Adjacent hills underlain by granite, sandstone, and perhaps shale. Quarrying of sandstone and granite will require use of power tools and blasting; are good construction materials. Ample supplies of sand and gravel on beaches. Boulder beach reported south of Binga Point. Ample supplies of timber suitable for construction locally available.

Water Supply: Surface supply probably limited to small intermittent streams flowing from adjacent hills. Shallow wells will provide moderate to good supplies. Wells near shore should not be overpumped because of danger of salt water encroachment.



Airfield site southeast Binga Point; view to northeast. (ONI 62813)



Source: U. S. C. and G. S. no. 4316.

8. INANDENG RIVER

Location, Suitability, Accessibility: Small coastal flat land on Imuruan Bay south-southwest of Islet Head; dimensions approximately 2 by 4 miles; lat $10^{\circ}32' N$, long $119^{\circ}17' E$. Similar to coastal lowland south of Binga Point (Area 7). May be suitable for runways parallel to shore which will accommodate heavy aircraft; approach glide angles less than $1/20$. Detailed character of terrain and course of Inandeng River across lowland not known.

Grading, Dispersal Areas, Hard Standings: Probably little grading necessary to provide level strips for runways; dozers and graders necessary. Ample room for dispersal areas and hard standings which can be concealed in dense forest.

Foundation, Drainage: Similar to Binga Point (Area 7).

Clearing, Grubbing: Area heavily wooded; primary forest. Power tools and blasting necessary for removal of forests. Heavy equipment needed to remove large trunks; blasting and use of heavy winches necessary for removal of buttressed stumps. Low growth can be cleared by dozers.

Construction Materials Available: Dark sandstone and shale underlie adjacent hills. Sandstone provides good construction material; for quarrying will require blasting and use of power tools. Abundant sand and gravel along beaches. Coral rock available across low divide to south near Crown Point; provides best construction material available for use on airfields. Coral rock can be obtained at low tide.

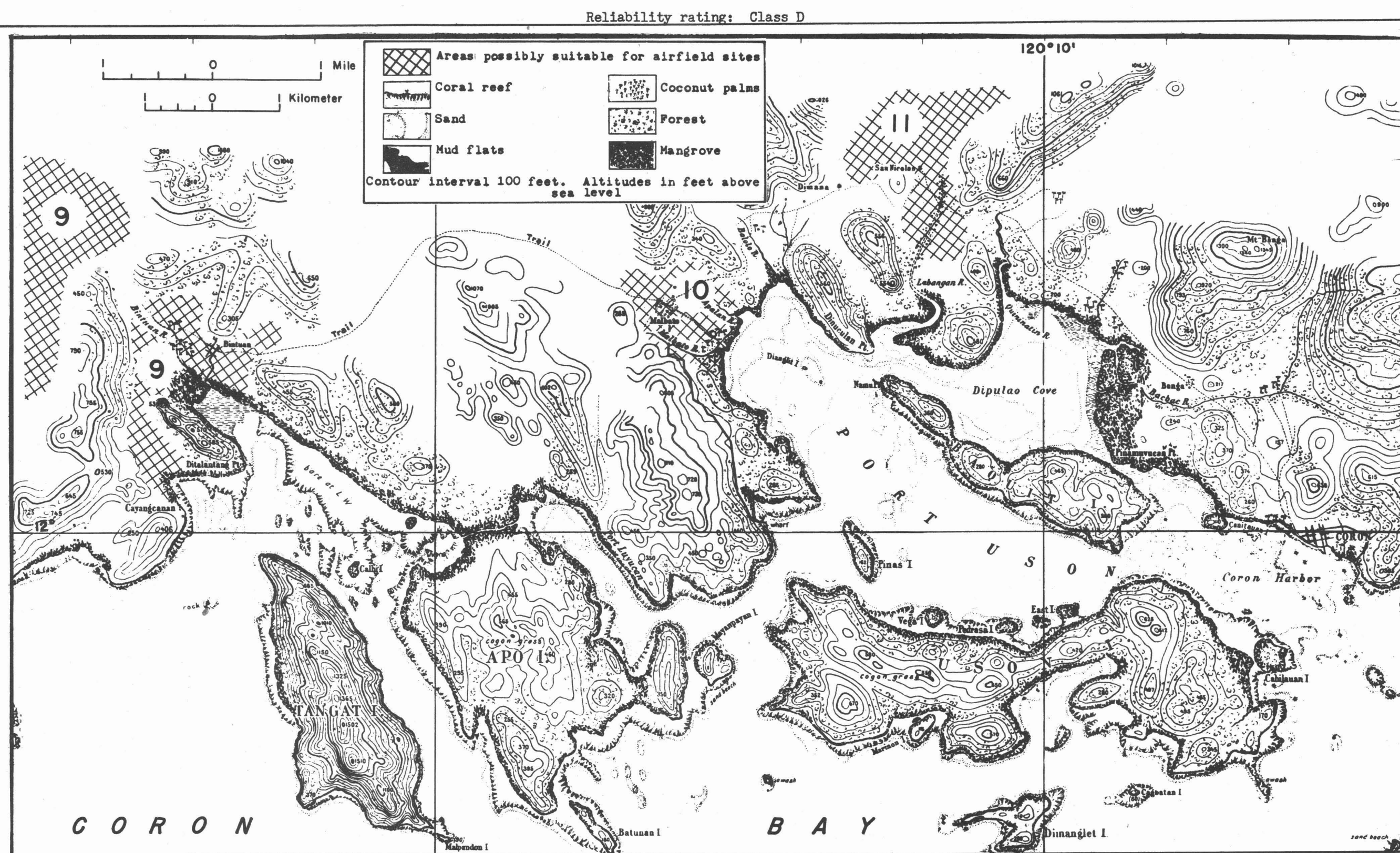
Water Supply: Inandeng River may furnish permanent supply of fresh water. Shallow wells in coastal alluvium will provide good supplies, but wells near shore should not be overpumped because of danger of encroachment by salt water.



Closeup view Binga Point airfield site. (ONI 62812)

PALAWAN PROVINCE (P.I.)

AIRFIELD CONSTRUCTION



Source U. S. C. and G. S. no. 4351

9. BINTUAN AREA

Location, Suitability, Accessibility: Southern part of Busuanga Island on Coron Bay near village of Bintuan; approximate lat $12^{\circ}01' N$, long $120^{\circ}03' E$. Small tracts of level ground along Bintuan River near mouth and inland in valley to west of village. Three thousand acres of level grassland reported about 1 1/2 miles west of village. Only established land route of access is foot trail from Malbato and Coron to east. Access from bay may be difficult because of mangrove swamps and fringing coral reefs. Sites appear small and suitable only for emergency landing fields.

Grading, Dispersal Areas, Hard Standings: Sites at river mouth require little grading except for fill in marshy areas. Grading with ordinary dozers and graders required in broad inland valley because of relatively steep slope of valley floor from sides to center. Room for dispersal areas and hard standings limited; little vegetation to provide concealment.

Foundation, Drainage: Plastic clay loam and swamp muck in coastal area with only moderate bearing strength, high water table and poor drainage. Inland soil is friable clay loam, may be in part lateritic; good bearing strength, lower water table, and relatively good drainage; dries readily. Raised subgrades with subdrains required for proper drainage in coastal regions. Coarse fractions must be added to soil to permit mechanical stabilization. Inland soil types probably contain sufficient coarse fractions to permit mechanical stabilization but will require canalization of stream in valley floor and suitable drainage of run-off from runway surface and valley walls.

Clearing, Grubbing: Little clearing or grubbing necessary except for swamp vegetation along coast (mangrove). Elsewhere areas possibly suitable for runways are grassy.

Construction Materials Available: Bedrock of Busuanga Island reported as mainly sandstone, in part hard. For quarrying sandstone will require blasting and power tools. Some sand and gravel may be available in stream beds and along beaches. Coral-reef rock exposed at low tide in fringing reefs along shore is excellent for airfield construction. Timber suitable for construction locally available on hill slopes.

Water Supply: Surface supplies limited to Bintuan River which may be intermittent stream. Shallow wells in alluvium will furnish best supplies. Wells near coast should not be over-pumped because of danger of salt water encroachment.

10. MALBATO AREA

Location, Suitability, Accessibility: Southern part of Busuanga Island on Coron Bay (Port Usón); approximate lat $12^{\circ}02' N$, long $120^{\circ}07' E$, near village of Malbato. Small area near village reported to be 3,600 feet square, grassy, smooth turtle-backed, suitable in present condition for small aircraft. Site can probably be extended in level area between Apalan and Malbato Rivers. Adjacent hill slopes probably obstacles to approaches. Site probably too small to accommodate heaviest aircraft. Area accessible from bay across narrow mangrove swamp and sandy beach or by foot trail from Bintuan and Busuanga on west and by partially surfaced generally all-weather road from San Nicolas, Banga, Coron on east, and north shore of island.

Grading, Dispersal Areas, Hard Standings: Probably little grading necessary. Minor irregularities can be smoothed with ordinary graders and dozers. Limited room for dispersal areas and hard standings; vegetation will provide concealment.

Foundation, Drainage: Similar to Bintuan Area (Area 9).

Clearing, Grubbing: Most of area is open grassland; some low trees which can be readily cleared with dozers.

Construction Materials Available: Similar to Bintuan Area (Area 9).

Water Supply: Similar to Bintuan Area (Area 9).

11. SAN NICOLAS AREA

Location, Suitability, Accessibility: Southern part of Busuanga Island near head of Port Usón on Coron Bay; approximate lat $12^{\circ}03' N$, long $120^{\circ}09' E$, near village of San Nicolas. Sloping grassy meadow several square miles in extent reported suitable for immediate landing operations. Exact location and detailed character not known. Site accessible from San Nicolas which is on Coron-Malbato-Bintuan foot trail. San Nicolas about 1 1/2 miles from sandy shore of Port Usón, can be reached by following Labangan River. Narrow fringes of mangrove swamp along shore.

Grading, Dispersal Areas, Hard Standings: Amount of grading necessary not known; probably can be accomplished with ordinary graders and dozers. Suitability for dispersal areas and hard standings not known.

Foundation, Drainage: Probably similar to Bintuan Area (Area 9) with friable, well-drained lateritic clay soil and moderately low water table.

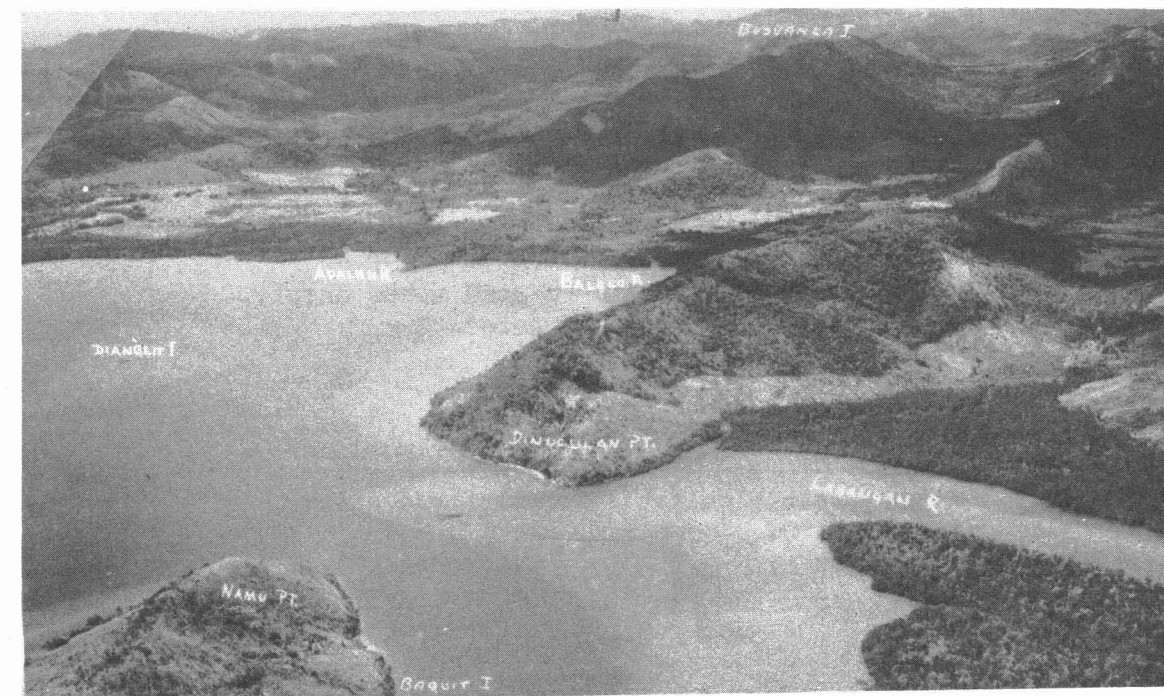
Clearing, Grubbing: Grasslands can be easily burned. Small clumps of low trees can be readily removed by dozers.

Construction Materials Available: Similar to Bintuan Area (Area 9).

Water Supply: Surface supplies probably limited; shallow wells will furnish moderate supplies. Labangan River may furnish adequate supplies at all seasons.



Airfield site 1 mi. W. Bintuan; view southeast. (ONI 62534)



Airfield site at Malbato near mouth of Apalan River; view to northwest. (ONI 62542)



View of terrain in region of Port Usón; view to northeast. (ONI 624930)

(continued)

Reliability rating: Class D

12. HALSEY HARBOR

Location, Suitability, Accessibility: Flat treeless meadow several square miles in extent reported at head of Halsey Harbor (Research Channel). Approximate lat 11°47' N, long 120°01' E. Area 1/2 by 1 mile wide reported (ONI, March 1942) suitable for emergency landing after one day's work. No roads or trails at site; accessible only from shore of Halsey Harbor or across rugged terrain from east shore of Culion Island. Detailed character of site not known.

Grading, Dispersal Areas, Hard Standings: Area suitable for airfield site probably will require little grading. Minor irregularities can be levelled and depressions filled by use of ordinary graders and dozers. Areas available for dispersal and hard standings probably limited.

Foundation, Drainage: Site underlain by friable, lateritic clay which has good bearing strength, drains readily; reported 'never boggy even during excessive rains'. If worked when wet, soil structure may be destroyed and mud will result. Addition of coarse fractions may be necessary for mechanical stabilization. Sodded runways may be suitable for lighter aircraft. Water table moderately high; can be reduced by drains and raised subgrades.

Clearing, Grubbing: Little clearing or grubbing reported necessary. Grass can be burned in dry weather. Small mangrove swamps line stream channels crossing field. All vegetation can probably be removed by dozers.

Construction Materials Available: Bedrock reported to be sandstone and shale, similar to Busuanga Island; in part hard and difficult to quarry or use for construction because of sharp, jagged edges. Where sandstone is less hard, it is a suitable construction material. Timber suitable for construction locally available on hill slopes.

Water Supply: Moderate amounts of surface water from small streams; shallow wells in alluvium at site will provide moderate amounts.

13. DEVIL RIVER

Location, Suitability, Accessibility: Delta and lowlands of Devil River on Palawan Island may be suitable for small landing fields. Location approximately lat 11°11' N, long 119°30' E. Accessible from sandy shore, in part fringed by coral reef and narrow mangrove swamp which continues inland for approximately 1 1/2 mile along Devil River. Lowland area surrounded by steep hills to altitudes of more than 1,500 feet. Foot trail along coast connects, to south of river, with foot trail from Bacuit on west coast of island. Exact location of trail not known.

Grading, Dispersal Areas, Hard Standings: Detailed character of lowland not known, but is probably suitable for runways for medium to small aircraft with minimum grading by ordinary graders and dozers. Areas for dispersal and hard standings limited. Small streams will need canalization to prevent flooding of runways during heavy rains.

Foundation, Drainage: Alluvial plain possibly underlain by some coral-reef rock. Soil generally plastic clay near shore, poorly drained with low bearing strength. Inland at slightly higher altitudes, soil is friable clay with moderate to good bearing strength and drainage. Some sand and gravel lenses. Soil generally will need addition of coarse fractions and drainage for mechanical stabilization. Raised subgrade, subdrains, and ditches may be necessary for proper drainage.

Clearing, Grubbing: Area may be covered in large part with secondary forest; some cultivated tracts. Adjacent hill slopes covered with primary forest. Clearing may require use of heavy equipment.

Construction Materials Available: Bedrock in hills adjacent to site probably sandstone and shale. Granite reported in upper course of Devil River. Bedrock will require blasting and use of power tools for quarrying. Sand and gravel locally available in stream channels and along shore. Coral-reef rock available at low tide along shore; is best construction material for airfields; suitable for surfacing runways. Good timber for construction available at site.

Water Supply: Devil River will furnish adequate fresh water; additional supplies obtainable from shallow wells in lowland. Bedrock in hills is poor source.

14. SHARK FIN BAY

Location, Suitability, Accessibility: Lowland extending from Shark Fin Bay to Mesecoy Bay between Silanga and Shark Fin Peaks, may be suitable for runway for heavy aircraft; details of terrain not known. Approximate location, lat 11°03' N, long 119°31' W. Accessible only from sandy reef-fringed shores of bays; no known trails.

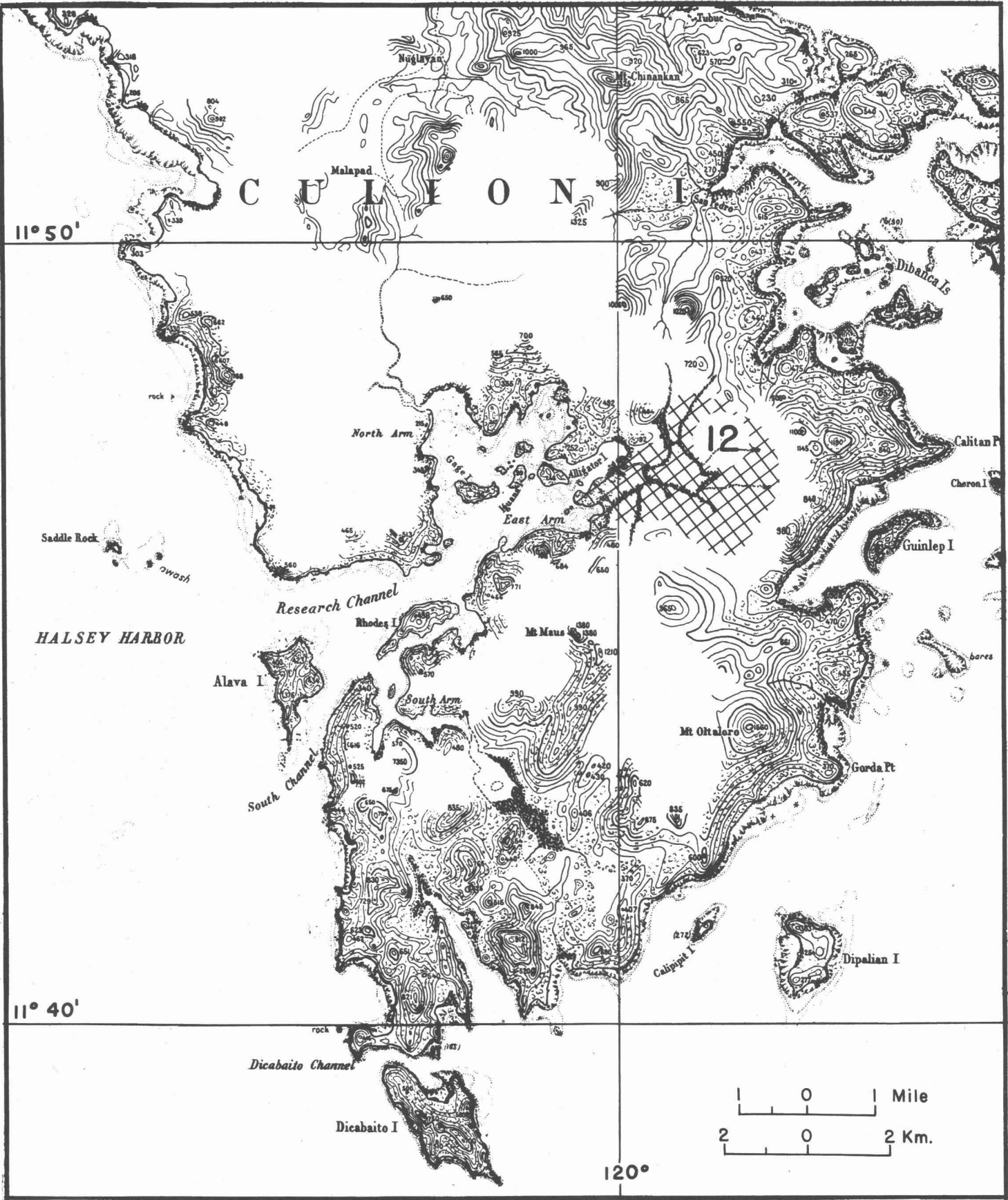
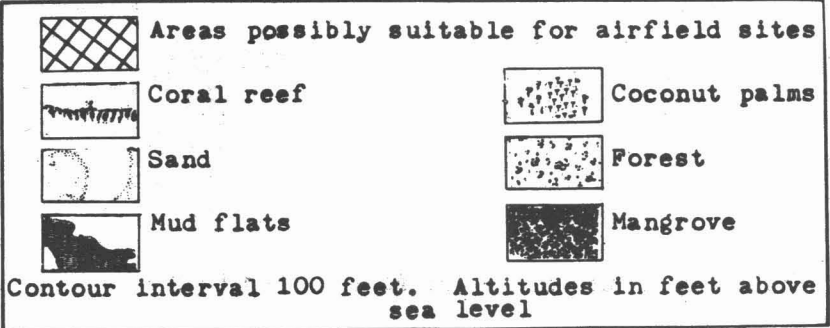
Grading, Dispersal Areas, Hard Standings: Lowland probably level; any minor irregularities may be leveled or filled by use of ordinary grader or dozer. Area possibly underlain by coral rock which may in part require blasting. Ample room for dispersal areas and hard standings; can be concealed in heavy vegetation.

Foundation, Drainage: Similar to those at Devil River (Area 13).

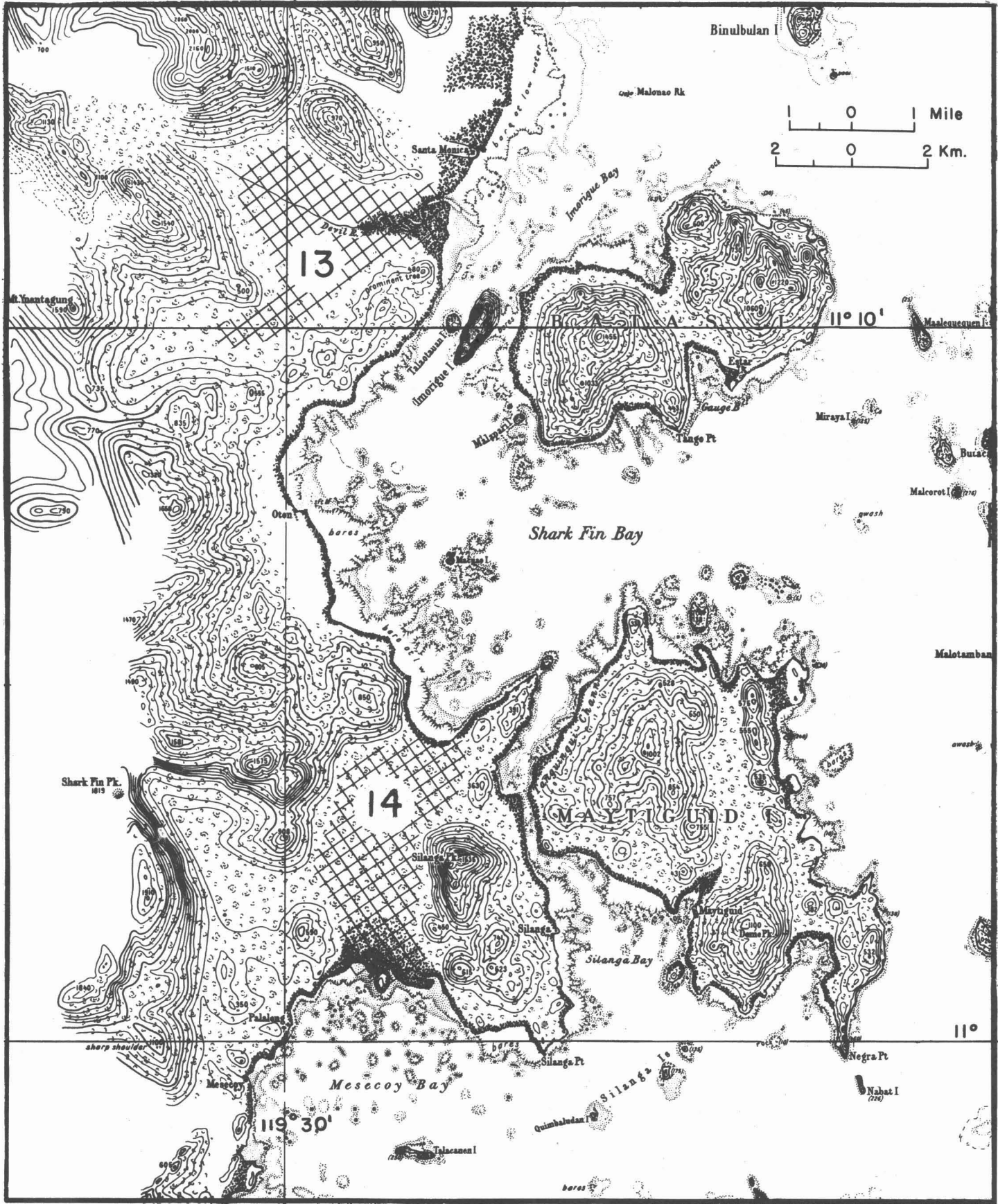
Clearing, Grubbing: Dense primary forest will require use of heavy equipment for clearing and grubbing. Heavy trucks, blocks and tackles, and power saws necessary. Removal of fallen trees necessary because of difficulty of burning.

Construction Materials Available: Adjacent hills underlain by sandstone and shale. Sandstone may be hard; requires use of power tools and blasting for quarrying. If sandstone is unusually hard, quarrying will be difficult and will require special crushing equipment. Ample supplies of timber for construction available at site.

Water Supply: Shallow wells will provide moderate to good water supply. Near shores, overpumping may cause encroachment by salt water.



Source: U. S. C. and G. S. no. 4315



Source: U. S. C. and G. S. no. 4317

(continued)

Reliability rating: Class D

15. GREEN ISLAND BAY

Location, Suitability, Accessibility: Small coastal lowlands on Palawan and two islands (North and South Verde) possibly suitable for airfield sites extend along Green Island Bay from lat 10°05' to 10°23' N. Area generally accessible from sea; sandy shores in part fringed with narrow mangrove swamps. Trails from west coast (Port Barton and Malampaya Sound) lead to Caramay and Barbacan (incompletely shown); no known trails parallel coast.

Grading, Dispersal Areas, Hard Standings: Coastal areas and island will require limited levelling; graders and dozers probably sufficient for all grading. Limited areas for dispersal and hard standings; dense vegetation suitable for concealment. Best site probably on coastal lowland adjacent to Pascoe Channel. Runway parallel to coast can have length of 8,500 feet; approach glide angle less than 1/20. Mangrove-covered islands, if cleared and supplied with adequate foundations and drainage, are suitable for emergency landing strips.

Foundation, Drainage: Coastal lowlands probably underlain by plastic clay which may in part be sandy. Bearing strength and drainage only moderately good. Water table near surface; can be somewhat reduced by construction of drainage canals. Foundations will need subdrains. Soils can be stabilized for subgrades with addition of coarse fractions and adequate drainage. If worked when wet, soil will usually become plastic mud. Soils on North and South Verde Island are plastic mud, partly waterlogged. For use as airfield sites will require building of raised subgrades; can be mechanically stabilized with addition of coarse fractions; suitable drainage is greatest construction problem. Water table at or near surface; bearing strength of soil low. Islands may not be as suitable for runways as adjacent coastal lowlands.

Clearing, Grubbing: Dense forests in coastal areas behind narrow fringing mangrove swamps will require use of power equipment, blasting, and grubbing of buttressed stumps. Mangrove on islands can be cleared with light equipment; clearing difficult because of poor footing. Burning or removal of larger tree trunks difficult; will require heavy equipment. Small areas of secondary growth or cultivated plots can be cleared by dozers.

Construction Materials Available: Character of bedrock of adjacent hills not known; may be sandstone and shale. Adequate supplies of sand and some coarse gravel obtainable from small stream channels and beaches. Coral-reef rock, best construction material, obtainable at low tide from fringing reefs; may require blasting. Ample supplies of good timber for construction locally available in forests.

Water Supply: Surface supplies in coastal areas limited to small streams; possibly some small springs. No fresh surface water on islands. Shallow wells in coastal lowlands will provide limited amounts of fresh water; should not be overpumped because of danger of salt water encroachment. Water obtained from shallow wells on islands will be brackish to salt. Best supplies from rain water.

16. PUERTO PRINCESA

Location, Suitability, Accessibility: Lowland areas adjacent to Puerto Princesa provide suitable sites for airfield runways of any orientation (see Iwahig Field, Area 2). Location on lowlands adjacent to Puerto Princesa; lat 9°44' N, long 118°44' E. Area accessible from sea along reef-fringed coast; reefs generally bare at low tide. Shores of Puerto Princesa bordered by mangrove swamps; most extensive on north. All-weather roads border bay and extend along shore to north and south (see Terrain Sheet NG 50-6). Trail crosses island from west coast to Puerto Princesa; exact location not known.

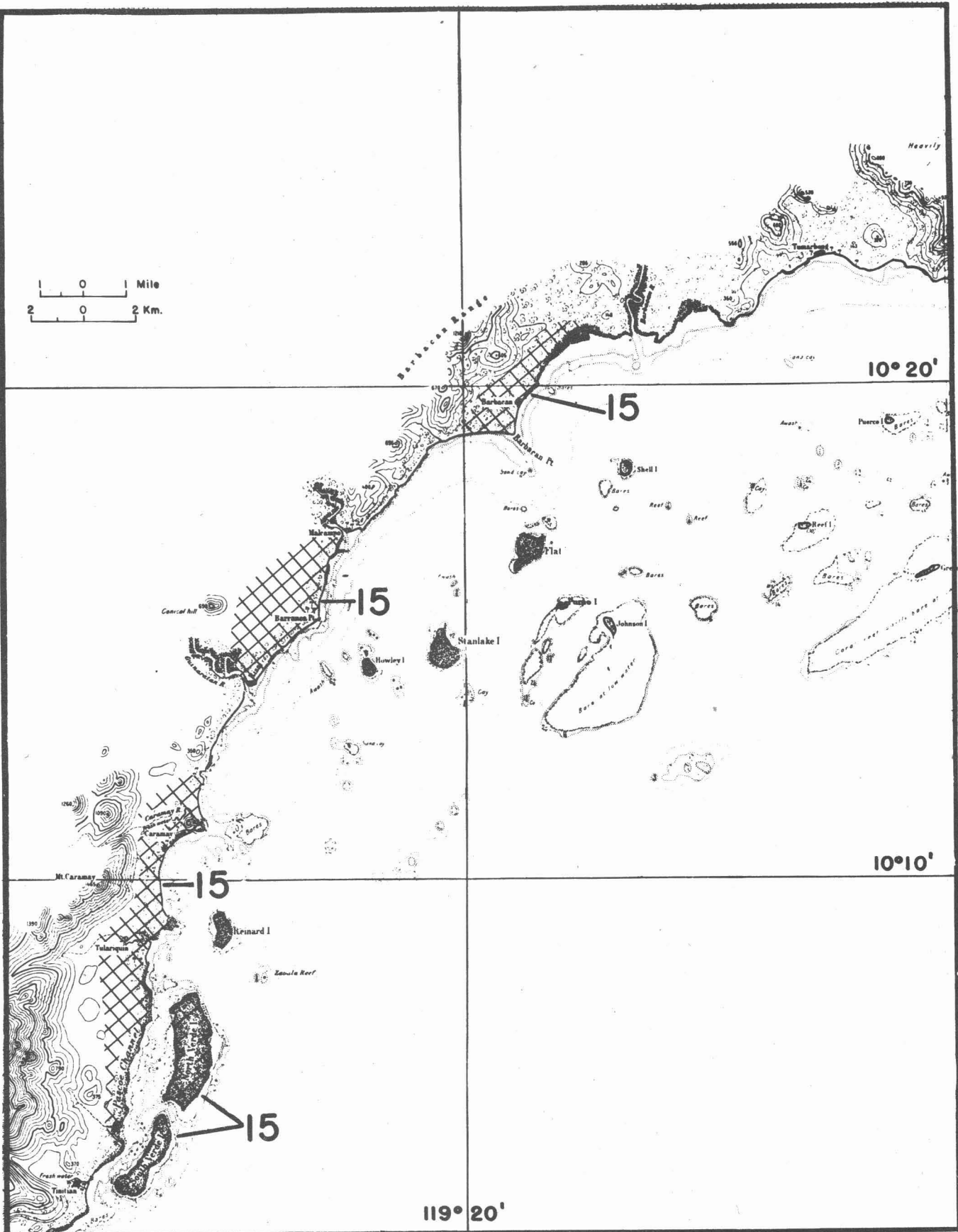
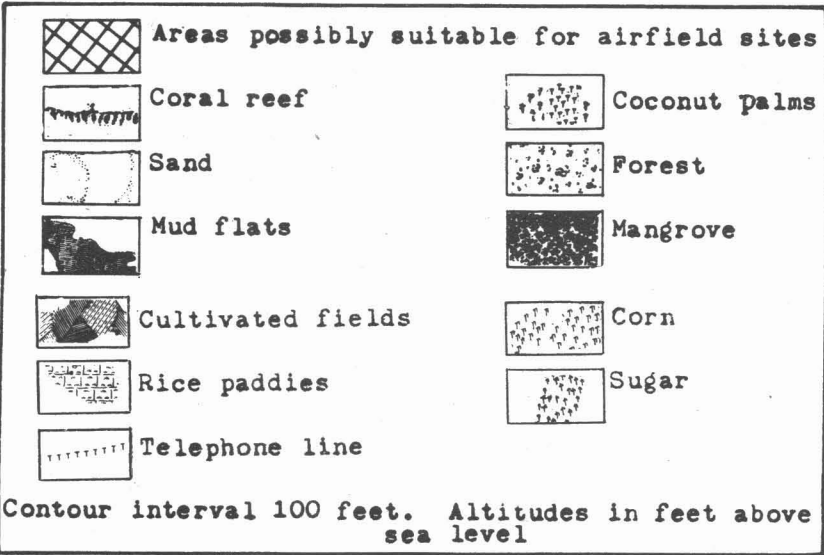
Grading, Dispersal Areas, Hard Standings: Coastal area generally level with some low, gently rounded elevations near inner margin; possibly upraised coral reefs. Ordinary graders and dozers adequate for levelling of runways. Ample room for dispersal areas and hard standings.

Foundation, Drainage: Soil at higher elevations is friable clay loam and sandy clay loam with good bearing strength and drainage; at lower elevation is plastic clay with moderate to poor bearing strength; water table high, drainage poor. Generally runways will require stabilized base course and subdrains. If runways are paved, side drainage channels along runway will be necessary to remove surface runoff.

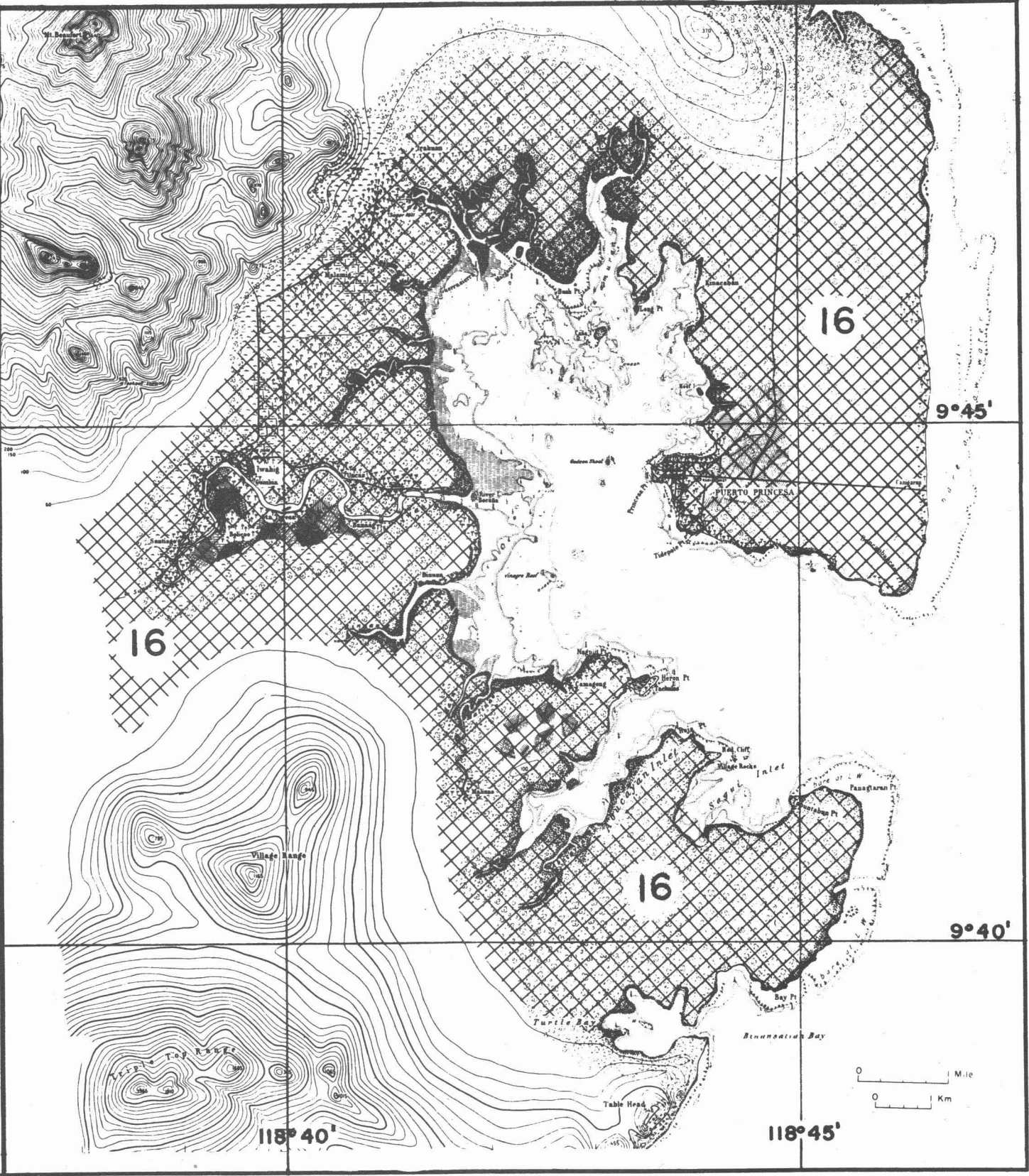
Clearing, Grubbing: Area generally cleared of dense forest cover and cultivated or planted to coconut groves which can be easily cleared with dozers. Small remnants of dense primary forest will require use of power equipment for clearing.

Construction Materials Available: Soft dark-green rock and dark granitic rock underlie adjacent hills. Only granitic rock suitable for heavy construction; for quarrying will require use of power tools and blasting. Abundant sand, in part limy, and gravel available in stream channels and along beaches. Best construction material is coral-reef rock; available in reefs fringing shore, bare at low tide.

Water Supply: Surface supplies from streams more suitable than ground water from driven wells.



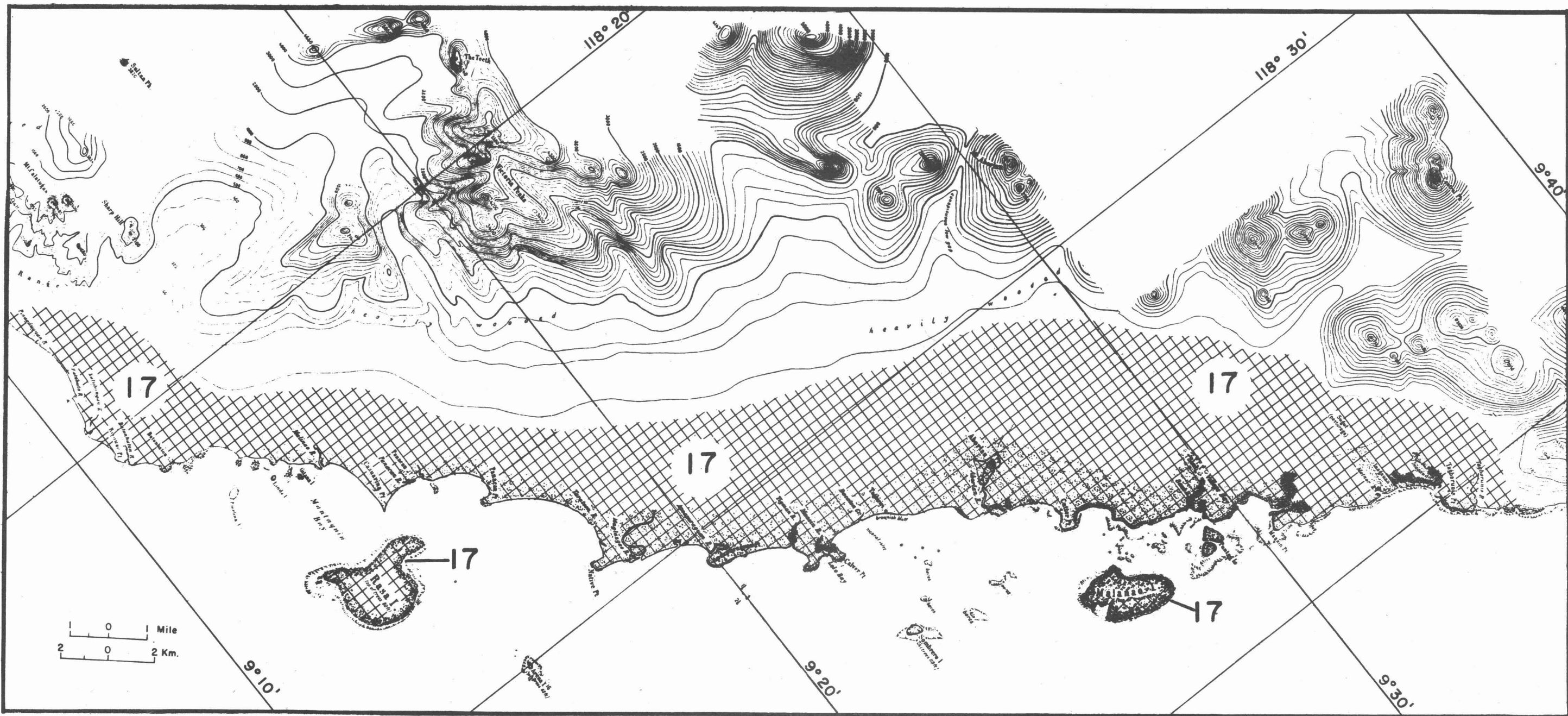
Source: U. S. C. and G. S. no. 4319



Source: U. S. C. and G. S. no. 4343

(continued)

Reliability rating: Class D



Source: U. S. C. and G. S. nos. 4321 and 4323

17. ABORLAN AREA

Location, Suitability, Accessibility: Coastal lowland in southeastern Palawan, rises gently from shore to mountains of interior. Generally suitable for runways parallel to shore. Length of area about 35 miles, maximum width about 4 miles. Rasa and Malanac Islands possibly suitable for emergency flight strips (see North and South Verde Islands, Area 15). Area easily accessible along sandy coast, in part fringed with coral reefs, in part bordered by narrow mangrove swamps. Road, probably all-weather, extends from Puerto Princesa south to Aborlan, may continue to south as dry-weather coastal road or trail. No known cross-island trails. Details of terrain not known.

Grading, Dispersal Areas, Hard Standings: Runways of any length oriented parallel to shore will require minimum grading with ordinary graders or dozers. Probably all grading will be in unconsolidated sand and gravel; no blasting required. Ample room for dispersal areas and hard standings which can be concealed in dense vegetation.

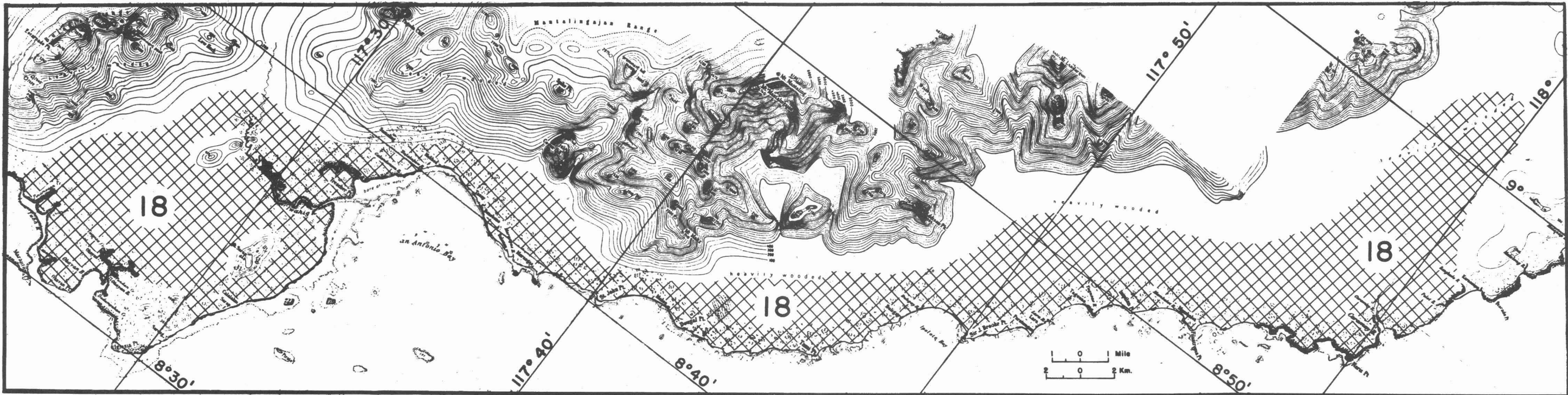
Foundation, Drainage: Sandy clay soil with good bearing strength and drainage will

provide good foundation. Soil may be readily stabilized mechanically. Soil not muddy after rains unless soil structure is destroyed by working when wet. Water table relatively low away from shore. Subdrains may not be necessary, but side collection channels along runway desirable for removal of runoff if surface is paved.

Clearing, Grubbing: Parts of area cleared for cultivation; elsewhere area covered by dense forests difficult to clear. Extensive use of power tools may be necessary.

Construction Materials Available: Lowland underlain by sand and gravel; some coral reefs fringe shore. Adjacent mountains probably underlain by granite. Quarrying of granite will require power tools and blasting; will furnish good construction material. Coral reef rock will supply best construction material for surfacing of runways; can be obtained along shore at low tide. No upraised coral reefs reported in this area.

Water Supply: Surface supplies from small streams draining adjacent mountains may be limited. Shallow wells in sand and gravel will provide good supply, but wells near shore should not be overpumped because of danger of salt water encroachment.



Source: U. S. C. and G. S. nos. 4323 and 4325

18. SAN ANTONIO BAY

Location, Suitability, Accessibility: Southeastern coast of Palawan Island has narrow coastal lowland possibly suitable for runways. Length about 55 miles, from Tuba River on S to Pescado Point on N (lat 8°30' to 8°57' N); average width about 3 miles. Accessible only from sea along sandy shore, in part fringed by mangrove. No roads or trails reported.

Grading, Dispersal Areas, Hard Standings: Details of terrain not known, but level runways parallel to shore will probably require minimum grading with dozers and graders. Runways may be any length; generally will have approach glide angles less than 1/20. Ample room for dispersal areas and hard standings which can be concealed in dense forests.

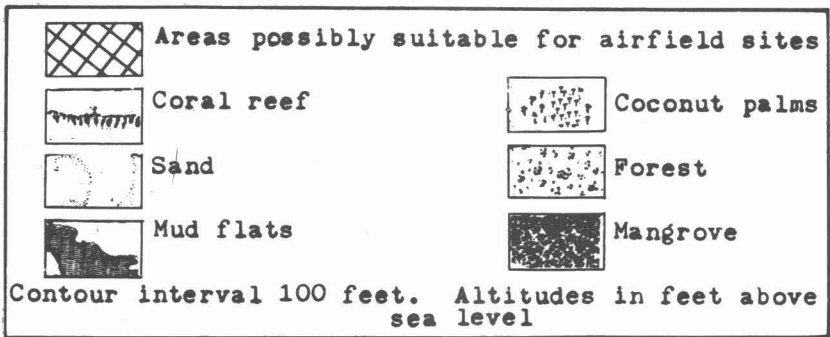
Foundation, Drainage: Soil is clay loam, probably friable and well drained at inner margin of lowland, plastic and possibly waterlogged near shore and along stream channels. Friable soil has good bearing strength, plastic has poor. Gravel and sand interbedded with soil and underlying coral-reef rock. Where developed on reef rock, soil may be relatively shallow but provides good foundation. With proper mixing of coarse fractions, soil may be readily stabilized mechanically. In part soils may be sandy (limy) and suitable for stabilization, elsewhere may require drainage and addition of coarse fractions. Water table at moderate depth at inner margin of

plain, at or near surface in coastal areas. Drainage ditches and subdrains reduce water table. Raised subgrades may be necessary in low coastal areas.

Clearing, Grubbing: Power tools and heavy equipment required for clearing dense primary forest. Large stumps will need blasting. Small cultivated areas may be cleared by dozers. Coconut plantations can be cleared by dozers.

Construction Materials Available: Limestone mountains along margin of coastal lowland will furnish good construction material, but will require quarrying with power tools and blasting. Coral-reef rock underlying plain is excellent construction material; may be quarried in part with hand tools. Sand, in part limy, and gravel abundantly exposed in stream channels and on beaches. Coral-reef rock exposed at low tide in south part of area. Abundant supplies of construction timber locally available.

Water Supply: Small surface supplies from streams draining mountain areas. Shallow wells in coastal lowland will provide supplies of fresh water, but care should be taken to avoid overpumping because of danger of salt water encroachment.



Reliability rating: Class D

19. CAPE BULILUYAN

Location, Suitability, Accessibility: South tip of Palawan Island is low plain suitable for airfield sites. Area approximately 4 by 5 miles; lat 8°21' N, long 117°11' E. Accessible from sea; east coast fringed by mangrove swamps, west coast by coral reef which is bare at low water. A single trail extends from Buliluyan at south to Malatub on north, following higher ground in southern part and swinging toward east coast in north. Details of terrain not known.

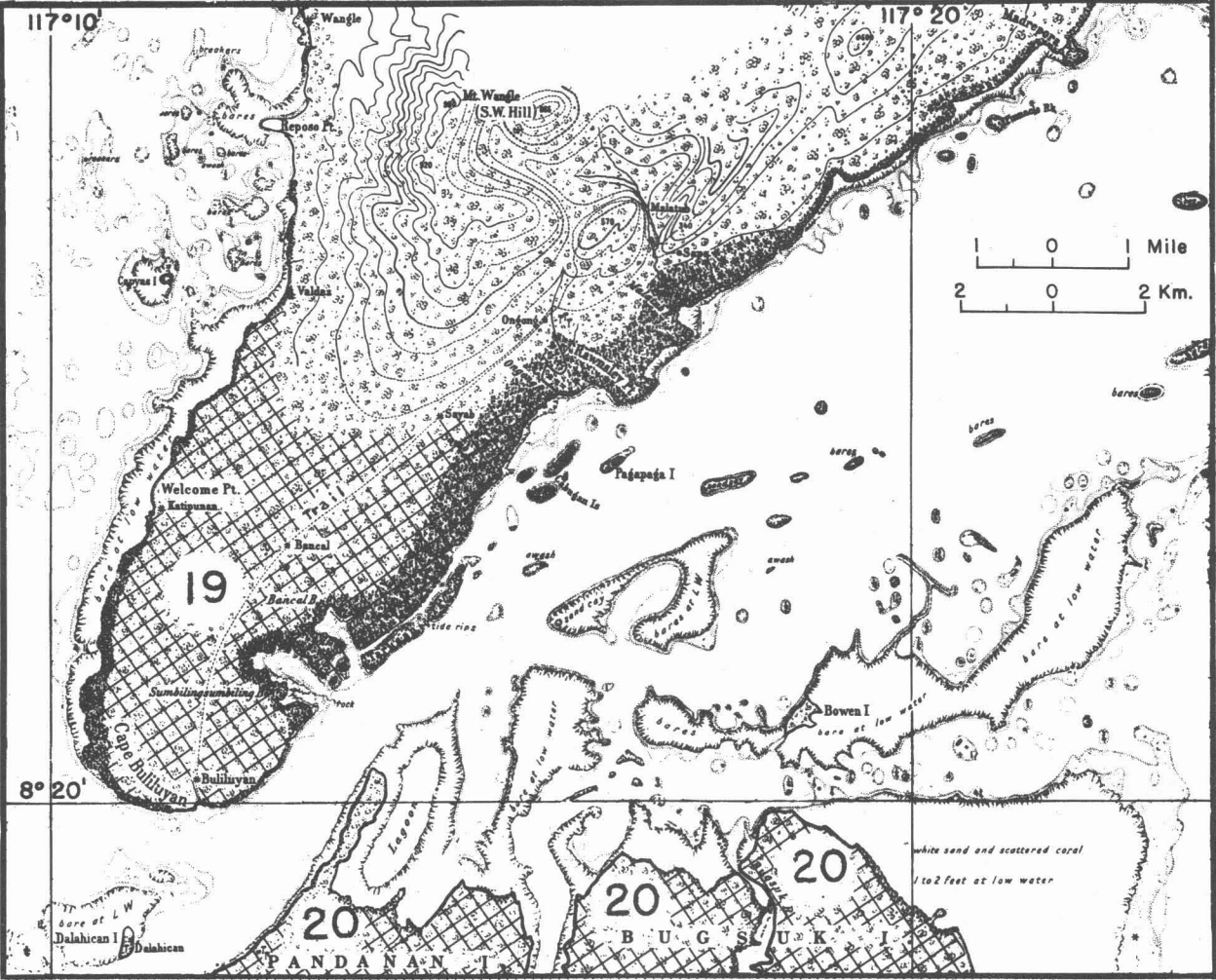
Grading, Dispersal Areas, Hard Standings: Area largely flat but may be a series of low step-like terraces marking upraised coral reefs. Runways may be oriented in all directions with little grading. Ordinary graders and dozers necessary; some blasting probably required. Ample room for dispersal areas and hard standings which may be concealed in dense forest.

Foundation, Drainage: Soil generally friable clay loam in highest parts; good bearing strength, drains readily but may become plastic mud if worked when wet. Low coastal areas and mangrove swamps are generally plastic mud with poor bearing strength and drainage. Water table at or near surface in coastal areas, at moderate depth in higher areas. Where drainage is good, soil may be mechanically stabilized with addition of coarse fractions. Drainage ditches and subdrains will reduce water table; side collection channels along runway necessary for removal of surface runoff when runways are paved.

Clearing and Grubbing: Power tools and heavy equipment required to clear dense primary forest. Small scattered cultivated areas and second-growth forest may be cleared by dozers. Removal of buttressed stumps will necessitate use of blasting and grubbing with power tools.

Construction Materials Available: Sand (limy) and gravel locally available in small stream channels and on beaches. Coral-reef rock underlying plain and exposed at low tide along west coast is excellent construction material. May in large part be worked with hand tools and blasting. Hills to north underlain by granite and limestone; power tools required for quarrying. Abundant supplies of timber suitable for heavy construction available locally.

Water Supply: Surface supplies of fresh water limited. Shallow wells and open pits will supply abundant fresh water. Near shore wells should not be overpumped because of danger of encroachment by salt water.



20. BUGSUK, PANDANAN, BANCALAN, AND MANTANGULE ISLANDS

Location, Suitability, Accessibility: Four small islands ranging in size from 2 by 3 1/2 miles to 5 by 10 miles, off south tip of Palawan Island. Believed suitable for landing fields accommodating largest aircraft. Accessible only from sea; islands in large part surrounded by broad fringing coral reefs which are bare at low tide; elsewhere sandy beaches. Mangrove swamps sparse, except on Bugsuk.

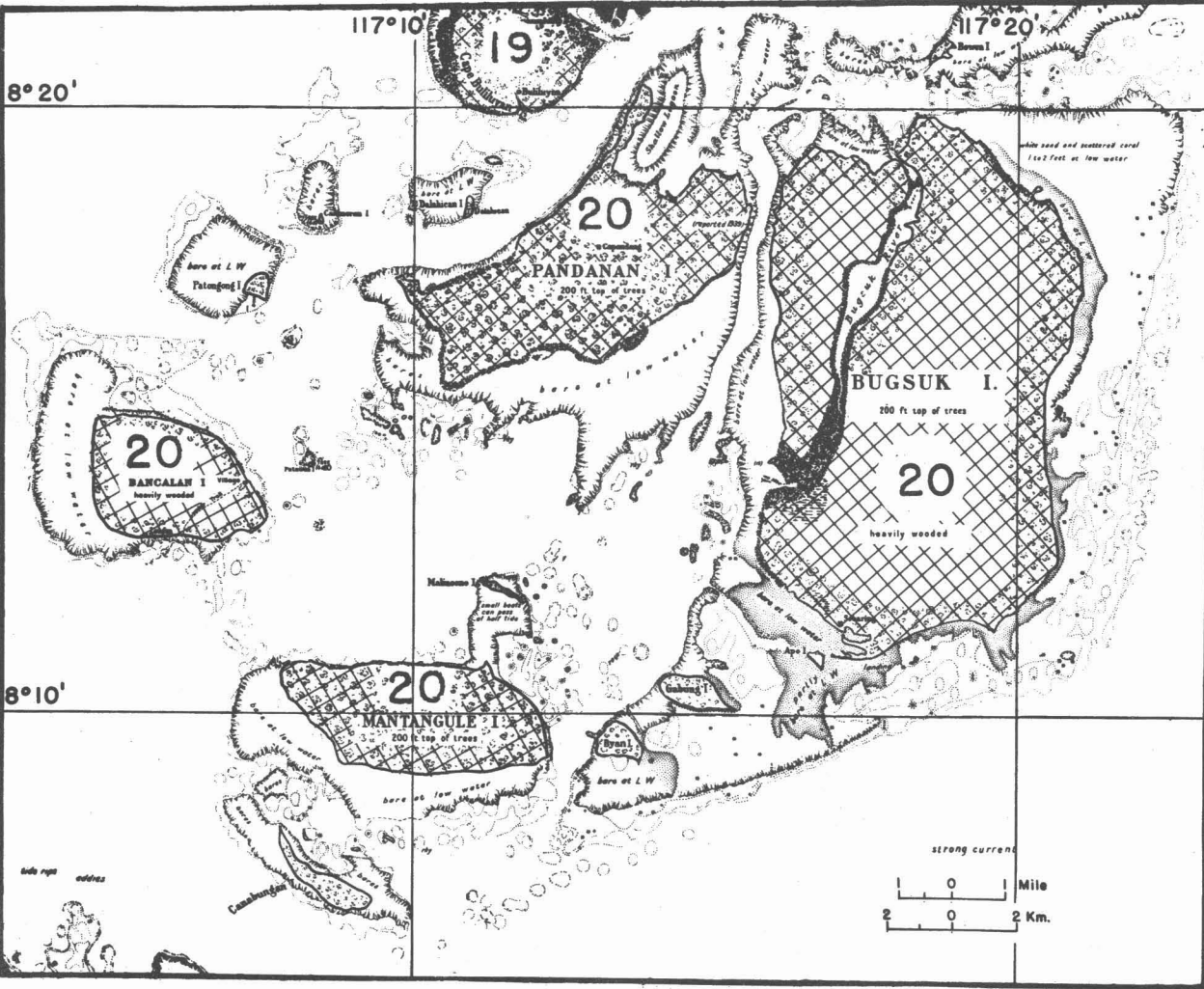
Grading, Dispersal Areas, Hard Standings: Character of island terrain not known but highest tree tops are only 200 feet above sea level; possibly some small step-like terraces between level areas. Bedrock believed to be upraised coral reef. Generally graders and dozers can prepare level runways; some blasting may be necessary. Ample room for extensive dispersal areas and hard standings which can be concealed in dense forest growth.

Foundation, Drainage: Generally similar to conditions on Cape Buliluyan (Area 19). In swampy coastal areas raised subgrades are necessary. Soil can probably be stabilized readily, has good bearing strength, and drains readily in higher parts.

Clearing, Grubbing: Islands are all heavily forested with primary growth. Clearing will require use of heavy power tools, grubbing and blasting of stumps. Secondary growth and small cultivated areas can be cleared with dozers.

Construction Materials Available: Coral-reef rock believed to underlie thin island soils; can probably be quarried with hand tools. Large areas of reef rock available along coasts at low tide. Sand and gravel (limy) readily available along beaches. Ample supplies of timber for construction available on all islands.

Water Supply: Surface water limited or lacking. Shallow wells near center of islands will provide greatest supply. Near coast wells should not be overpumped because of danger of encroachment of salt water. Auxiliary supplies from rain water.



21. BALABAC AND RAMOS ISLANDS

Location, Suitability, Accessibility: Two large islands lying off south tip of Palawan having coastal-lowland areas suitable for airfield sites. Details of terrain not known, but most runways must be oriented parallel to shore except on Ramos Island where they may have almost any orientation. Islands accessible from sea; coast generally fringed with wide coral reefs and partly lined with mangrove swamps. A single trail is reported to cross Balabac Island from Catagupan Bay on west to Balabac on east coast. Island in part heavily forested and rugged, interior relatively unknown.

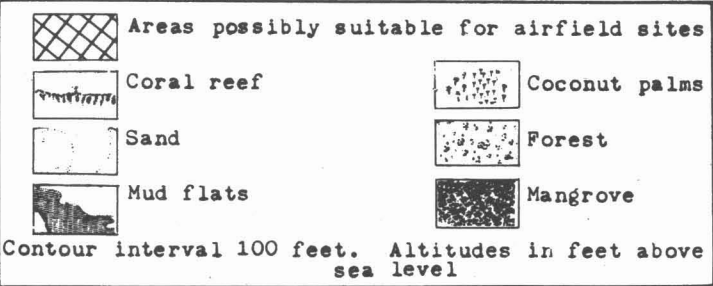
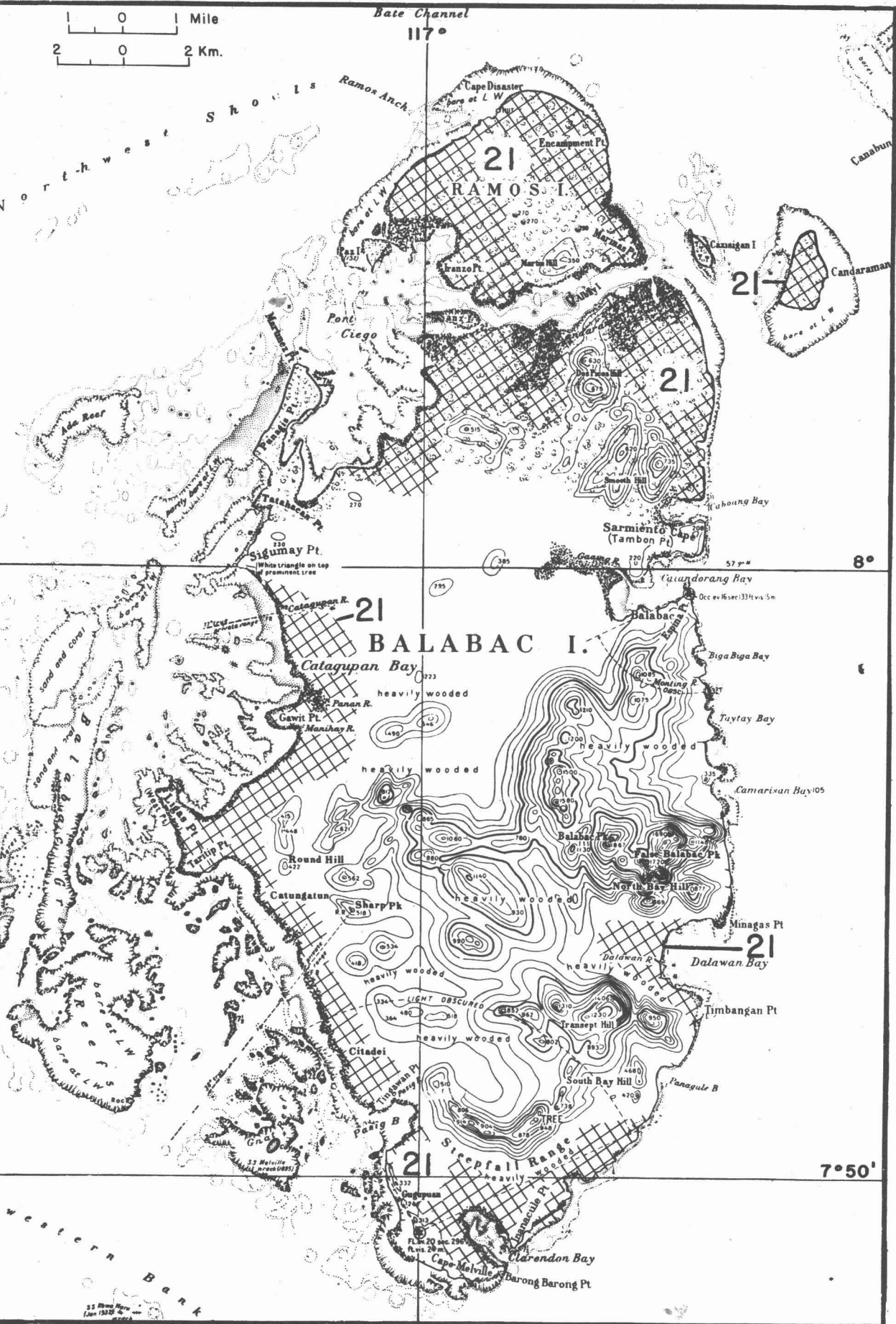
Grading, Dispersal Areas, Hard Standings: Coastal lowlands, probably underlain by raised reef rock, believed to be relatively level so that runways may be constructed with ordinary graders and dozers. Conditions generally similar to those on Bugsuk and adjacent islands (Area 20) and Cape Buliluyan (Area 19). Room for dispersal areas and hard standings limited on Balabac but not on Ramos; can be concealed in dense forest.

Foundation, Drainage: Generally similar to conditions on Bugsuk and adjacent islands (Area 20) and Cape Buliluyan (Area 19).

Clearing, Grubbing: Similar to Areas 19 and 20.

Construction Materials Available: Bedrock of Balabac and Ramos Islands not known except for brownish clayey sandstone in vicinity of Balabac Village. Some igneous rock reported, but character and distribution not known. Coastal lowlands believed underlain by raised reef limestone which is excellent construction material for runways. Reef rock available along shore at low tide. Abundant sand and gravel available along beaches and in small stream valleys. Sandstone may be good construction material; will require quarrying, possibly use of power tools. Abundant timber available for construction.

Water Supply: Small streams will provide limited supplies of surface water. Shallow wells in coastal lowlands will supply fresh water but must not be overpumped because of danger of salt water encroachment. Auxiliary supplies of rain water may be desirable.

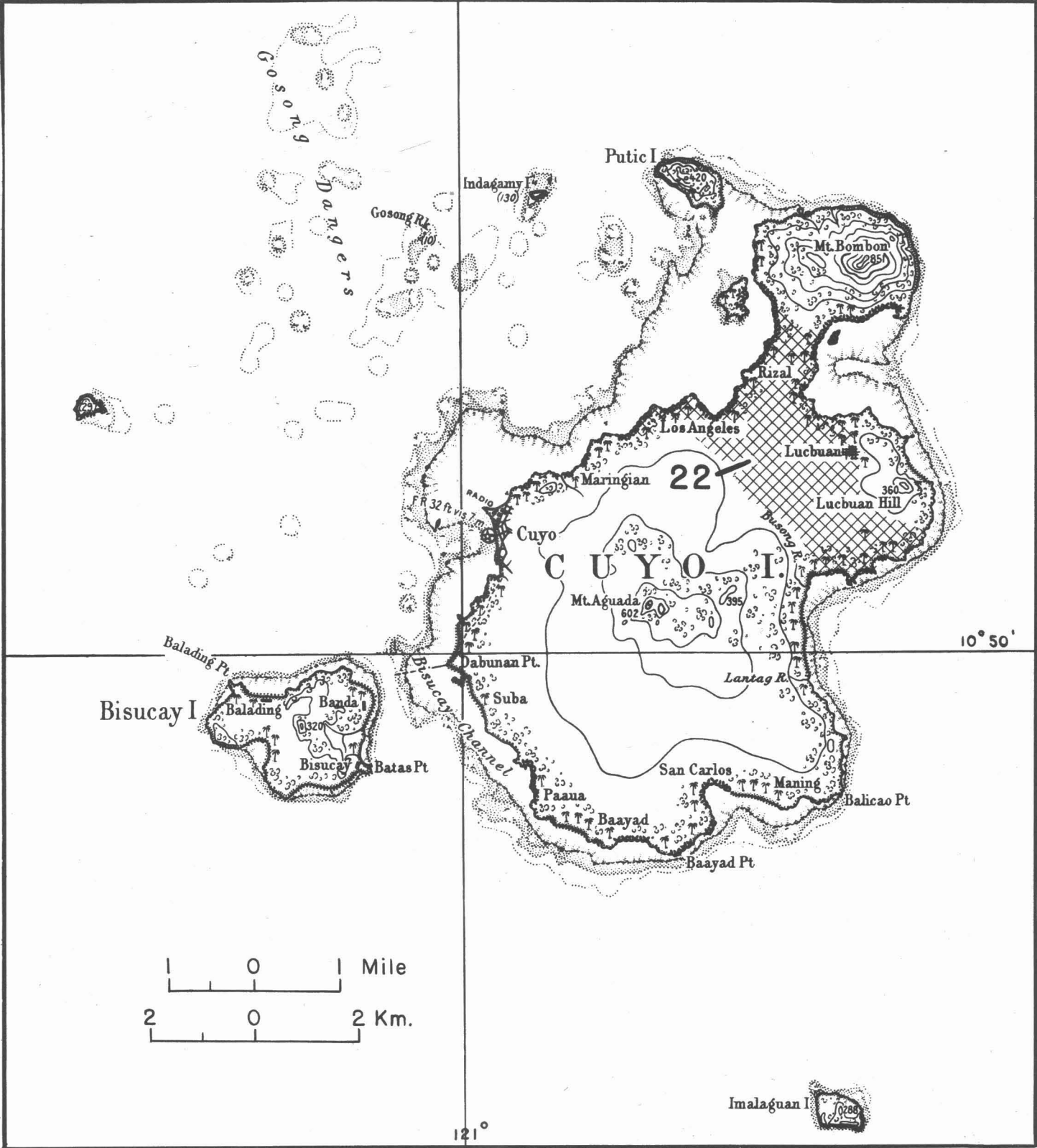


Source: U. S. C. and G. S. no. 4326

(continued)

AIRFIELD CONSTRUCTIONPALAWAN PROVINCE (P. I.)

Reliability rating: Class D



Source U. S. C. and G. S. no. 4312

22. CUYO ISLAND

Location, Suitability, Accessibility: Small volcanic island east of northern Palawan Island having small lowland probably suitable for small airfield; lat 10°51' N, long 121°02' E. Detailed character of terrain not known. Area accessible from sea across coral reefs which are most extensive on west where there is also a narrow zone of coastal mangrove swamp. Poor roads connect settlements with Cuyo, largest village on island. Roads muddy, may be almost impassable in wet weather.

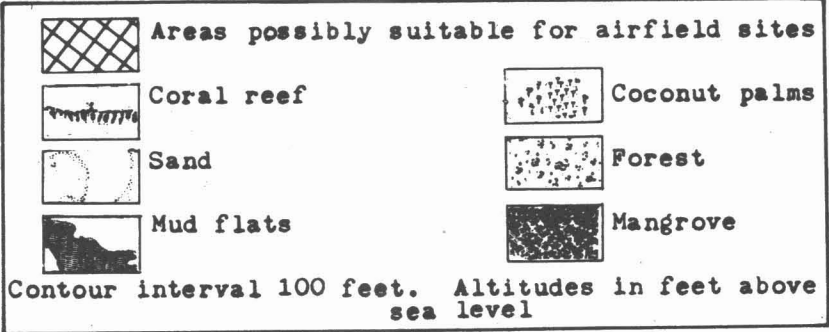
Grading, Dispersal Areas, Hard Standings: Lowland may consist of series of low step-like terraces or relatively flat plain. Runway with NW orientation and length of 8,000 feet can probably be built with limited grading by ordinary graders and dozers. Blasting may not be necessary. Limited room for dispersal areas and hard standings; may be concealed in forest vegetation.

Foundation, Drainage: Area may be underlain by upraised coral-reef rock. Soil probably thin, gravelly clay loam; bearing strength good, drainage good in higher parts, may be poor in low coastal areas. Water table at or near surface along shore; moderately low near marginal hills. Soil may be suitable for mechanical stabilization. Raised subgrades probably not necessary; subdrains and side collection channels along runways desirable for removal of surface run-off and lowering of water table.

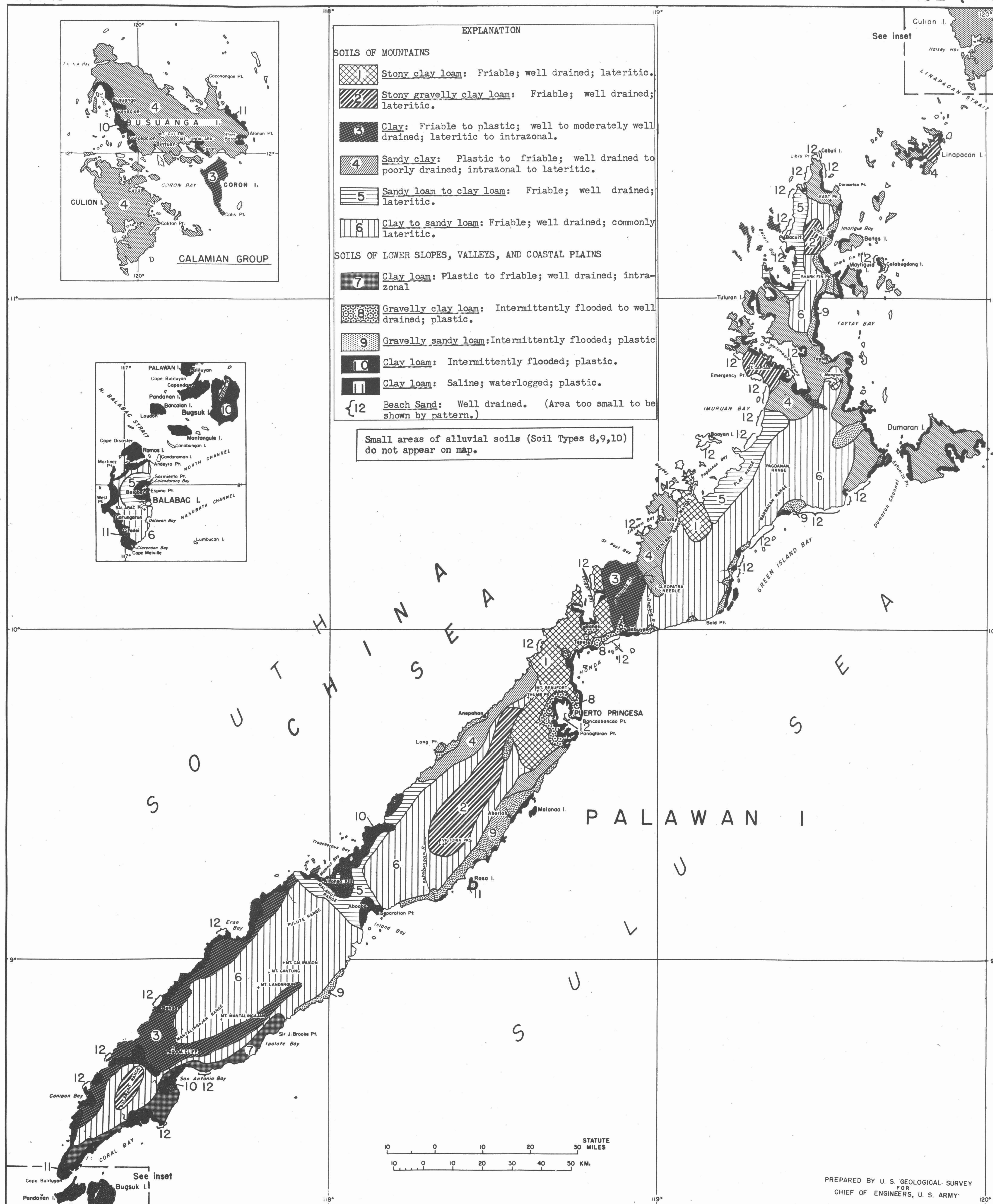
Clearing, Grubbing: Major part of area probably cultivated; will require little clearing. Coconut palms can be removed by dozers; larger forest trees will require power tools and blasting.

Construction Material Available: Bedrock of hills adjacent to site reported to be volcanic; probably basalt. Basalt where unweathered is good construction material; will require blasting and power tools for quarrying. Lowland may be underlain by coral-reef rock; excellent construction material for airfields. Reef rock may be in part quarried with hand tools. Reef rock obtainable at low tide from reefs fringing shore. Probably little sand or gravel except limy shell sand on beaches. Abundant timber for heavy construction on hill slopes.

Water Supply: Surface supply limited. Shallow wells in lowland will provide moderate supplies; auxiliary supplies can be obtained from rain water. Wells near shore should not be overpumped because of danger of salt water encroachment.



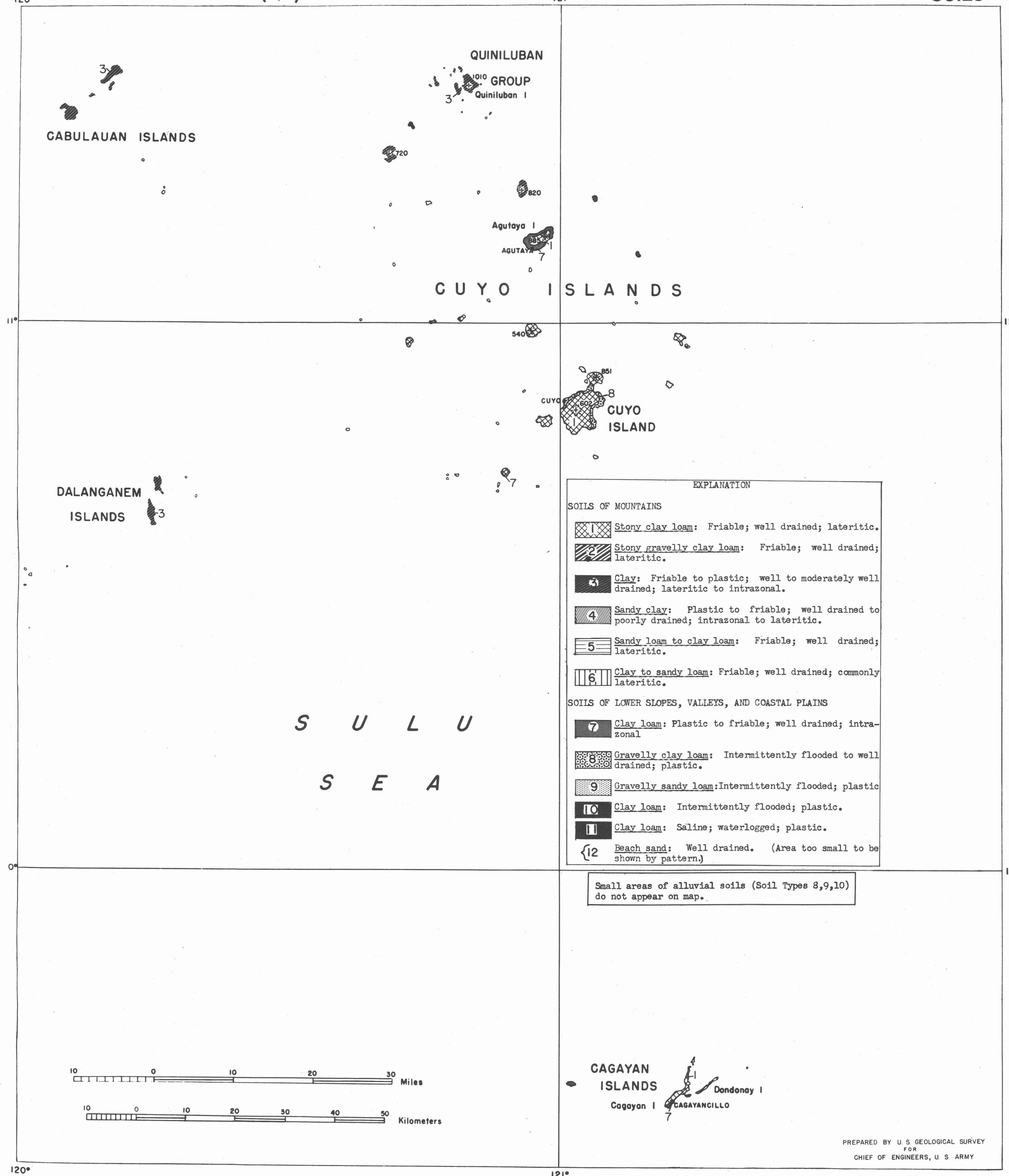
Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army



120° PALAWAN PROVINCE (P.I.)

121°

SOILS



PALAWAN PROVINCE (P. I.)

SOILS: ENGINEERING PROPERTIES

PALAWAN PROVINCE (P. I.)												
Reliability ratings: Class D												
INTRODUCTION												
See also Introduction to Soils: Basic Data												
The tabular summary given below is an interpretation of basic properties of soils of Palawan. This interpretation, as well as nomenclature employed in it, follows usage of War Department Technical Manual 5-255, with a few modifications. Allowances have been made, however, for certain trends in texture-moisture and other relationships which, in the humid tropics, are not quite the same as they are elsewhere. Properties before Construction Treatment Cohesion in dry state depends chiefly on proportion, kind, and binding properties of fines. Foundation value is inferred chiefly from engineering group in which soil is classified.			Expansion and shrinkage depend chiefly on proportion, kind, and properties of the fines. Permeability, capacity of soil to permit passage of water when drainage is not impeded by external conditions, depends on texture and structure of soil and also on kind of fines present. Original field dry weight, dry weight of solids per unit volume of undisturbed soil, is determined largely by soil texture and structure. Coarse-textured sands weigh much more per unit volume than fine-textured clays; highly plastic structureless clays weigh more than granular clays. Void ratio, ratio of volume occupied by air and water to volume occupied by solids, per unit volume of undisturbed soil, is estimated from field dry weight of the soil. Void ratio = $(1-V)/V$, where V is volume of solid substance per unit volume of undisturbed soil. Percent pore space or porosity is proportion of volume of undisturbed soil occupied by voids. Percent pore space = $(1-V) \times 100$, where V is volume of solid substance per unit volume of undisturbed soil. From percent pore space, percent volume occupied by solid substance can be easily calculated. For example, if percent pore space is 55, percent volume occupied by solid substance is 45 (100 minus 55). Moisture retention after free drainage, expressed as percentage on dry weight basis, depends chiefly on soil texture and on amount of organic matter present. Sands, free from fines, retain roughly 5% moisture; silts retain			roughly 25%, and soils composed wholly of clays, roughly 60%. Moisture retained is also expressed as inches of water per foot of soil. The latter relationship is expressed on volume basis rather than percentage basis. The moisture retention data may enable the engineer to estimate: (1) Amount of water retained by a well-drained soil within a few days after rain that has wetted soil to a considerable depth. (2) Moisture content below which the well-drained soil cannot be wetted uniformly by a mere addition of water to the surface of the mass of soil. (Example): A given level mass of uniform soil is capable of retaining, after drainage,			3 inches of water per foot. It is desired to wet 4 feet of this soil uniformly so that every foot would contain 3 inches of water. $3 \times 4 = 12$; hence 12 inches of water must be applied to the dry soil in order to obtain desired result. If, instead of 12, only 6 inches of water is applied, entire depth of dry soil will not be wetted uniformly to 1.5 inches per foot; instead, upper 2 feet would be wetted to the extent of 3 inches of water per foot of soil and the lower 2 feet would remain unwetted. (3) Moisture content of air-dry soil; this estimated value falls commonly between 1/4 and 1/5 of the moisture-retention percentage; it is lower for coarse materials, and somewhat higher for some ferruginous clays. Estimated Properties Dependent on Construction Treatment Dry weight, moisture percentage at optimum compaction, and bearing ratio percentage (bearing ratio of crushed rock is 100) are taken from War Department Technical Manual 5-255. Moisture content at optimum compaction can also be expressed as inches of water per foot of soil. Void ratio, and percent pore space, calculated as above, refer here to optimum compaction conditions. Important: All estimates in this table are based upon fine earth consisting of particles not larger than 0.08 inch in diameter. The estimates for soils described as gravelly or stony are too low in reference to their original field dry weight, dry weight after compaction, and bearing ratio. The estimates are too high in reference to their original void ratio, moisture retention, and bearing ratio. Deviations from estimated values are roughly proportional to amounts of gravel and stone contained by the soil.			
EXPLANATION OF PATTERNS USED IN SOIL DIAGRAMS												
Soil Type (Map Unit No.)	1. Stony clay loam; lateritic; friable; well drained	2. Stony gravelly clay loam; lateritic; friable; well drained	3. Clay; lateritic to intrazonal; friable to plastic; well to moderately well drained	4. Sandy clay; plastic to friable; intrazonal to lateritic; well drained to poorly drained	5. Sandy loam to clay loam; lateritic; friable; well drained	6. Clay to sandy loam; commonly lateritic; friable; well drained	7. Clay loam; intrazonal; plastic to friable; well drained	8. Gravelly clay loam; plastic; intermittently flooded to well drained	9. Gravelly sandy loam; plastic; intermittently flooded	10. Clay loam; plastic; intermittently flooded	11. Clay loam; plastic; saline; waterlogged	12. Beach sand; well drained
Soil Profile												
Depth, in feet	0 to (0.5-6)' and below	0 to (0.5-3)' and below	0 to (0.3-2)'	0 to (0.3-3)'	0 to (3-6)' and below	0 to (0.3-6)' and below	0 to (0.5-2.5)'	0 to (4-6)'	0 to (1-3)' and below	0 to (3-6)' and below	0 to (3-6)'	0 to (3-6)' and below
Engineering Name	Stony lean inorganic clay of low plasticity	Stony gravelly lean inorganic clay of low to medium plasticity	Lean inorganic clay of medium plasticity	Lean inorganic clay of medium plasticity	Sand-gravel-clay mixtures and lean inorganic clay of medium plasticity	Lean inorganic clays of low to medium plasticity and sand-gravel-clay mixtures	Lean inorganic clays of low to medium plasticity	Gravelly lean inorganic clay of medium to low plasticity	Sand-gravel-clay mixtures of variable plasticity	Lean inorganic clay of medium plasticity	Inorganic clay of medium to high plasticity	Sands
Engineering Group Symbol and P.R.A. Class ^{a/}	ML, CL (stony); A-4, A-6 (stony)	CL, ML (stony, gravelly); A-6, A-7, A-4 (stony, gravelly)	CL; A-6	CL, SF; A-6, A-7, A-2	SF, SC, CL, ML; A-2, A-6, A-4, A-3, A-2, A-1	CL, ML, SF, SC (may be stony); A-7, A-6, A-4, A-3, A-2, A-1 (may be stony)	CL, ML; A-6, A-7, A-4	ML, CL (gravelly); A-4, A-6 (gravelly)	SF, GF, GC, SC, ML; A-2, A-1, A-4	CL, ML; A-4, A-6, A-7	ML, CL; A-6, A-7	SF, GF, SC; A-3
Properties before Construction Treatment	Cohesion in Dry State	Medium to low	Medium	Medium to high	Medium to high	Medium to high	High to low	Medium	Fair to poor	Fair to good	Poor to fair	Fair
	Foundation Value	Fair to good	Fair	Poor	Poor	Poor	Poor to good	Fair	Fair to poor	Fair to good	Poor to fair	Fair
	Expansion and Shrinkage	Medium to low	Medium	Medium	Medium to high	Medium to low	Low to high	Medium	Medium	Medium to low	Low	High
	Permeability	High	Medium to high	Medium to low	Low to medium	High to medium	Medium	Medium	Medium	Medium to low	Low	High
	Original Field Dry Weight, lbs./ft. ³	70-90	75-90	65-90	75-90	65-110	65-85	75-95	85-110	75-90	b/	85-110
	Original Void Ratio	1.4-0.85	1.2-0.85	1.4-0.85	1.2-0.85	1.5-0.50	1.5-0.95	1.2-0.75	0.95-0.50	1.4-1.2	b/	0.95-0.45
	Original Percent Pore Space	58-46	55-46	58-46	55-39	60-33	55-43	49-33	49-33	59-54	b/	49-31
Properties upon Construction at Optimum Compaction	Moisture Retention after Free Drainage at Original Field Dry Weight	35-20 5.5-2.8 ins./ft.	35-25 5.5-3.6 ins./ft.	35-25 6.0-3.6 ins./ft.	35-25 5.2-2.8 ins./ft.	40-12 6.4-2.0 ins./ft.	30-20 4.9-2.5 ins./ft.	38-25 6.4-3.6 ins./ft.	20-12 4.2-2.0 ins./ft.	40-25 6.4-3.6 ins./ft.	b/	1.0-0.6 110-130 ins./ft.
	Dry Weight, lbs./ft.	100-125 and higher	100-125	100-120	100-120	0.7-0.4	0.7-0.3	0.7-0.4	0.5-0.3	0.7-0.5	b/	0.5-0.3
	Void Ratio	0.7-0.3 and lower	0.7-0.3	0.7-0.4	0.7-0.4	0.7-0.3	0.7-0.3	0.7-0.3	0.7-0.3	0.7-0.3	b/	0.7-0.3
	Percent Pore Space	43-23 and lower	43-23	43-28	43-28	43-23	43-23	43-28	43-23	43-23	b/	33-23
	Moisture Content, %	20-11 and lower	22-11	22-15	22-13	22-13	22-9	22-15	22-13	22-15	b/	17-9
	Moisture Content, ins./ft.	4.0-2.1 and lower	4.2-2.1	4.2-2.7	4.2-2.5	4.2-1.8	4.2-2.5	4.2-2.5	4.2-2.5	4.2-2.7	b/	3.5-2.0
	Bearing Ratio	4-25	4-20	4-15	4-15	4-15	4-15	4-15	4-15	4-15	b/	15-30
Suitability for Construction												
Kind of Aggregate and Binder: Generally low in aggregate. Rock fragments may be found in shallower soils. Binder is ferruginous clay of low plasticity. Mechanical Stabilization: May be compacted by rolling in layers of moderate thickness. Careful moisture control is essential. Additions of sand and gravel to the surface are probably required to assure stability under heavy traffic. Suitability for Subgrade or Base Course: If properly compacted and well drained would make a fair subgrade or base course. Should have a surface layer of sand and gravel added for best results. Suitability for Stabilization with Portland Cement or Bitumen: Too high in clay to be stabilized with cement. May be fairly well suited for bitumen, in places.												
Kind of Aggregate and Binder: Aggregate may be of good quality but in insufficient amount except in places where it has become concentrated through erosion of the finer material. Binder is commonly of fair to good quality and in adequate amounts. Mechanical Stabilization: May be less easy to stabilize than Soil Type 1. Sheepfoot or smooth-faced rollers may give best results. Close moisture control is essential. Additions of sand may be required. Suitability for Subgrade or Base Course: If properly compacted and well drained, would make a fair subgrade or base course but probably inferior to Soil Type 1. Suitability for Stabilization with Portland Cement or Bitumen: May be suited for either in places where erosion has reduced the proportion of the fine-textured materials.												
Kind of Aggregate and Binder: Aggregate is commonly not found in sufficient amounts but can be easily obtained by crushing limestone bedrock. Binder is limestone clay. Mechanical Stabilization: Addition of large amounts of aggregate may be necessary for best results. Careful moisture control at compaction is most essential. Unless mixed with sufficient aggregate of good quality, will lack stability under traffic in wet weather. Suitability for Subgrade or Base Course: Not well suited for either, unless properly mixed with additional aggregate and binder. Suitability for Stabilization with Portland Cement or Bitumen: Not suitable.												
Kind of Aggregate and Binder: Aggregate is chiefly quartz sand, probably present in insufficient amounts except where the finer material was removed through erosion. Binder is a lean clay, commonly of medium plasticity. Mechanical Stabilization: May be difficult to stabilize. Careful moisture control at compaction is most essential. Unless mixed with sufficient aggregate of good quality, will lack stability under traffic in wet weather. Suitability for Subgrade or Base Course: Not well suited for either, unless properly mixed with additional aggregate and binder. Suitability for Stabilization with Portland Cement or Bitumen: Too high in clay to be stabilized with cement and probably unsuited for bitumen.												
Kind of Aggregate and Binder: Aggregate may be lacking where shale is the predominant parent rock. Elsewhere the aggregate is chiefly coarse and medium sand with very little gravel. Binder is commonly abundant; may be of fair to inferior quality. Mechanical Stabilization: Addition of aggregate probably required. Fairly close moisture control is necessary during compaction. Smooth-faced rollers may give best results on the clay loam. Suitability for Subgrade or Base Course: Sandy soils within this type would make fair subgrade or base course if well drained. Finer-textured soils need a layer of sand and gravel at surface for best results. Suitability for Stabilization with Portland Cement or Bitumen: May be suited for bitumen but not for cement mixtures; sandy loams may be suited for either.												
Engineering properties of this most inclusive soil type are similar to those of Soil Types 1, 2, 3, 4, 5, and 7. Appraisal not feasible as this soil type includes, of necessity, a wide variety of properties.												
Kind of Aggregate and Binder: Aggregate consists of small amounts of coral sand. The parent coral rock, a few feet below the soil surface, may be crushed and used as aggregate. Binder is coral-limestone clay. Mechanical Stabilization: Underlying coral rock, applied as excavated, without screening, and rolled into the surface, makes good surface course although dusty when dry. Further addition of fines is probably unnecessary. Fill required in many places and is desirable at all times. Suitability for Subgrade or Base Course: If properly compacted and drained, might make a fair subgrade. Should have a surface layer of sand, gravel, or crushed rock for best results for subgrade or base course. Suitability for Stabilization with Portland Cement or Bitumen: Too high in clay for use with cement; probably unsatisfactory for bitumen, unless mixed with sand and crushed rock.												
Kind of Aggregate and Binder: Aggregate is chiefly concretions of iron and some rock fragments. Binder is a lean ferruginous clay of medium to low plasticity. Mechanical Stabilization: Probably not too difficult to stabilize by rolling, with or without tamping, at a closely maintained optimum moisture. If well drained, might provide a firm riding surface with little rebound on removal of load, stable over a fair range of moisture content. Suitability for Subgrade or Base Course: If adequately drained and well compacted, may provide a subgrade of fair value; probably suited for base course where undisturbed by agriculture and naturally well drained. Suitability for Stabilization with Portland Cement or Bitumen: Too high in clay for use with cement. Needs sand for best results with bitumen.												
Kind of Aggregate and Binder: Aggregate is chiefly gravel; some angular rock fragments may be present. Binder is a lean clay, generally of medium plasticity. The soil is probably poorly graded, except in small areas where well-graded (A-1) sand-clay-gravel mixtures may be found. Mechanical Stabilization: May be stabilized without much difficulty. Moisture control at compaction may be less essential than in Soil Types 8 or 10. Tractors or rollers are best for compaction; sheepfoot rollers desirable in areas of finer texture. When well drained, should have good bearing power, fair wearing surface. Suitability for Subgrade or Base Course: Generally fairly well suited for either if drainage is provided when necessary. Suitability for Stabilization with Portland Cement or Bitumen: Generally suited for either. Additions of sand may be needed in areas of fine texture.												
Kind of Aggregate and Binder: Aggregate is lacking in the surface soil, except near foothills where rock fragments may be present. Ample binder of fair quality. Additional aggregate may be secured from nearby sources. Mechanical Stabilization: Addition of fines probably unnecessary but aggregate must be added for best compaction. Heavy rolling with tamping requires maintenance of well-controlled optimum moisture. Maintenance of drainage is most essential. Soil is permeable but the water table is probably high. Suitability for Subgrade or Base Course: Despite high clay content, shrinkage and expansion are not too high. Maintenance of drainage is the chief consideration. Insulation of surface from subgrade may be required to minimize the probable effect of fluctuating water table in low-lying places. Suitability for Stabilization with Portland Cement or Bitumen: Not well suited for either, unless mixed with sufficient aggregate.												
Mangrove swamps; unsuited for engineering treatment.												
Kind of Aggregate and Binder: Aggregate is largely sand with some limestone and rock fragments. Larger fragments may be angular, but sand is commonly coarse and rounded. Low in binder. In areas near mangrove swamps (Soil Type 11) may grade into finer-textured soils. Mechanical Stabilization: Can be compacted or settled by disk and ponding but too poorly graded and too low in binder to be adequately stabilized. Confining may be required. More stable when damp than when dry. Suitability for Subgrade or Base Course: Fairly well suited; addition of some gravel and binder is generally desirable. Suitability for Stabilization with Portland Cement or Bitumen: Suitable, but could be improved in places by addition of some binder and coarse aggregate.												

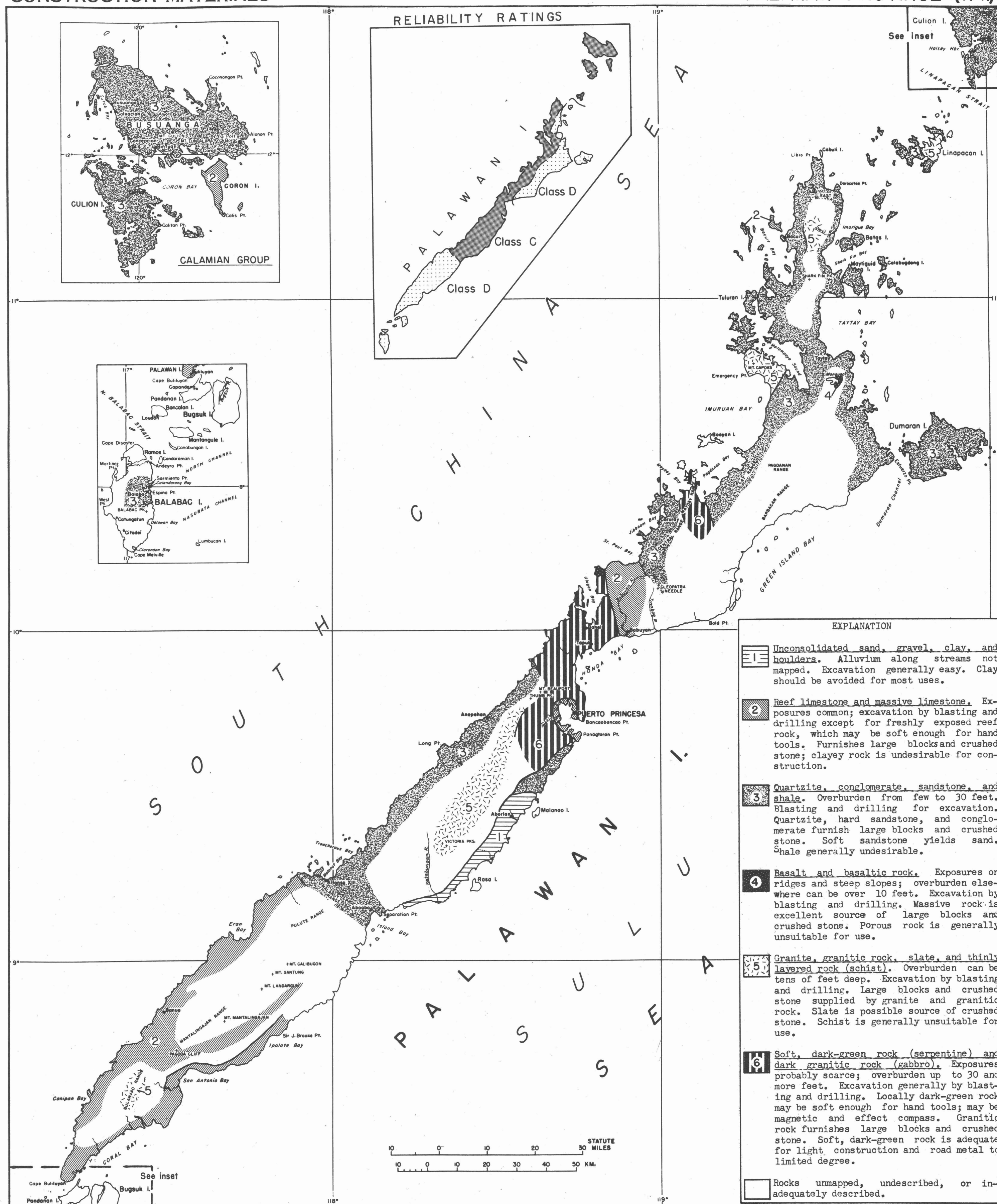
Prepared by U. S. Geological Survey for Chief of Engineers, U. S. Army.

^{a/} Soil symbols follow classification of U. S. Public Roads Administration, Principles of Highway Construction (June 1943) and War Department, Technical Manual 5-255 (December 1942), with the following modifications: ML may include A-6, A-7; CL may include A-4, A-7; CL may include A-4, A-7, but does not include A-6; CL and GL may include A-6.

^{b/} Unsuitable for engineering treatment.

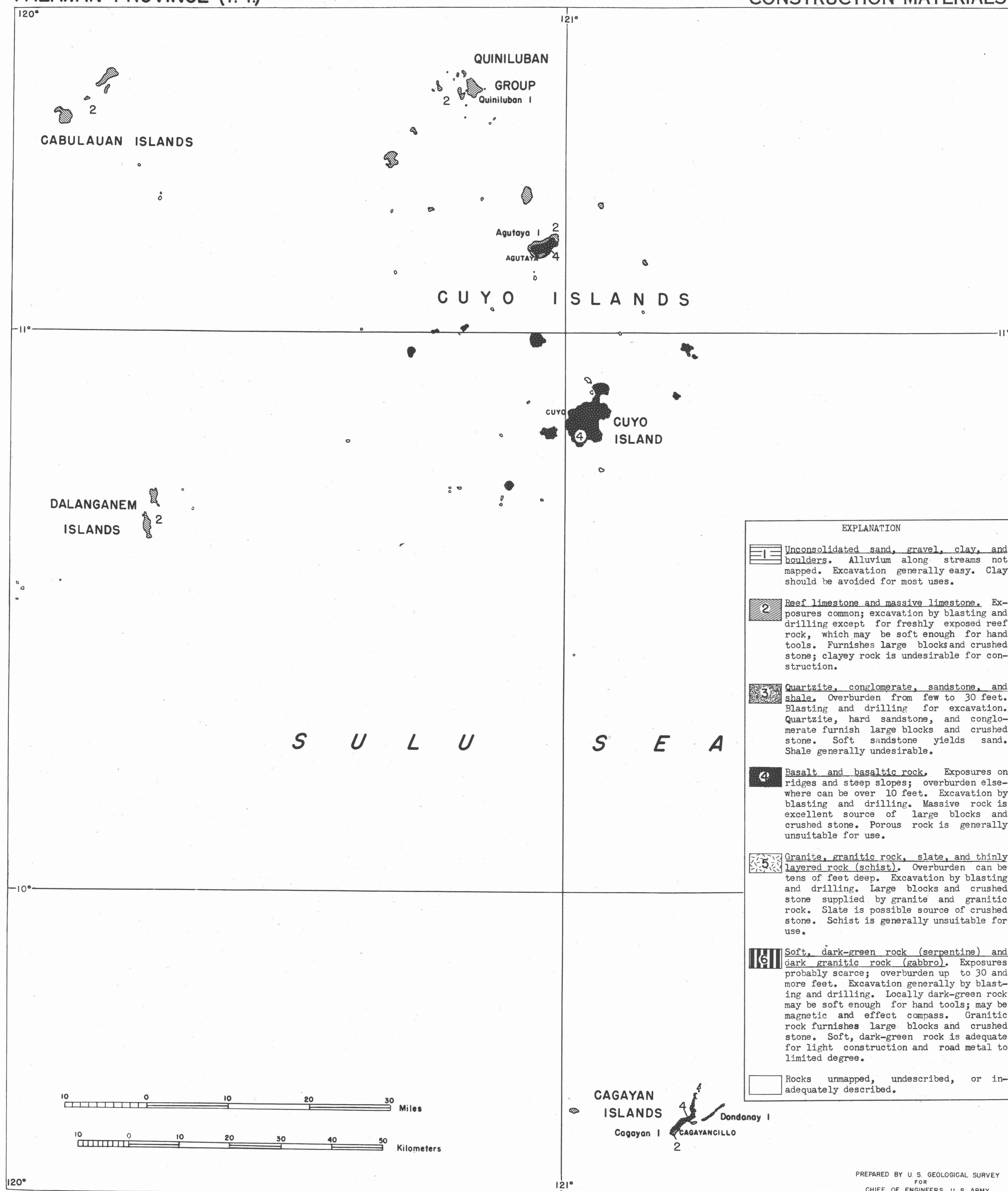
CONSTRUCTION MATERIALS

PALAWAN PROVINCE (P. I.)



PALAWAN PROVINCE (P. I.)

CONSTRUCTION MATERIALS



CONSTRUCTION MATERIALS

PALAWAN PROVINCE (P. I.)

Reliability ratings: Class C and D							
(For Palawan and adjacent islands, see inset on Construction Materials Map; all other islands Class D)							
INTRODUCTION							
The bedrock and surficial rock materials of Palawan Province include sources of sand, gravel, concrete aggregate, road metal, riprap, lime, and construction stone. Exposures of bedrock are reported to be generally scarce; in most places, soil cover is 10 feet or more deep. Dense vegetation, which spreads over almost the entire area, also interferes with easy recognition of bedrock. Only in stream gorges and on upper slopes and crests of hills and mountains can exposures be expected in the interior; some parts of the coasts are faced with rocky bluffs or cliffs. Limestone is probably the most readily accessible bedrock, having a thin overburden or none at all; massive, cavernous limestone is exposed in very rugged terrain; reef limestone (probably in part porous, in part compact) underlies fairly level, low coastal areas. Timber for construction is available throughout Palawan Province. Some types may require replacement within a short time if not treated.				Construction materials cannot be obtained far from the point of proposed utilization, as transportation is difficult generally. Roads are scarce, especially in Palawan Island; cross-country movement is restricted largely to coastal areas and is complicated by the necessity for many stream crossings. No pits or quarries are known to be present, except the manganese mines of Busuanga Island. The stockpiles of ore at the mines, if still available, should furnish supplies of broken rock (mainly boulders but possibly some gravel) in this area. The nearest developed source of coal is Semirara Island, about 75 miles east of Busuanga (not included in area of accompanying maps). There are unconfirmed reports of a coal deposit in Balabac Island, about 8 miles from town of Balabac.			
Map Unit No. and Kind of Material	Description of Material	Topographic Expression	Engineering Features	Uses			
				Sand and Gravel	Concrete Aggregate	Road Metal and Riprap	Construction and Other Uses
1 Unconsolidated sand, gravel, clay and boulders	In coastal plain extending from north of Aborlan almost to Island Bay (Palawan Island), consists of sand with thin clay layers, fine gravel, and at base mixed boulders and gravel; material all somewhat limy; maximum thickness about 200 feet. Character elsewhere not described, but probably similar. Alluvial deposits in stream valleys (not differentiated on map) consist of waste from bedrock in areas adjoining streams.	On coasts, coastal-plain deposits and sandy beaches underlie level to gently sloping low land; scattered hills may represent exposures of resistant bedrock; in places, low bluffs face coast. In stream valleys and at stream mouths, alluvium forms level areas adjoining stream channels.	<u>Excavation:</u> Generally easy; sand can be worked with shovel, gravel and boulders with pick and shovel; some slightly compacted material may require use of pick or wedge. Power shovels will be useful in excavating thick deposits of finer material. <u>Stability:</u> Poor, especially in fine or clayey material; fine sand may be moderately stable when wet. <u>Foundation Value:</u> Fair to poor; danger of lateral displacement of material when subjected to load.	Excellent source in most places, except where clay is abundant or material is bouldery.	Mixed sand and gravel are good for aggregate; excessive fine material or clay should be avoided.	Gravel and possibly coarse sand are suitable as road metal. Some boulders may be large enough for riprap.	Generally unsuitable for construction; boulders may have use if no other material is available.
2 Reef limestone and massive limestone	Character of reef limestone not known; probably porous in part, elsewhere compact. Massive limestone in Palawan is buff-colored, hard rock; in Coron Island, reported to be darker and to weather more readily; no description for other islands; contains caverns at or near sea level and also at altitudes of 200 and 300 feet.	Reef limestone forms flat or gently sloping lowlands or islands; on coasts may form bluffs or cliffs; probably covered in most places with limestone rubble; soil cover generally thin. Coral reefs surround most islands; rock exposed in part at low tide; not mapped. Massive limestone underlies rugged terrain; soil cover thin (as little as 1 foot); rock exposures common; forms steep cliffs.	<u>Excavation:</u> Reef rock, when freshly exposed, is soft and probably can be excavated with hand tools; case-hardens on exposure. Old reef limestone and massive limestone require blasting and drilling; cavernous rock may be easier to excavate. <u>Stability:</u> Good in flat-lying rock layers; danger of slipping where layers are inclined. <u>Foundation Value:</u> Generally good where rock is not porous or cavernous.	Some crushed reef limestone and rock debris suitable for use as gravel and possibly as sand. Massive limestone may yield some gravel at or near exposures.	Adequate to good source, where rock is not porous or clayey. Porous rock probably more common in reef limestone than in massive limestone.	Good source of road metal, but may require frequent replacement if traffic is heavy; bonds well. Massive limestone crushed or in large blocks good for road metal and riprap, respectively.	Good for masonry; reef limestone used extensively in tropical regions. Homogeneous, pure limestone excellent source of lime.
3 Quartzite, conglomerate, sandstone, and shale	Quartzite in Calamian Group and northern Palawan (including adjacent islands) is light yellow to pink, very hard rock; in places in thin layers separated by shale or white, hard clay layers; quartzite contains reddish flint and black or gray earthy or metallic rock (manganese ore) in lens-shaped and rounded masses of different sizes, especially in Busuanga Island; conglomerate containing many large granite boulders and blocks of quartz associated with the quartzite. In western Palawan, soft, crumbly dark-colored sandstone and dark shale, locally very much contorted, are common. Sandstone, in part limy (possibly sandy limestone), and limy shale in flat-lying layers are bedrock in parts of central Palawan; similar rock probably abundant in Balabac Island.	Quartzite, sandstone, and associated rocks underlie areas of different relief; commonly hilly with steep slopes; locally low, gently sloping land, such as open valleys of Busuanga Island. Rock exposures are not as common as in Map Unit 2; soil cover may be 10 to 30 feet deep, especially on lower slopes.	<u>Excavation:</u> Most rock types require drilling and blasting; applies particularly to quartzite and hard sandstone. Crumbly or limy sandstone may yield to drills and hand tools without blasting. <u>Stability:</u> Generally good; danger of slipping greatest in limy sandstone and shale when layers are inclined. <u>Foundation Value:</u> Good in all massive rocks; poor in porous, crumbly rocks or rocks with thin steeply tilted layers.	Crumbly or limy sandstone may furnish sand. Gravel can be obtained from some sandstone, conglomerate, and shale exposures. Material may be most abundant in nearby stream channels and banks. Quartzite is probably poor source.	Quartzite and hard sandstone, when crushed, are good source; conglomerate suitable if boulders are not too large. Metallic substances, as in quartzite of Busuanga Island, may undergo chemical changes upon exposure to atmosphere, which will weaken aggregate.	Quartzite is good source; hard sandstone and conglomerate are suitable. Soft sandstone and shale are generally poor; disintegrate under wear.	Hard sandstone is good construction stone; all types of sandstone probably suitable for light construction.
4 Basalt and basaltic rock	Dark-gray basalt at Ulugan Bay, Palawan Island. No description of basalt at Lake Manguao published; probably gray to black rock. Rock in Cuyo Islands partly massive, partly porous.	Underlies hilly terrain in Palawan. Volcanic cones in Cuyo Islands with smooth slopes, many gentle, some up to 25%. Rock exposures on ridges and steep slopes. Soil cover, especially on lower slopes, may be 10 feet and more thick; in Cuyo Islands, soil is reddish.	<u>Excavation:</u> Requires blasting and drilling of massive beds; joints, if present, will permit wedging out of blocks; porous layers probably easier to excavate than massive ones. <u>Stability:</u> Good in massive layers; lower in jointed rock and porous layers. <u>Foundation Value:</u> Excellent generally; poor in soft, porous layers and highly jointed rock.	Weathered massive rock probably suitable source of gravel. Soft, porous rock may have cover of sandy waste than can be screened.	Massive rock, when crushed, is excellent for concrete aggregate; jointed rock, if joints are close, is somewhat less desirable; porous rock is unsuitable. Rock containing light-colored fibrous or needle-like crystals in cavities is apt to cause disintegration of concrete.	Massive rock is excellent source; jointed rock may furnish large blocks for riprap; porous rock is unsuitable.	Massive rock is excellent source of building stone.

(continued)

PALAWAN PROVINCE (P.I.)

CONSTRUCTION MATERIALS

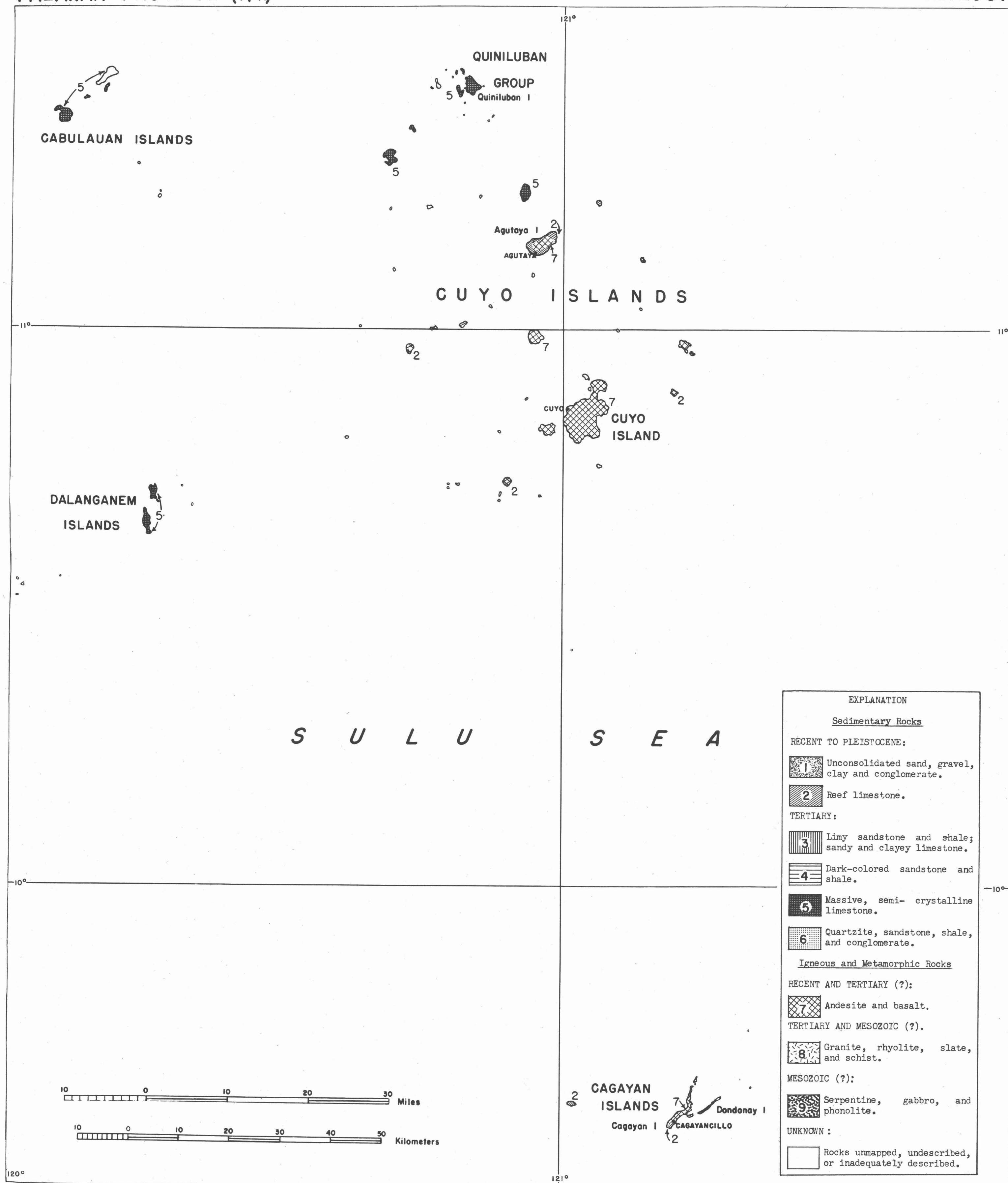
Reliability ratings: Class C and D							
(For Palawan and adjacent islands, see inset on Construction Materials Map; all other islands Class D)							
Map Unit No. and Kind of Material	Description of Material	Topographic Expression	Engineering Features	Uses			
				Sand and Gravel	Concrete Aggregate	Road Metal and Riprap	Construction and Other Uses
5 Granite, granitic rock, slate, and thinly layered rock (schist)	Granite is pale gray, fine-grained mica-bearing rock, in many places with dark patches or streaks. No description of granitic rock available; probably similar to granite, but finer grained. Slate is iron-gray hard rock breaking readily into thin parallel layers. Thinly layered rock (schist) includes several types, such as rock distinguished by abundance of (1) greenish mica, (2) black, very soft, shiny mineral (graphite), or (3) greenish soft greasy mineral (talc). Slate and schist are generally found in small exposures associated closely with granite.	Known to occur only in mountainous or hilly areas; full extent of distribution is not known. Exposures may be scarce except in stream gorges, upper slopes, and mountain or hill crests. Overburden can be tens of feet deep. Slate and thinly layered rock (schist) probably present in lower-lying parts of areas.	<u>Excavation:</u> Requires blasting and drilling of granite and granitic rock; slate and thinly layered rock (schist) may shatter and, if large blocks are needed, care must be exercised. <u>Stability:</u> Granite and granitic rock excellent; slate and schist good, but if layers are steeply tilted, danger of slipping exists. <u>Foundation Value:</u> Granite is excellent; slate and schist generally adequate.	Granite and granitic rock, where weathered, may yield sand and gravel, probably accumulated in stream channels traversing areas of exposure.	Crushed granite, granitic rock are good sources; slate and thinly layered rock (schist) are poor to unsuitable.	Granite and granitic rock are good sources of road metal and riprap; slate and schist are generally poor.	Granite and granitic rock are excellent building stone. Slate is excellent roofing material and may yield paving stone where layering is not too fine.
6 Soft, dark-green rock (serpentine) and dark granitic rock (gabbro)	Serpentine is soft, dark-green rock with smooth or greasy feel; may be olive green or gray in places; parts contain black magnetic metallic grains which, where abundant, will affect compass. Associated granitic rock is dark gray; characteristics not described.	Underlies hilly and mountainous region and also extends beneath adjacent lowlands. Exposures are probably scarce. Soil cover may be 30 or more feet deep.	<u>Excavation:</u> Requires blasting and drilling; in places, soft, dark-green rock (serpentine) may be sufficiently soft and disintegrated to permit excavation with hand tools. <u>Stability:</u> Granitic rock probably good; serpentine is highly variable. <u>Foundation Value:</u> Granitic rock, excellent; serpentine may be subject to slipping.	Granitic rock may furnish sand and gravel where weathered; accumulation probable in streams. Serpentine is poor source.	Granitic rock is good source of road metal and riprap. Serpentine may be adequate source of road metal where other materials are lacking, but if subjected to heavy traffic when wet becomes slippery and sticky.	Crushed granitic rock is generally good source. Serpentine is unsuitable; may undergo chemical changes that tend to weaken aggregate.	Granitic rock is good source of building stone. Serpentine can be used for light construction.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.



PALAWAN PROVINCE (P.I.)

GEOLOGY



PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

PALAWAN PROVINCE (P.I.)

GEOLOGY

Reliability rating: Class C and D
(For Palawan and adjacent islands, see inset on Geologic Map; all other islands Class D)

INTRODUCTION

Palawan Province comprises over 1,150 islands and islets with a combined land area of 14,746 square kilometers (5,693 square miles). The great majority of the islands are aligned in a northeast-trending belt extending from the Calamian Group at the north through Palawan Island to Balabac Island at the south. The province also includes several groups of small islands to the east; the main ones are Cuyo and Cagayan Islands. The Palawan islands have characteristics distinct from those of the other Philippines; geologically, botanically, and zoologically, they are more closely related to Borneo and the Malay Peninsula.

Little geologic work has been undertaken in Palawan Province. An incomplete geologic map of Palawan Island and the Calamian Group with a description of the rocks was published in 1941. Some detailed information is available on manganese-mining areas in Busuanga Island. Data on geology in other parts of the province are derived mainly from incidental remarks in non-technical literature.

GENERAL DESCRIPTION

The island group as a whole is mountainous. Palawan Island, the main land mass, has a core of igneous and metamorphic rocks, exposed at several places in the central mountain range. Surrounding the core are younger sediments and volcanic rocks, some of which are highly deformed. The rocks of the Calamian Group are mainly quartzite and limestone. Little is known of Balabac and adjoining islands, but they probably have bedrock similar to that of southern Palawan. Cuyo and Cagayan Islands are of two main types: volcanic and limestone.

The geologic history of Palawan Province is largely conjectural; the age of the rocks is based mainly on indirect evidence. Alluvial deposits and raised coral reefs along the coasts were probably formed during Recent and Pleistocene time. Most of the sedimentary and volcanic rocks are dated as Tertiary. The older metamorphic rocks and igneous intrusives may be early Tertiary, but are probably in part Mesozoic.

It is possible that the island belt originated as a Tertiary folded mountain range. Intense folding and faulting have been observed in places. An important north-south fault is reported to cross Palawan Island between Honda and Ulugan Bays; it may have created two main segments along which unlike movements have occurred in Recent time.

DESCRIPTION OF ROCK UNITS

Sedimentary Rocks

1 RECENT TO PLEISTOCENE: UNCONSOLIDATED SAND, GRAVEL, CLAY, AND CONGLOMERATE.

Distribution: Greatest development on eastern coast of Palawan Island from north of Aborlan south to Island Bay. Alluvial sand, gravel, and clay are present but unmapped, in many embayments and river valleys near coasts of most islands. Sandy beaches are common in Imuruan Bay on western coast and Green Island Bay on eastern coast of Palawan Island; many settlements are located on sandy beaches.

Description: Alluvial deposits of Aborlan coastal plain are all somewhat calcareous and unconsolidated; consist of sand with thin clay beds, fine gravel, and at base, conglomerate. Maximum thickness estimated about 200 feet. Deposits extend inland to lower mountain slopes.

2 RECENT TO PLEISTOCENE: REEF LIMESTONE.

Distribution: Exposed in coastal belt of Palawan from vicinity of Sir J. Brooke Point southward at least to San Antonio Bay, probably extends to southern tip of island (Cape Buliluyan). Forms bedrock of small islets in Cuyo and Cagayan Islands; probably present in coastal areas of larger islands in these groups.

Description: Raised coral reef limestone forms broad flat terraces generally covered with limestone rubble. In Palawan, elevation reported to be about 20 feet above sea level. No data are available on character of reef limestone in this region.

3 TERTIARY: LIMY SANDSTONE AND SHALE.

Distribution: Exposed in hills along western coast of Palawan Island from Moorsom Point to Malanut Bay area and in belt across island to Island Bay. Sandstone present in northern and central Balabac Island.

Description: Predominantly soft limy sandstone and shale; possibly some sandy and clayey limestone. Beds are generally flat-lying; may be gently folded; greater deformation likely in area between Alfonso XIII and Separation Point, where faulting is reported. Sandstone in Balabac Island is soft and yellow.

4 TERTIARY: DARK-COLORED SANDSTONE AND SHALE.

Distribution: Known only from western coast of Palawan Island in two belts: (1) Bacuit Bay and coast to north; (2) Imuruan and Pagdanan Bays.

Description: Generally soft, friable, dark sandstone overlain by dark shale. In places, sandstone is more highly cemented. Beds steeply inclined, locally highly contorted; may be involved in fault zones.

5 TERTIARY: MASSIVE, SEMI-CRYSTALLINE LIMESTONE.

Distribution: Exposed at Bacuit on Palawan Island and in islands offshore, in belt from St. Paul Bay across island to Babuyan, in Malanut Bay, in area west of San Antonio Bay, and probably widely in southwestern coastal area. Forms all of Coron Island (Calamian Group); probably bedrock of Dalanganem Islands, Cabuluan Islands, and Quiniluban Group.

Description: On western coast of Palawan Island and adjacent islands is hard, buff limestone lacking any visible stratification. Exposed typically in vertical cliffs, in places with caves on seaward side; some caves at or near sea level, others at altitudes of 200 and 300 feet. Limestone peaks with precipitous slopes are prominent landmarks. In Coron Island, limestone is darker and is reported to weather more easily than in Palawan; also contains numerous caverns. No description available of limestone in islands east of Palawan.

6 TERTIARY: QUARTZITE, SANDSTONE, SHALE, AND CONGLOMERATE.

Distribution: Predominant rock unit in Calamian Group, Linapacan Island, Dumaran Island and numerous small islands off eastern coast of Palawan. Widely exposed in central and northern Palawan Island; extent is incompletely known and may be greater than indicated on map.

Description: Quartzite in Busuanga, Culion, Linapacan, and northern Palawan is light yellow to pink, very hard rock. In part massive, but well-stratified beds composed of thin quartzite layers separated by shale layers (now weathered to hard white clay) are abundant. Quartzite contains discontinuous lenses and seams of manganese ore associated with reddish, cherty jasper. Underlain by coarse conglomerate (or breccia), containing many large granite boulders and blocks of quartz. Earthy hematite forms masses in the quartzite and coatings on boulders in the conglomerate. South of Puerto Princesa in Palawan, fine-grained black quartzite and dark shale may correspond in age to the lighter-colored rocks in the north. On western coast of Palawan, conglomerate and sandstone may be more common than quartzite. In Busuanga and Culion Islands, the rocks are highly contorted and in places faulted; vertical joints are common. Steep dips are typical except in Linapacan Island where rocks show relatively little disturbance other than jointing and minor faulting.

Igneous and Metamorphic Rocks

7 RECENT AND TERTIARY: ANDESITE AND BASALT.

Distribution: Small areas of volcanic rock are reported on west coast of Palawan at Ulugan Bay and in northern Palawan at Lake Manguao near Taytay Bay; other exposures are probable as indicated by presence of andesite fragments in conglomerate east of Anepahan. Most of Cuyo Islands are volcanic cones composed of andesitic or basaltic lava. Cagayan Islands are probably composed in large part of similar rock.

Description: Andesite at Ulugan Bay is dark gray rock. Basalt dams Lake Manguao; no description of rock available. Andesite or basalt in Cuyo Islands is in part vesicular; generally weathered to red soil; contains no tuff beds.

8 TERTIARY AND MESOZOIC: GRANITE, RHYOLITE, SLATE, SCHIST.

Distribution: Granite is present east of Bacuit and in Mt. Capoas area (western Palawan) and in central mountains west and southwest of Puerto Princesa; probably extensive in central ranges. Exposed also in eastern Linapacan Island. Rhyolite is reported from Bulanjao Range in southern Palawan. Slate and schist have small areal exposure on eastern flank of Mt. Capoas; similar rocks are found as debris at other known granite localities and may be a common associate of granite elsewhere in Palawan. Schist is found in an unspecified locality near Taytay.

Description: Pale-gray, fine-grained biotite granite containing much quartz; in many places porphyritic; generally shows dark patches or streaks (schlieren). No description of rhyolite available. Schist includes chlorite, graphite, and talc varieties. Slate is dark iron-gray, hard homogeneous rock with excellent cleavage; thin parallel layers that are separated equal roofing slate in quality; beds dip at moderately high angles, but are not contorted or closely folded; thickness of beds ranges from about 20 to 30 feet. Schist and slate considered to be oldest rocks of region; intruded by granite.

9 MESOZOIC: SERPENTINE, GABBRO, AND PHONOLITE.

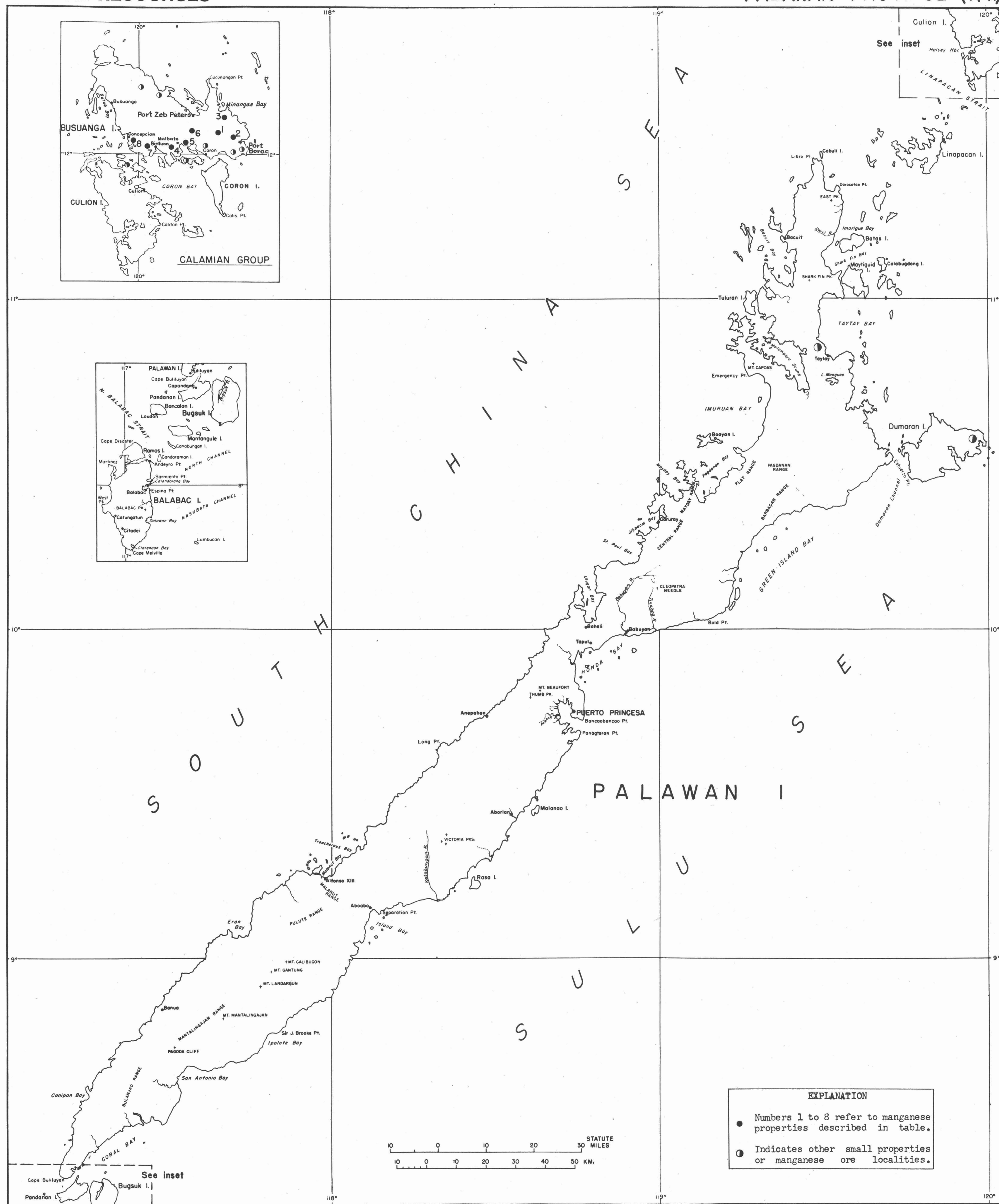
Distribution: Serpentine exposed extensively in Puerto Princesa area and north to Ulugan Bay; also in Mayday Range area of western Palawan; gabbro associated, but less common. Phonolite is found only as dikes west of Puerto Princesa.

Description: In Ulugan Bay area and elsewhere, some serpentine contains chromite and iron-ore minerals. Gabbro is associated with serpentine on eastern side of Ulugan Bay and near Baheli; character unknown. Gray-green phonolite weathers readily and breaks into concentric shells.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

MINERAL RESOURCES

PALAWAN PROVINCE (P.I.)



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CHIEF OF ENGINEERS, U. S. ARMY

PALAWAN PROVINCE (P. I.)

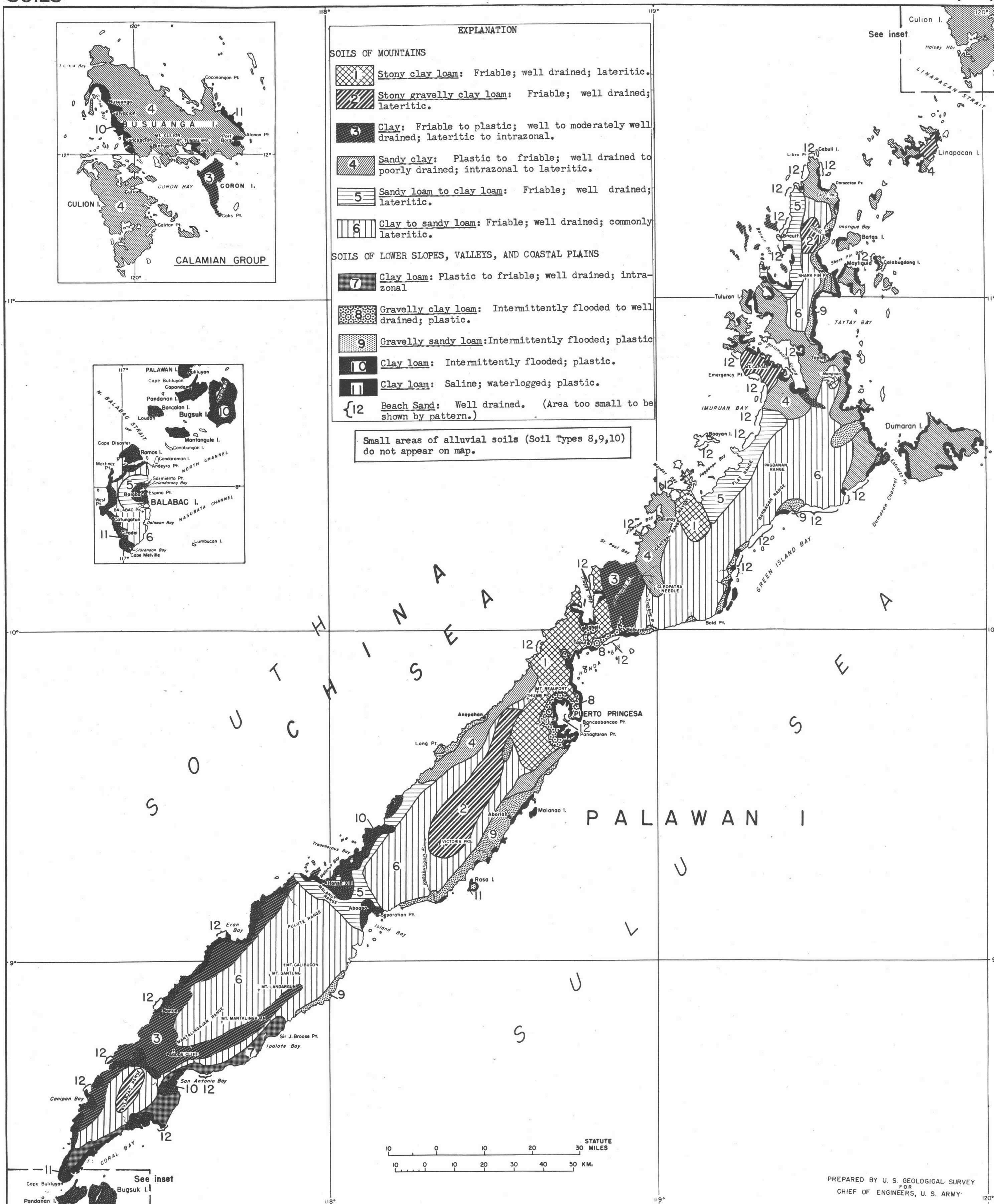
MINERAL RESOURCES

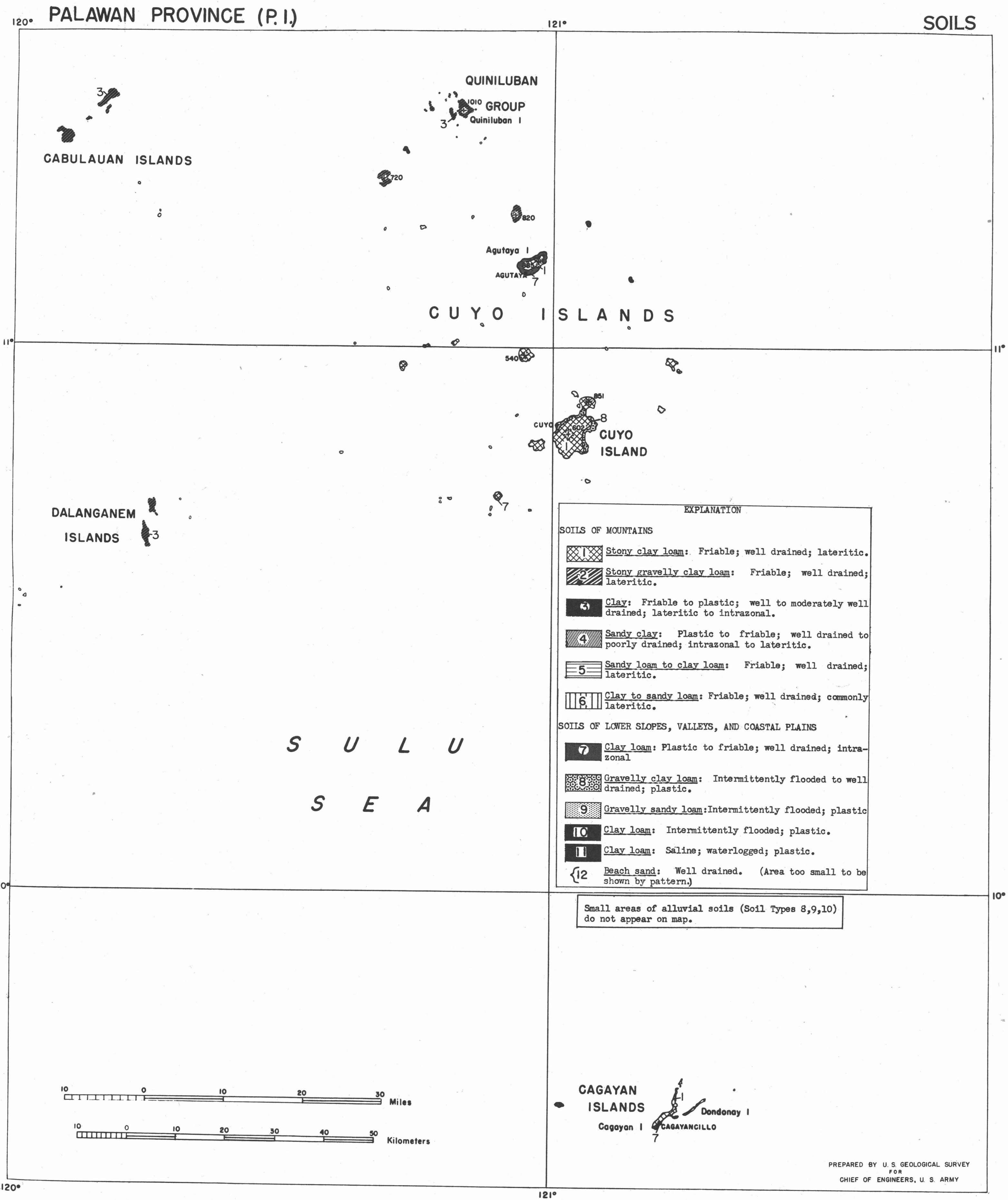
Reliability rating: Class B					
INTRODUCTION		continuous seams of different sizes. Widths of solid ore as great as 15 feet are described and series of ore bodies are traced for several hundred feet.		milling; when necessary, ore may be handsorted or cobbled.	
Manganese, chromite, iron, tin, tungsten, copper, and gold are among the many ores reported in Palawan Province. The only developed mineral resources are manganese deposits in Busuanga and small adjoining islands, which came into production about 1937. In 1941, these deposits yielded a large part of the total Philippine manganese output of approximately 125,000 tons; Busuanga produced almost as much as all other areas in the Philippines combined. Only a small part of Busuanga has been developed, but it is apparent that the mineralized areas are extensive. Manganese deposits are also reported in northern Palawan Island and eastern Dumaran Island.		Ore: Massive, hard psilomelane (impure manganese oxide) is the chief ore mineral. Grade of ore is consistently high, in some deposits averaging over 50% metallic manganese; silica and iron content is generally low. Following is an average assay of ore shipped by the largest producer:		Labor: Unskilled labor is plentiful and serves adequately for the simple mining operation. Skilled labor is reported to have been employed in the mines in 1941.	
MANGANESE DEPOSITS OF BUSUANGA ISLAND		Mn..... 54.76% Fe..... 1.42 SiO ₂ 3.2 Moisture... 4.7%		Roads and Shipping: Road construction and maintenance have proved to be relatively cheap. Almost all properties in Busuanga are accessible by way of provincial highway and connected private roads. Ore is shipped from Port Zeb Peters on the northern coast. Some ore is taken on lighters from other harbors to Port Zeb Peters for transshipment. A wooden and steel T-end pier (500 feet long, 100-foot face, 23-foot depth alongside) with a daily loading capacity of 1,000-2,000 tons of ore is located at the shipping port.	
Geologic Setting: Folded and faulted quartzite is the country rock in all the mineralized areas. The ore, which is regularly associated with reddish jaspery chert, forms more or less steeply dipping lenses or dis-		Mining: Mining is accomplished mainly by open-cut method; some underground operations are combined with open cuts. The ore is lump for most part and little concentration is necessary. There are no provisions for		Mines: Details on the main properties are given in the accompanying table. In addition, eight small properties were operated in Busuanga and adjoining islands; together they produced about 1,000 tons of high-grade ore monthly.	
Data on Larger Manganese Deposits of Busuanga Island					
Location	Accessibility and Shipment	Mining Methods	Equipment	Kind and Grade of Ore	Production (Long tons)
1 Singay: approx. 12°4'0" N., 120°14'30" E.	About 19 kms from Coron by provincial highway (to Km 5) and private roads. Also road and telephone line to Port Zeb Peters. Shipment from Port Zeb Peters.	Principally open-cut from 6 benches, connected by chutes. Hand operation only.	Machine shop for minor repairs. Four 2-ton trucks. 100-ton ore bin.	Large lump, breaks quite clean. Extremely hard; probably psilomelane. Average shipment (1939): 54% Mn.	1937: 338; 1938: 4,936; 1939 (7 mos.): 4,526. Rate last reported (probably 1941): 1,000 tons monthly.
2 Port Borac: approx. 12°3'10" N., 120°17'30" E.	No road; accessible only by water (1939). Ore lightered to Port Zeb Peters.	No data available; probably open-cut.	3,000-ton ore bin; pier for lighters at Port Borac; two 80-ton lighters.	Hard, compact psilomelane. Many ore boulders, up to 3 ft. in size, on surface. Grade of boulders: 46 to 55% Mn.	Rate of (2) and (3) combined reported as 1,000 tons high-grade ore monthly.
3 Minangas Bay: approx. 12°7'10" N., 120°16'10" E.	About 4.5 kms by road from Minangas Bay. Ore lightered to Port Zeb Peters.	No data available; probably open-cut.	800-ton ore bin; pier for lighters at Minangas.	Grade somewhat lower than in (2).	See (2) above.
4 Malbato: approx. 12°1'30" N., 120°6'10" E.	About 16.5 kms west of Coron by provincial highway (to Km 14) and private road. About 8.5 kms to Malbato. Ore lightered to Port Zeb Peters.	Underground operation; two tunnels.	Well-equipped camp; compressor, engine room. At Malbato, pier for lighters, ten 30-ton lighters, small gasoline tug; 2,000-ton ore bin.	Average shipment (1938-39): 52-54% Mn.	1938-39 - approximately 9,000. Rate (1939): 500-600 tons monthly
5 Malbato: approx. 12°2'30" N., 120°8'10" E.	Highway to Coron. Ore lightered to Malbato.	No data available.	2 old hulls of inter-island vessels for lighterage.	No data available.	Rate 300 tons high grade ore monthly. Capable of producing 1,000 tons monthly.
6 Barrio San Nicolas: approx. 12°4'10" N., 120°10'10" E.	Road to Coron. Ore trucked to Port Zeb Peters.	Open-cut.	No data available.	No data available.	Rate of (4) and (6) combined: 1,000 tons high grade ore monthly.
7 Bintuan: approx. 12°2'10" N., 120°2'30" E.	Ore lightered from Bintuan to Port Zeb Peters.	No data available; probably open-cut.	Pier for lighters.	No data available.	Rate of (7) and (8) combined, 500 tons high-grade ore monthly.
8 Concepcion: approx. 12°3'10" N., 119°59'10" E.	Ore lightered from Concepcion to Port Zeb Peters.	No data available; probably open-cut.	Pier for lighter.	No data available.	See (7) above.

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for Chief of Engineers, U. S. Army

SOILS

PALAWAN PROVINCE (P.I.)





SOILS: BASIC DATA

PALAWAN PROVINCE (P.I.)

Reliability rating: Class D

INTRODUCTION

The accompanying soil map is an interpretation of the data of topography, geology, vegetation, and climate. There has been no soil survey in Palawan and no description of soil sections or profiles has been made. The representative soil profiles given below are interpretations of the net effect of soil-forming processes on a given parent material in a given environment. The map and table are intended to present an over-all view of the soils of the island rather than to provide detailed information. Soil boundaries shown on the map are only approximate. They are made to coincide, in many places, with topographic or geologic boundaries. Appraisal of engineering properties of the soils is made in accordance with the usage of Technical Manual 5-255 (see Soils: Engineering Properties, page 53). In this appraisal, allowances were made for certain trends in the texture-moisture relationships which are not quite the same in the humid tropics as elsewhere.

Major Soil Groups

Soils of Mountains: Most widely distributed types. They are chiefly clay loams, gravelly clay loams, clays, sandy clays, and gravelly sandy clays. The structure of these fine-textured soils is, as a rule, well developed. The soils are well drained despite their relatively high clay content. Their depth ranges from a few inches (as in Soil Types 3, 4, and 7) to several feet (as in Soil Types 1, 2, and 5). In every soil type, the soil is more shallow on steeper slopes and on ridges. The weathered mantle overlying unweathered bedrock may be tens of feet thick, as on granite in Soil Type 2, on sandstone in Soil Type 5, or on serpentine (dark-green, soft, sheared rock)

in Soil Type 1; or it may be of negligible thickness, as on limestone in Soil Type 3 or on quartzite in Soil Type 4. The weathered mantle overlying other parent rocks may be of moderate thickness (between the two extremes mentioned above), as on basalt and andesite (volcanic rock) in Soil Type 1, on argillite (hard clay rock) in Soil Type 4, on shale and other sedimentary rocks in Soil Type 5, and on schist (flaky, thin-layered rock) and some other metamorphic rocks in Soil Types 2 and 4. The unweathered bedrock may be exposed, however, in canyons, on ridges and very steep slopes, and other places where the soil has been eroded.

Soils of Lower Mountain Slopes, Hills, Valleys, and Coastal Plains: Cover a small proportion of the total surface area. These soils range in texture from clay to gravel. Their structure is not as well developed as that of the mountain soils. In many lowlands they are likely to be flooded intermittently. Drainage of the lowland soils is determined largely by topographic conditions and by depth to the water table. They are more permeable than soils in the same textural grade developed in non-tropical regions. Alluvial soils of valleys and coastal plains are developed on transported water-worked deposits of diverse origin and kind. The combined depth of the soil and of the underlying alluvium may exceed 100 feet.

Peculiarities of Some Tropical Soils

Iron and Aluminum: The bright colors of many tropical soils are due commonly to iron and aluminum oxides. The purple tinge of the upper few inches of some tropical clay loams is probably due to titanium oxides. The high iron and aluminum content of many tropical soils results

from relatively rapid removal of silica from the soil where rainfall is abundant and prevailing temperatures are high. Under such conditions, iron and aluminum are leached out at a much slower rate and accordingly tend to accumulate in the soil. Soils losing their silica, through leaching, at a higher rate than they are losing iron and aluminum, are commonly known as lateritic. Accumulation of iron and aluminum in the soil may lead, in many instances, to formation of granules, aggregates, or concretions consisting chiefly of hydrated oxides of these metals.

Organic Matter: Not likely to be present in significant quantities, except in swamps and in poorly aerated soils. In the region of mossy forest, within the cloud belt (see Vegetation Sheet), the forest floor may be covered with a layer of plant detritus a few inches deep. Peat bogs may be found, especially at high altitudes, but none has been reported in Palawan Province.

Texture-moisture Relationship: Engineering appraisal of a given soil depends a great deal on soil texture. Moisture retention, hygroscopicity, and other characteristics depend on soil texture and kind of material constituting the finer-textured fractions of the soil. Knowledge of the texture-moisture relationship rests chiefly on data accumulated in non-tropical regions. There are very few corresponding data for the tropics. Soil-forming processes in the humid tropics differ from those of other regions; consequently many tropical upland clays resemble loams of non-tropical regions in their engineering properties and moisture relationships and many tropical loams may resemble very fine sands of temperate regions. Tropical gravels and coarse sands, on the other hand, do not differ appreciably from gravels and sands elsewhere.

Soil Type 1 Stony clay loam; lateritic; friable; well drained 0 to (0.5-6)' and below: Stony clay loam to stony clay; dark brown to gray brown or reddish brown; iron concretions may be present; granular open structure. (0.5-6)' and below: Stony clay to stony clay loam; brown to dark yellow or red; iron concretions may be present; granular open structure less well developed than in upper horizon. Depth to Unweathered Bedrock: 10 to 30 feet and deeper, except where bedrock is exposed through erosion of soil and on ridges and steep slopes where soil is thinner. Slightly weathered large boulders may be found embedded in soil mass at different depths. Parent Material: Dark green, soft, sheared rock (serpentine), basalt, fine-grained volcanic rock (andesite), dark, coarse-grained crystalline rock (gabbro). Relief: Mountains, mountain valleys, and higher slopes at altitude of a few hundred to 5,000 feet and higher. Vegetation: Primary jungle; little secondary growth; some cogon grass; some mossy forest within the cloud belt. Properties: Better footing in rainy weather than on Soil Types 2, 3, 4, and 5; stable, open-granular structure permits excellent drainage despite high clay content; granular structure will be lost if soil is subjected to heavy traffic in rain or is worked severely when too wet; soil will then become a sticky mud. If properly compacted and well drained, soil may provide a surface stable in all kinds of weather under not too heavy traffic load. Neutral to acid; acidity probably increases with altitude. Low in organic matter. Fertile, unless weathered severely; red color commonly indicates low fertility. Engineering Group Symbol and P.R.A. Class^{a/}: ML, CL (stony); A-4, A-6 (stony).	Soil Type 2 Stony gravelly clay loam; lateritic; friable; well-drained 0 to (0.5-3)': Stony gravelly clay loam to sandy clay; grayish brown, brown, or dark yellow; may be red or reddish; paler shades of these colors are common at higher altitudes; iron concretions may be present; the upper few inches may contain much sand; commonly loose open structure. (0.5-3)' and below: Clay to sandy clay or clay loam; may be gravelly, stony; brown, yellow, or red; may be mottled; iron concretions and concretionary gravel may be present; structure may be fairly open or poorly developed. Depth to Unweathered Bedrock: Tens of feet and deeper; very deep on granite which is commonly overlain by a thick weathered mantle preserving appearance of original rock but soft enough to be cut with a spade; on other rocks, weathered mantle is much thinner. Parent Material: Granite; massive flaky thinly layered rock (schist); fine-grained volcanic rock low in iron (rhyolite). Relief: Mountains, mountain valleys, and higher slopes at altitude of few hundred to 5,000 feet and higher. Vegetation: Primary jungle; some secondary growth and cogon grass; mossy forest within cloud belt. Properties: Poorer footing than on Soil Type 1, in rainy weather, but better than on Soil Types 3, 4, and 5; good drainage despite high clay content; fairly stable surface over a wide range of soil moisture; may support light traffic, if compacted carefully and well drained. Probably more acid than Soil Type 1; low in organic matter; less fertile on granite than on other rocks. Engineering Group Symbol and P.R.A. Class^{a/}: CL, ML (gravelly, stony); A-6, A-7, A-4 (gravelly, stony).	Soil Type 3 Clay; lateritic to intrazonal^{b/}; friable; to plastic; well to moderately well-drained 0 to (0.3-2)'; rarely deeper: Clay to clay loam; dark brown to almost black; limestone fragments and iron concretions may be present; lime concretions are rare; undisturbed soil has well-developed structure. Depth to Unweathered Bedrock: Probably not over few feet; in places bedrock may be very near surface; weathered mantle is commonly very thin, in places lacking and clay may rest on solid bedrock. Parent Material: Massive semicrystalline limestone. Relief: Rugged mountains, mountain valleys, and higher slopes at altitudes of few hundred to 5,000 feet and higher; not easily passable. Vegetation: Primary and secondary jungle; molave trees, cogon grass. Properties: Poor footing in rainy weather as soil is very sticky, slippery, although permeable and commonly well-drained in undisturbed state; high moisture-holding capacity; when dry, soil has firm, stable surface; compressible with relatively little rebound on removal of load; not easily eroded, except where very thin, as on ridges and very steep slopes. Neutral to slightly acid; some organic matter commonly present; very fertile, where sufficiently deep to support vegetation. Engineering Group Symbol and P.R.A. Class^{a/}: CL; A-6. Local Features: Caves in limestone islands in Bacuit Bay.	Soil Type 4 Sandy clay; plastic to friable; intrazonal^{b/}; to lateritic; well-drained to poorly drained 0 to (0.3-3)'; rarely deeper: Sandy clay to sandy loam; may contain quartz gravel; grayish yellow to almost white; rarely brown; structure may be well developed or practically lacking. (0.3-3)' and below: Slightly weathered bedrock in places, particularly on hill and mountain slopes; in valleys and depressions, soil is deeper and is chiefly alluvial, probably structureless, gravelly sandy clay or clay loam. Depth to Bedrock: May be less than 1 foot on mountains and hills; silica-rich bedrock may be exposed through erosion of soil; in valleys and depressions, unweathered bedrock may lie at considerable depth. Parent Material: Quartzite, highly siliceous sandstone, argillite (hard clay rock), and other metamorphic rocks high in silica. Relief: Mountains, mountain valleys, and hills commonly at altitudes not over 1,000 to 2,000 feet. Vegetation: Barren in many places; some pasture grasses and cogon; where soil is deeper, some trees and bamboo thickets. Properties: Poor footing in rainy weather and poor internal drainage; relatively high moisture-holding capacity; may require much time to dry after rain; easily puddled; commonly plastic rather than friable; slightly acid to acid; low fertility. Engineering Group Symbol and P.R.A. Class^{a/}: CL, SP (may be gravelly); A-6, A-7, A-2 (may be gravelly). Local Features: White clay in water holes on Busuanga Island.
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^{a/} Soil symbols follow classification of U. S. Public Roads Administration, Principles of Highway Construction (June 1943) and War Department, Technical Manual 5-255 (December 1942), with the following modifications: ML may include A-6, A-7; CL may include A-4, A-7; OL may include A-4, A-7, but does not include A-6; OH and CH may include A-6.

^{b/} Intrazonal Soil: One which reflects dominating influence of some local factor of relief, parent material or age over the normal effect of the climate and vegetation.

EXPLANATION OF PATTERNS USED IN SOIL DIAGRAMS															
	BEDROCK		WEATHERED PARENT MATERIAL		GRAVEL		LOAM		SAND		SILT		CLAY		BOULDER

(continued)

PALAWAN PROVINCE (P. I.)

SOILS: BASIC DATA

Reliability ratings: Class D

Soil Type 5 <u>Sandy loam to clay loam; lateritic; friable; well-drained</u> 0 to (3-6)' and below: Sandy loam to clay loam; may be gravelly, stony; may contain sand or clay lenses at varying depths; reddish gray to brown or drab; iron concretions may be present where soil has weathered sufficiently. (3-6)' and below: Clay to sandy loam; brown to grayish dark yellow; white clay, sand, and gravel lenses, and weathered fragments of soft parent rock may be present. <u>Depth to Unweathered Bedrock:</u> 10 to 20 feet and deeper. <u>Parent Material:</u> Undifferentiated sandstone, shale, conglomerate, limy clay, and other sedimentary materials. <u>Relief:</u> Mountains, mountain valleys, slopes, and hills at altitudes commonly not over 3,000 feet. <u>Vegetation:</u> Primary jungle; grasses; some secondary growth. <u>Properties:</u> Commonly poor footing in rainy weather, despite very good drainage and a generally well-developed structure; when dry, may be locally dusty; moisture-holding capacity relatively high; the clay loam probably dries more slowly than Soil Types 1 and 2 but more rapidly than Soil Type 4, other conditions being equal. Slightly acid to slightly alkaline; a little organic matter may be present; moderately fertile. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> SF, SC, CL, ML; A-2, A-1, A-4, A-6, A-7.	Soil Type 6 <u>Clay to sandy loam; commonly lateritic; friable; well-drained</u> 0 to (0.3-6)' and below: Clay to sandy loam and clay loam; commonly stony, may be gravelly; brown, gray, yellow, red, of varied shades; color commonly paler with increase in altitude; iron concretions may be present, except where soil is insufficiently weathered. (0.3-6)' and below: Clay loam or clay; commonly stony; color generally paler than color of surface soil; in places, bedrock, weathered or unweathered, may be encountered. <u>Depth to Unweathered Bedrock:</u> Few feet to tens of feet and deeper. <u>Parent Material:</u> Unclassified rocks of diverse kinds. <u>Relief:</u> Mountains, mountain valleys, and higher slopes at altitudes up to 5,000 feet and higher. <u>Vegetation:</u> Primary jungle, probably some mossy forest; cogon grass; little secondary growth. <u>Properties:</u> Similar to Soil Types 1, 2, 3, 4, 5, 7. Most soils within Soil Type 6 may offer poor footing in rainy weather, despite their good drainage and well developed structure in undisturbed state; stability of soil structure under load varies within wide range. Acidity probably increases with altitude; at 4,000 to 5,000 feet pH of soil may be 4.5 to 4.0; organic-matter content probably diminishes with altitude; fertility varies over wide range. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> CL, ML, SF, SW, SC (may be stony); A-7, A-6, A-4, A-3, A-2, A-1 (may be stony).	Soil Type 7 <u>Clay loam; intrazonal^{b/}; plastic to friable; well-drained</u> 0 to (0.5-2.5)': Clay loam to clay; dark brown to almost black. (0.5-2.5) to (1-4)': Commonly hard compact sand, cemented with lime and silica; locally, fairly loose sand with coral and shell fragments; this horizon may be absent and clay loam may rest on almost unweathered coral limestone. (1-4)' and below: Unweathered bedrock. <u>Parent Material:</u> Coral limestone. <u>Relief:</u> Raised coral reefs at altitude generally not over 300 feet. <u>Vegetation:</u> Molave and some other trees; grasses and shrubs. <u>Properties:</u> Poor footing in rainy weather as soil is sticky, slippery; high moisture-holding capacity; fair to good drainage; when dry, has firm riding surface, compressible with little rebound on removal of load; may require less time to dry after rain than Soil Type 3 but more time than Soil Type 1. Slightly acid to slightly alkaline; organic matter may be present; concretionary lime is rare; chiefly a calcium-saturated clay; fertile. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> CL, ML; A-6, A-7, A-4. <u>Local features:</u> Considerable mixing with alluvium of diverse kinds may have occurred in places where topographic conditions are favorable; depth to unweathered bedrock is likely to exceed 4 feet where coral limestone is covered by alluvium and not by clay loam formed in place.	Soil Type 8 <u>Gravelly clay loam; plastic; intermittently flooded to well-drained</u> 0 to (4-6)': Gravelly clay loam; brown to grayish brown or black; iron concretions commonly present except where soil is insufficiently weathered; narrow areas of silt loam along stream courses. (4-6)' and below: Clay loam, with veins of precipitated aluminum hydroxide forming reticulated patterns; also alluvium, ranging in texture from clay to gravel, and fragments of stone, except for stiff plastic clays, underlying alluvium is probably not compact. <u>Depth to Unweathered Bedrock:</u> Tens of feet, in places more than 200 feet deep; soil shallow on raised coral reefs. <u>Parent Material:</u> Water-worked alluvium derived chiefly from Soil Type 1 and from diverse rocks of high iron content. <u>Relief:</u> Lowlands at altitudes commonly below 100 feet. <u>Vegetation:</u> Chiefly secondary jungle and cultivated rice and other crops. <u>Properties:</u> Poor footing in rainy weather, particularly where drainage is poor; firm surface in dry weather with little rebound on removal of load; despite high clay content, soil is permeable and drainage is determined chiefly by topography and by water table depth which may be only few feet. In old rice paddies a zone of compaction may have developed at 1 to 2 feet below the surface. Slightly acid to slightly alkaline; some organic matter in low-lying areas; fertile. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> ML, CL (gravelly); A-4, A-6 (gravelly). <u>Local Features:</u> (1) At Puerto Princesa gravelly clay loam overlies both shattered and solid coral rock. (2) In Iwahig River basin, gravelly clay loam is underlain by very plastic clays. (3) Little or no sand in river beds or along river courses in Iwahig-Puerto Princesa area but gravel and boulders may possibly be found.
Soil Type 9 <u>Gravelly sandy loam; plastic; intermittently flooded</u> 0 to (1-3)' and below: Gravelly sandy loam or sandy loam; grayish brown, gray, brown, or drab; iron concretions rare; lenses of silt loam or, near the coast, of clay loam may be found. (1-3)' and below: Great variety of deposits of different texture, from clay to gravelly sand, including also coral detritus and raised coral reefs. <u>Depth to Unweathered Bedrock:</u> May exceed 100 feet, except where soil rests on raised coral reefs; in latter case, depth is not likely to exceed 10 to 15 feet; see geologic map for locations of raised reefs. <u>Parent Material:</u> Water-worked alluvium of diverse kind. <u>Relief:</u> Lowlands at altitudes commonly below 100 feet. <u>Vegetation:</u> Coconuts; casuarina; shrubs and grasses; some primary and secondary jungle. <u>Properties:</u> Satisfactory footing probably is afforded as long as good drainage is maintained; locally surface may be stable under traffic in all weather; plastic character of soil is probably more pronounced in areas bordering on Soil Type 4. Slightly acid to slightly alkaline; organic matter probably very low; moderately fertile. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> SF, GF, GC, SC, ML; A-2, A-1, A-4. <u>Local Features:</u> (1) Possible tendency toward friability in this soil type in central and southern parts of Palawan Island. (2) Casuarina and coconut palm grow on a variety of soils, but are especially common on Soil Type 9 in Palawan; presence of either of these trees generally indicates sandy soil, commonly sandy loam.	Soil Type 10 <u>Clay loam; plastic; intermittently flooded</u> 0 to (3-6)' and deeper: Clay loam; grayish brown to brown or reddish brown; silt loam and gravel may be found in small lenses along stream banks; iron concretions may be present at different depths. (3-6)' and below: Varied textures, from clay to gravelly sand. <u>Depth to Unweathered Bedrock:</u> May exceed 100 feet. <u>Parent Material:</u> Water-worked alluvium of diverse kind. <u>Relief:</u> Lowlands at altitudes commonly below 100 feet. <u>Vegetation:</u> Primary jungle; some secondary jungle and grass; bamboo thickets; some rice paddies. <u>Properties:</u> Poor footing in rainy weather; probably requires more time to dry than Soil Types 8 and 9; when dry, may provide stable, reasonably firm surface. Likely to rut easily under traffic in wet weather and, despite permeability, will require most careful drainage. More plastic than friable, the soil is not devoid of structure either in dry or in rainy weather. Neutral to slightly acid; some organic matter is generally present; probably fertile in areas adjoining those of Soil Type 3. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> CL, ML; A-4, A-6, A-7. <u>Local Features:</u> (1) Area around Island Bay: 6 to 12 feet of red alluvial clay loam overlying a raised coral reef. (2) Sandy clay in grassy small plains near Malampaya Sound. (3) In poorly drained small valleys on Busuanga Island blue-white clay reported found in water holes.	Soil Type 11 <u>Clay loam; plastic; saline; waterlogged</u> 0 to (3-6)': Clay loam to clay; bluish gray; a few shell fragments and a little gravel may be present. (3-6)' and below: Clay to clay loam; mottled dark yellow or grayish yellow with rusty flecks. <u>Depth to Unweathered Bedrock:</u> May exceed 100 feet. <u>Parent Material:</u> Water-worked alluvium of diverse kind. <u>Relief:</u> Tidal swamps; salt water may be 2 to 6 feet deep at high tide. <u>Vegetation:</u> Mangroves; some nipa palms on the inner margin of swamps where the water is less saline. <u>Properties:</u> Upper few feet is sticky viscous mud; clay loam firmer below 3 to 6 feet. Poor footing; soil has low permeability. dries in firm hard lumps. Acidity increases with depth; organic matter and sea salts are present; soil is chiefly a sodium- and magnesium-saturated clay. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> CL, ML, some OH; A-6, A-7. <u>Local Features:</u> Strips of fairly clean sand may be present along either margin of mangrove swamps.	Soil Type 12 <u>Beach sand; well drained</u> 0 to (3-6)' and below: Sand, coarse, medium and fine; white, pale yellow, or grayish; very little fines; proportion of fines may increase with depth; gravel, boulders and stones may be present. (3-6)' and below: Coarse unconsolidated deposits; in places bedrock. <u>Depth to Unweathered Bedrock:</u> May exceed 10 to 15 feet. <u>Parent Material:</u> Rocks of diverse origin and kind. <u>Relief:</u> Narrow coastal beaches of varying length. <u>Vegetation:</u> Commonly barren; some coconuts and casuarina trees, some shrubs and grass on inner margin of beaches where sand commonly contains some fines. <u>Properties:</u> Good footing in all kinds of weather; stable surface when wet; firm sand, when damp, can support traffic loads; devoid of structure, cohesion, and elasticity; excellent drainage. Chiefly inert silica. <u>Engineering Group Symbol and P.R.A. Class^{a/}:</u> SP, SW, GP; A-3. <u>Local Features:</u> (1) Hard firm sand on eastern shore of Ulugan Bay. (2) Coarse sand with shells at beach northwest of Banua. (3) Sand beach erosion is known to proceed, in places, so rapidly as to cause disappearance of several feet of sand within one or two years' time, exposing underlying stones or bedrock; caution is urged therefore in relying on the presence of Soil Type 12 in places shown on the map, particularly where construction works (piers, moles, etc.) have been undertaken in recent years.

^{a/} Soil symbols follow classification of U. S. Public Roads Administration, Principles of Highway Construction (June 1943) and War Department, Technical Manual 5-255 (December 1942), with the following modifications: ML may include A-6, A-7; CL may include A-4, A-7; OL may include A-4, A-7, but does not include A-6; CH and OH may include A-6.

^{b/} Intrazonal Soil: One which reflects dominating influence of some local factor of relief, parent material or age over the normal effect of the climate and vegetation.

^{c/} Small areas of alluvial soils (Soil Types 8,9,10) do not appear on map.

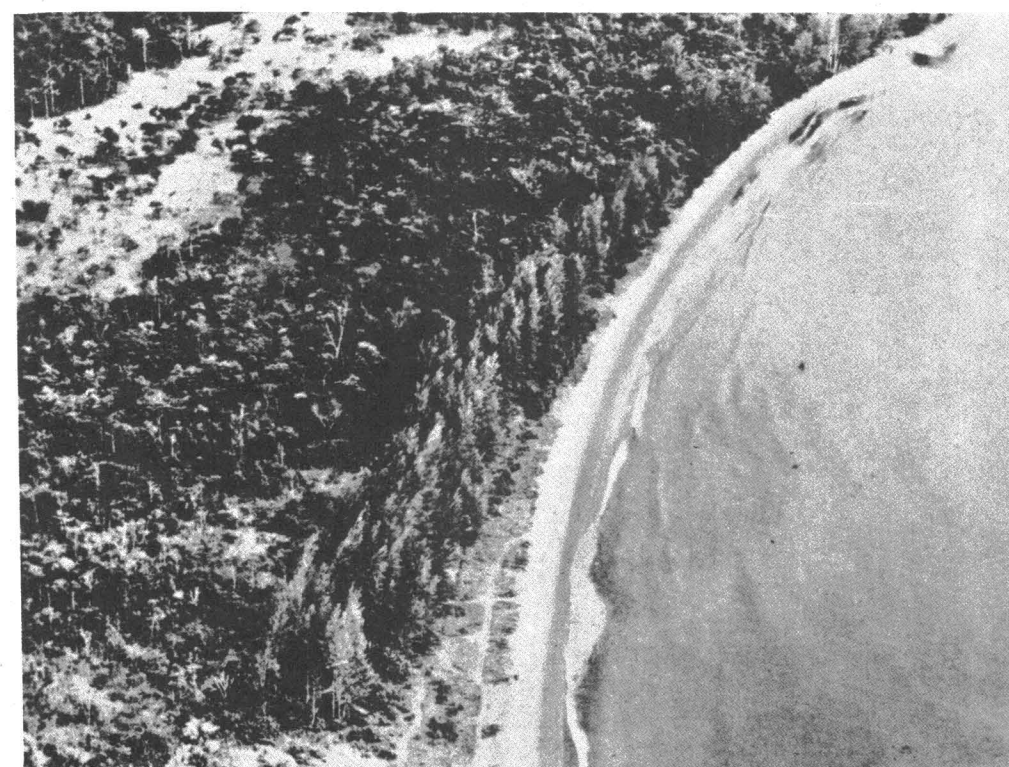
VEGETATION

FOR DISTRIBUTION OF VEGETATION TYPES, SEE AMS 5401 QUADRANGLE MAPS THAT FOLLOW VEGETATION VIEWS

PALAWAN PROVINCE (P.I.)

Reliability rating: Class B							
Vegetation Type	Distribution	Description	Movement	Effect on Military Operations		Clearing and Grubbing	Uses
				Observation	Concealment		
SANDY BEACH	On bold coasts, sandy beaches are absent and mixed inland flora reaches the sea; distinct beach flora lacking. Beaches commonly narrow, in places only a few yards wide. Settlements common on beaches; in many places original forest has been cleared for cultivation (see Cultivated Land). Casuarina (Agoho) trees in places occupy narrow belt along coast. Other beaches have several kinds of low-growing vegetation; pandan, or screw pine (Pandanus), may be abundant.	Casuarina type: Casuarina forms forests of medium-sized trees, 50 to 100 feet tall and 8 inches to 2 feet or more in diameter. Little undergrowth other than Casuarina seedlings; ground is carpeted with fallen twigs. Spacing is irregular, but trees commonly form fairly continuous canopy. Casuarina resembles pine and can be recognized from considerable distance offshore. Other types: Fairly thick tangled undergrowth of low shrubs, vines, and creepers common. Pandan is low, scrubby tree with long, broad, spiny-edged leaves; trunks may be 6 inches in diameter.	Vehicles: Casuarina stands offer little obstruction to cross-country movement. Spacing of trees irregular, but many lanes are wide enough for trucks. Open sandy beaches afford free movement. Other trees may have thick undergrowth that obstructs movement. Pandan grows fairly thickly; not difficult to clear; clearing probably not required for treaded vehicles. Foot troops: Movement on Casuarina beaches generally unimpeded; on some other beaches cutting is necessary. Broad spiny-edged leaves of pandan trees are a nuisance; paths readily cut.	Visibility little obstructed in Casuarina forests where undergrowth consists of Casuarina seedlings; may be only few tens of yards in forests with undergrowth.	All forest types afford fair to good concealment from aerial observation. Concealment from ground observation depends on density of undergrowth, which differs from place to place.	Casuarina trees require cutting or blasting; smaller trees of other types require cutting by power or hand saws; can be grubbed by angle-doser. Paths through dense undergrowth can be hacked out with bolos.	Casuarina wood very hard, heavy, and somewhat difficult to saw. Makes excellent firewood; suitable for house posts which will last 6 to 7 years. Trunks up to 2 feet, rarely 3 feet, in diameter. Other types of vegetation are scrubby and have little value.
MANGROVE SWAMP	Swamp areas not surveyed in detail; not very extensive, except in southernmost part of Palawan Island. Mangrove forests grow in salt and brackish water; generally occupy narrow belt a few yards to 1 or 2 miles wide; common around river mouths in heads of protected bays. Range limited by mud and tides; mangroves fringe streams to upper limit of tide; at high tide, water 3 to 4 feet deep in mangrove swamps; at low tide, ground may be exposed, but is wet and muddy. Forests interrupted by tortuous tidal channels of varying widths and depths. Nipa palms tolerate fresher water than other swamp forms; in places grow in inner margin of swamp, bordering estuaries, and along lower courses of rivers; in some areas form dense pure stands, without undergrowth, but in places are mixed with other forms; locally grow even on seaward edge of swamp.	Mangrove forests include several kinds of trees; some reach heights of 80 to 100 feet and diameters of 2 feet or more, but most are smaller. Trees form dense stands; nearly closed overhead canopy and little undergrowth. Various kinds of air roots extend upward to high-water level; may be straight, vertical stick-like roots standing close together, or dense tangles of curved roots (convex upward and outward from trunk). Nipa palms have creeping stems that send up clumps of leaves 8 to 12 feet high; generally in close pure stands without undergrowth, but in places mixed with mangrove and other kinds of trees; not distinguished from mangrove on map. Swamp interior may contain taban trees, rarely up to 2 feet in diameter, usually scattered. Straight, slender langeray trees 6 to 8 inches in diameter, rarely up to 16 inches, form pure stands in many places. Large trees, known as dumogon-lata are scattered locally along landward edge of swamp.	Vehicles: Barrier areas. Even where vegetation is cleared, areas are impassable; at high tide, ground is under 3 to 4 feet (more in tidal channels); foot travel is then practically impossible. At low tide footing is bad owing to soft mud and common air roots, in many places covered with sharp-edged shells. Common practice is to walk the tangle of air roots, using trunks and branches for support; footing poor on slippery roots. Many deep, muddy tidal channels; thick tangles of vines and other undergrowth in places at landward edge of swamp. Nipa stands are dense and difficult to penetrate. Crocodiles are common and sometimes troublesome. Poisonous snakes are much commoner than elsewhere, but are sluggish and rarely cause trouble. Biting flies and mosquitoes are most disagreeable features; sometimes very abundant, at other times scarcely noticeable. Boats: At high tide, landing craft and canoes may push through mangrove forest in many places; at low tide confined to tidal channels. Penetration of nipa swamp is difficult as water is generally too shallow; possible along open channels. Abundant nipa along a stream indicates fairly deep water.	Visibility generally restricted to a few score feet.	Concealment of personnel from ground and aerial observation, is excellent.	Trees must be felled by hand or power saws. Logs and roots, where accessible to land equipment, may be removed by tractor and angle-doser; elsewhere they may be dragged out by winch and cable carried out on foot; larger timbers for piling or other heavy construction are dragged out by winch and cable on anchored boats. Nipa and tangles of mangrove roots can be cut out with saws and bolos.	Mangrove forest is prime source of firewood. Larger trees have hard, heavy, rather straight-grained wood, strong enough for house posts and for temporary construction; in the ground, wood lasts 5 to 8 years. Firewood is cut by hand and carried out on foot; larger timbers for piling or other heavy construction are dragged out by winch and cable on boats. Slender trunks of langeray trees (6 to 8 inches in diameter) are useful for temporary piling and will last 1 to 5 years. The dumogon-lata tree furnishes strong, exceedingly tough wood suitable for heavy construction; one of the few local woods that can withstand repeated shocks; recommended for bridge timbering. Taban trees, if sufficiently large, can furnish wood of excellent durability for salt-water piling. Bark of several species of trees contains much tannin; widely used for staining and preserving fish nets and useful for preserving other fabrics, such as camouflage nets; stain is brown; principal use of nipa is for making prefabricated thatching, which lasts 5 to 7 years.
CULTIVATED LAND	Limited generally to small coastal areas, because of scanty population. Principal crops are coconuts and rice. Coconut palms are most common on sandy soil on or near beaches. Two types of rice in the Philippines: irrigated rice in lowlands; dryland or upland rice, generally cultivated in small patches in hilly country, after cutting and burning forest cover. In Palawan Island, irrigated rice paddies are known around Iwahig (near Puerto Princesa) and are probably present in areas of Malampaya Sound and Taytay Bay. Dryland rice is known to have been cultivated in places on eastern coast of Palawan Island. Fruit trees and vegetables may be grown in garden plots.	Coconut palms are planted in regular rows, generally 30 feet or more apart. Most trees are 30 to 50 feet high, but may reach 80 feet; trunks 8 to 12 inches in diameter. In many places they form a fairly close overhead canopy; elsewhere they are more widely spaced. Irrigated or lowland rice land is divided into small level paddies enclosed by earthen dikes about 8 inches to 1 foot high and 1 to 2 feet wide. In harvesting season, most rice fields are dry; ground softens very quickly during rains. Bamboo is also known; forms dense clumps and thickets. Experimental sugar plantations reported in vicinity of Puerto Princesa.	Vehicles: Free movement in coconut groves wherever slope and ground permit. Irrigated rice fields difficult to cross when wet; those on higher ground can be drained by breaking dikes; when dry are firm and readily crossed by wheeled vehicles; if dikes are breached; ground quickly becomes muddy during rains. Foot troops: Movement easy everywhere except in wet rice lands; these most easily crossed over narrow paths on dikes.	Visibility good in most places.	Most coconut groves can conceal vehicles and personnel from aerial observation, but not from nearby ground observation.	Coconut palms are readily pushed over by tractor, or may be felled by hand saw. Most other cultivated growth readily cleared with bolo knives.	Food crops. Trunks of coconut palms, generally 8 to 12 inches in diameter, useful in constructing temporary corduroy roads on boggy ground, temporary retaining walls, and other similar structures.
GRASSLAND	Burned over and abandoned areas are occupied by the coarse grass known as cogon (alang alang in Netherlands Indies); such areas known as cogonales. Much less extensive than in other Philippine islands, because of scanty population. Principal areas are in Busuanga Island. Found at altitudes from sea level to about 5,000 feet on all types of terrain except permanently swampy ground. Its presence generally indicates relatively dry ground; other somewhat similar grasses may occupy swampy land.	Cogon is a very coarse wild grass generally 2 to 5 feet high; in moist localities, such as valley bottoms, up to 8 feet high. Forms low, thick matting; burns readily when dry and makes a quick hot fire; after being burned off, grows back quickly.	Vehicles: Generally passable to motor traffic where slope and ground permit. Larger permanent streams flowing through grassland areas are generally marked by shrubs or trees. Very small or intermittent streams, and the gullies they follow, may be concealed from ground observation by the dense grass; are hazards to movement off trails. Foot troops: Movement off trails possible everywhere, but tedious owing to density and coarseness of grass, to an irritating dust from dry leaves, and to intense heat of direct and reflected sunlight; sharp grass blades cut skin; trampled grass forms slippery footing on slopes, but grass clumps can provide handholds. In dry months, large grass fires spread swiftly and may be a hazard.	Visibility excellent where grass is not too tall.	Tall cogon grass provides good concealment from ground observation, but not from aerial observation.	In dry months, cogon grass may be readily cleared by burning; at other times by mower or by hand.	Young shoots of cogon grass make rather poor forage; older grass is too harsh. Bundles of cogon widely used for thatching.
SECONDARY FOREST	Secondary forest may occupy any kind of terrain except swamps; covers large areas originally occupied by virgin forest which was cut and burned to permit cultivation. After short period of cultivation such cleared areas are abandoned and generally revert to cogon grass, which in turn is replaced by secondary forest; that ultimately becomes primary forest.	Secondary forest is varied in composition. Where clearing was comparatively recent (especially at edge of high forests), there is an exceedingly dense growth of low, mostly soft-wood trees and vines, and a scattering of large and partly rotted logs. Where original forest was cut many years ago and fires have been frequent, there are open park-like grassy areas with scattered thickets of scrubby trees.	Vehicles: Open park-like areas suitable for free movement where slope and ground permit. Wheeled vehicles cannot move through dense secondary forest; heavy clearing necessary. Tracked vehicles can penetrate some younger secondary growth. Foot troops: In dense thickets of younger secondary forest, penetration is slow and difficult; necessitates much cutting. Movement easy in open park-like areas.	Visibility limited to a few yards in many dense thickets; good visibility in park-like areas.	Dense thickets provide good concealment for personnel and parked vehicles; open park-like areas offer limited concealment.	Clearing of dense thickets requires much cutting with hand tools, some blasting and grubbing with clearing equipment. Paths for foot troops may be cleared with bolos.	Secondary forest has little value. Wood is soft and small; makes fair firewood. Some kinds can be used for light temporary construction, but most are useless.
PRIMARY FOREST (including Mossy Forest)	Primary forest (tropical rain forest) is widespread in higher hills and mountains and on some lowlands; originally it covered nearly all the land area. Humidity is higher in primary forest, especially near ground, than in other areas; humidity highest in mossy forest. At higher altitudes, where humidity is always great and approximates complete saturation for long periods, primary forest gives way to mossy forest; altitude of transition may be 3,000 feet or higher, depending on prevailing altitude of cloud layers. Large stands of molave trees grow on limy soil, ipil trees on alluvial soils.	Many big trees tower over successively smaller trees. Forest canopy is thick enough to shut out sunlight almost completely; may be 100 or more feet high with some trees standing higher. Spacing of trees irregular, but in many places wide enough to permit passage of trucks. Trunks up to 6 feet or more in diameter; many have large buttresses (vertical-supporting walls) a few inches to a foot thick, 10 to 20 feet high, and some extending as much as 30 feet out from trunks. Undergrowth may be fairly dense, but in many types of forest it is negligible. At edge of forest a dense secondary growth of vines and creepers forms a wall generally only a few yards wide but reaching to tree tops. Mossy forest consists of dwarf trees; at lower edge of forest these may be about 40 feet high; smaller at higher altitudes. Branches are tangled and distorted near ground; many roots grow above ground, forming tangles 3 or 4 feet high. Leaves, branches, trunks, exposed roots, and ground are covered with spongy, soggy mosses and similar growths.	Vehicles: In many places movement through high forest nearly unimpeded by vegetation; elsewhere, especially at edge of forest, cutting of vines and undergrowth is necessary; much clearing necessary in mossy forest. Foot troops: Going is easy in high forest; in some types, occasional cutting of vines and small growth is required. Going is difficult in dense growth at edge of forest; in mossy forest, low distorted branches and tangles of exposed roots, largely festooned and concealed by damp mosses, make going slow and difficult. Sounds quickly absorbed in mossy forest; movement makes little noise.	In many places it is impossible to see more than 20 or 30 yards in any direction. Some tree tops provide lookouts.	Dense forest canopy gives perfect concealment from aerial observation. Good concealment from ground observation provided by larger trees, especially those with broad buttresses (trunks can give limited cover from small-arms fire).	Heavy equipment and blasting required to remove large trees. Undergrowth can generally be cleared with hand tools. Burning of high forest possible with some difficulty, in drier months; practically impossible in mossy forest owing to saturation.	Primary forest provides many kinds of excellent timber suitable for light and heavy construction; supplies of firewood readily obtained from fallen trees. Molave and ipil trees are important source of heavy construction timber (hardwood).

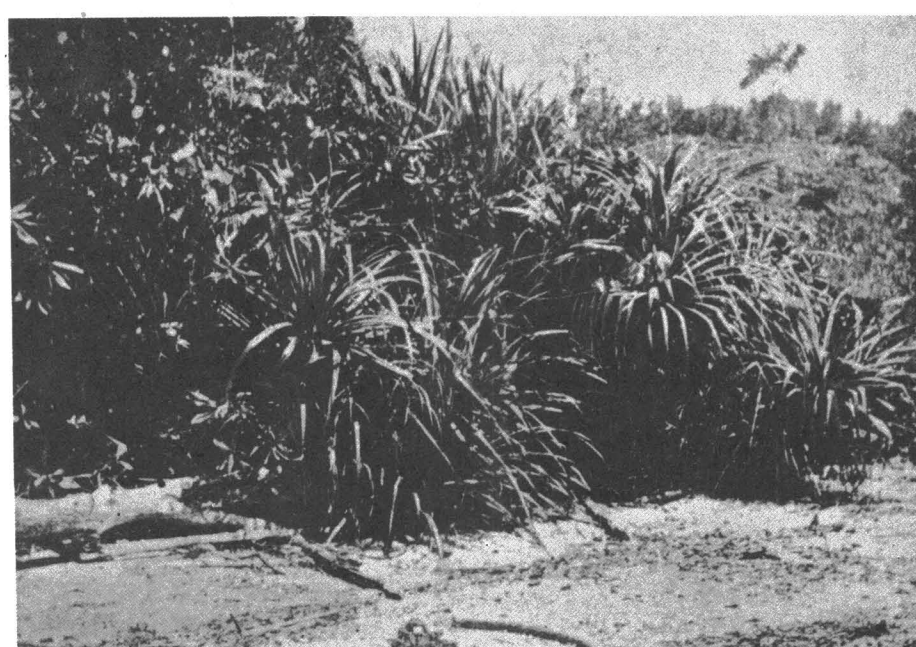
Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.



1 Casuarina trees may commonly fringe low shores. Pine-like in appearance, they are generally so spaced that they are no obstacle to movement. Undergrowth sparse or lacking. Casuarina trees commonly grow on relatively well-drained sandy shores. (Janis, Military Geography Netherlands New Guinea, M-71)



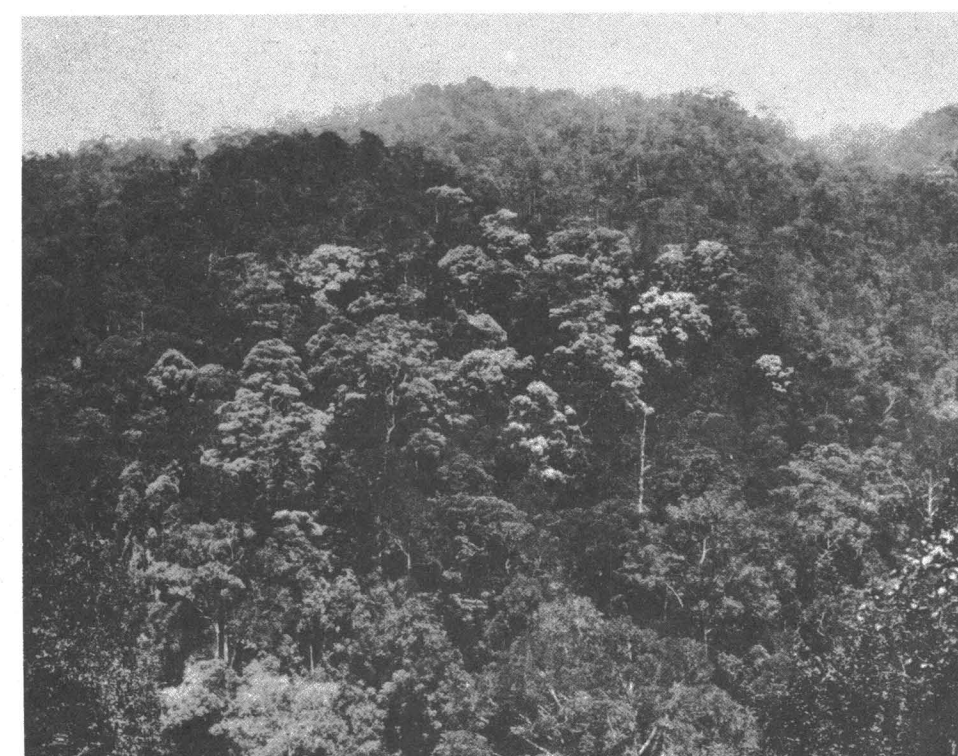
2 Mangrove swamps along low muddy shores form dense thickets through which movement is difficult. At low tide, air-roots and muddy ground hinder movement; at high tide, water reaches approximately to tops of air-roots. Small channels and passages through mangrove swamps are common. Visibility limited; concealment from ground and aerial observation good. (Whitford, Forests of the Philippines)



3 Pandanus or screw pine may be common along shores and in areas of swampy ground. Trunks, frequently lying on ground, and rank growth of sharp spiny leaves troublesome. (Schimper, Plant Geography)



4 Dense primary forests consist of tall trees whose crowns form almost complete canopy topping smaller trees. Undergrowth may be relatively sparse and forest sufficiently open for relatively easy movement. Tangles of low shrubs, vines, and creepers common. Visibility limited; concealment from ground and aerial observation excellent. (Whitford, Forests of the Philippines)



5 Primary forest in hilly terrain shows dense leafy canopy. Few trees extend above the general canopy level, which may be as much as 150 feet high. Such forests are most extensive vegetation type on Palawan Island. Concealment excellent. (Foxworthy, Commercial Timber Trees of the Malay Peninsula)



6 Moss forests are found only at high altitudes where low-lying clouds keep the vegetation bathed in mist. Trees are smaller than in typical primary forest and covered with thick growths of moss. The thick moss mat covering the ground and fallen, rotting trees, hinders easy movement and damps sound. (W. H. Brown, Vegetation of Philippine Mountains)



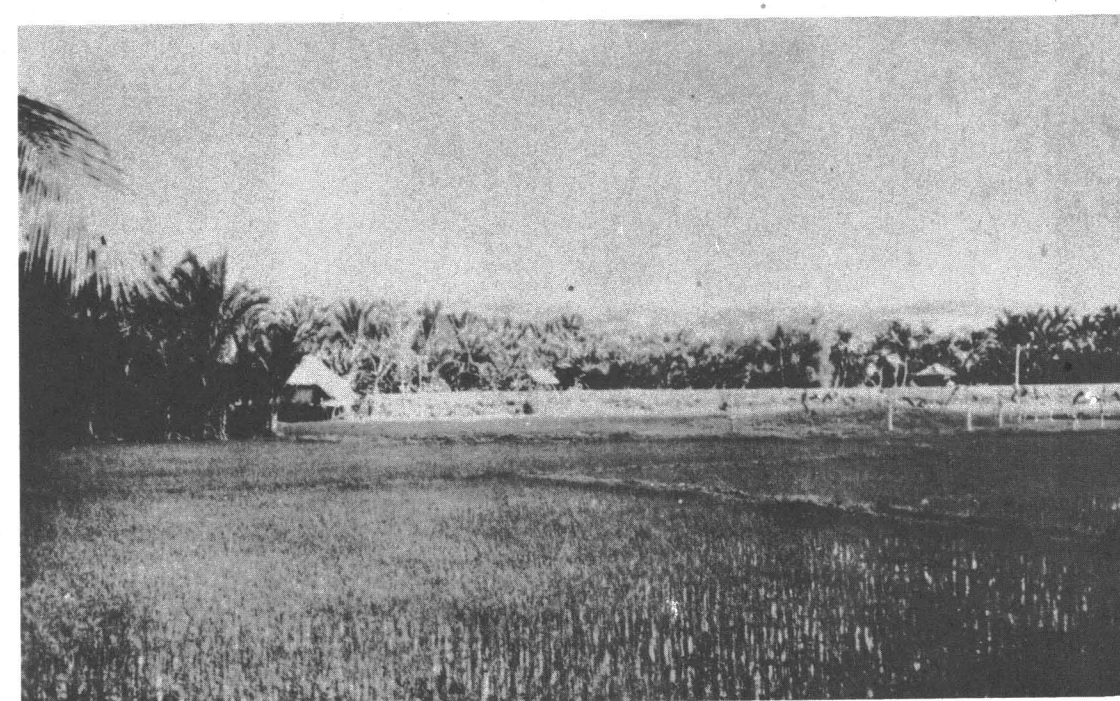
7 Secondary forest consists of rank growth of low trees and shrubs forming almost impenetrable thickets. Older secondary forests have less undergrowth and a few higher trees. Movement through secondary forests difficult. (Whitford, Forests of the Philippines)



8 Cogon grassland characteristic of large cleared areas. Coarse grass generally grows to height of 2 to 3 feet, rarely to 6 feet or more. Dense grass usually chokes and prevents growth of other vegetation. During dry periods grass can be burned. (OSS 113242)



9 Cultivated coconut plantations have trees planted in regular rows 25 to 30 feet apart. Plantations are generally cleared of undergrowth; motorized units can pass between trees. Footing usually good. (Janis, Military Geography Netherlands New Guinea, M-71)



10 Irrigated rice paddies are separated by low dikes for control of water. When flooded, paddies are muddy to depths of approximately 2 feet; at other seasons provide firm footing. Several crops a year may be grown on the same field. Some paddies may be flooded when those adjacent are dry. Drainage of paddy fields generally easy. (ONI 221-055)

PHILIPPINE ISLANDS 1:500,000

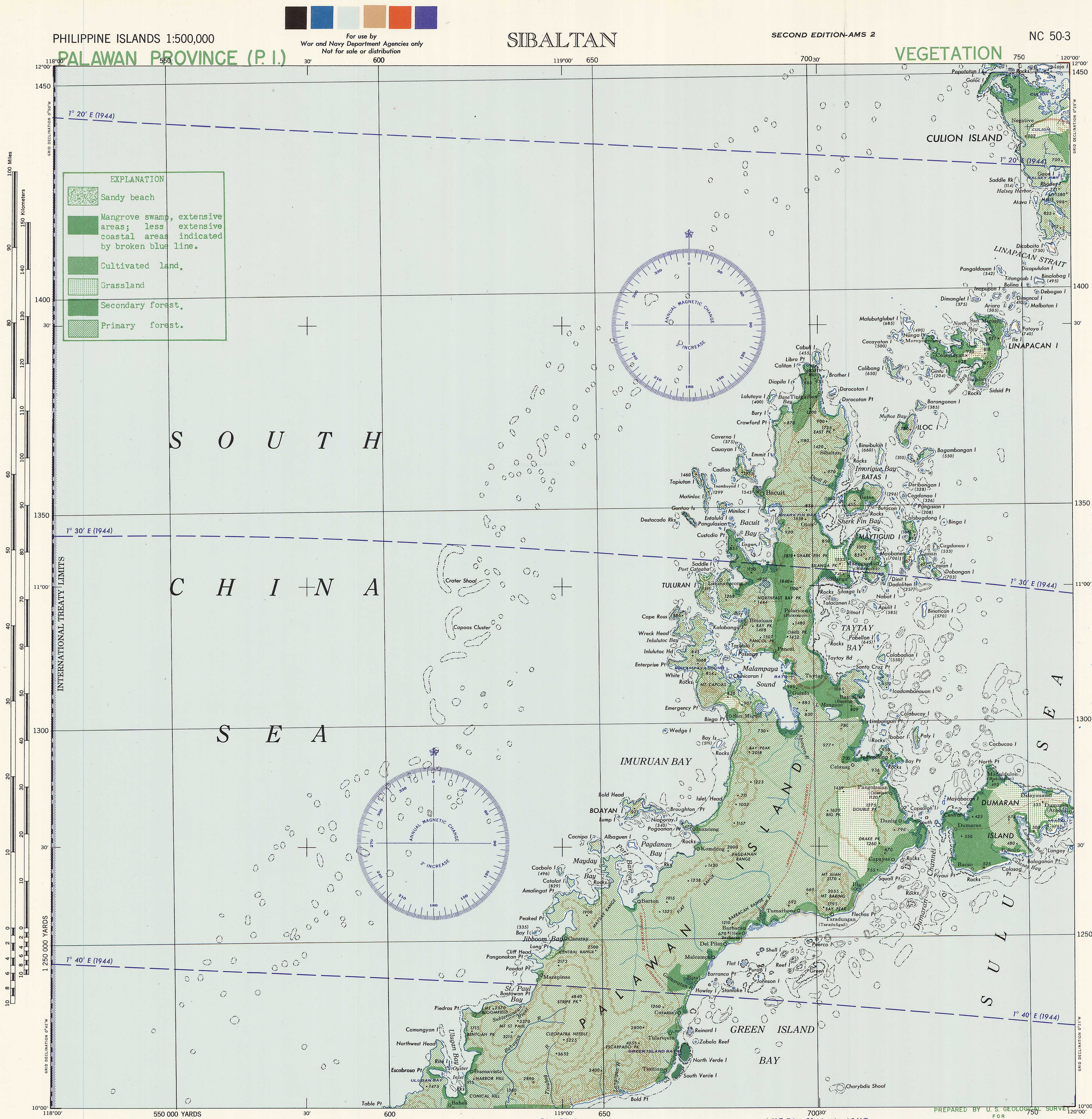
PALAWAN PROVINCE (P. I.)

SIBALTAN

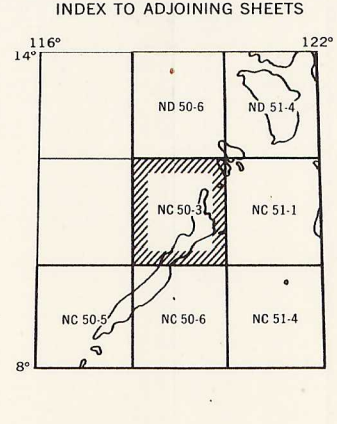
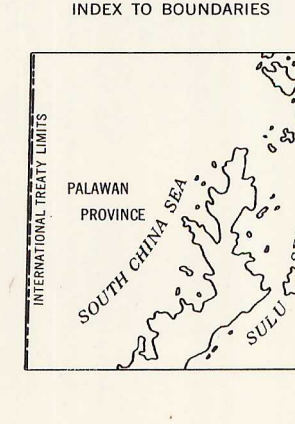
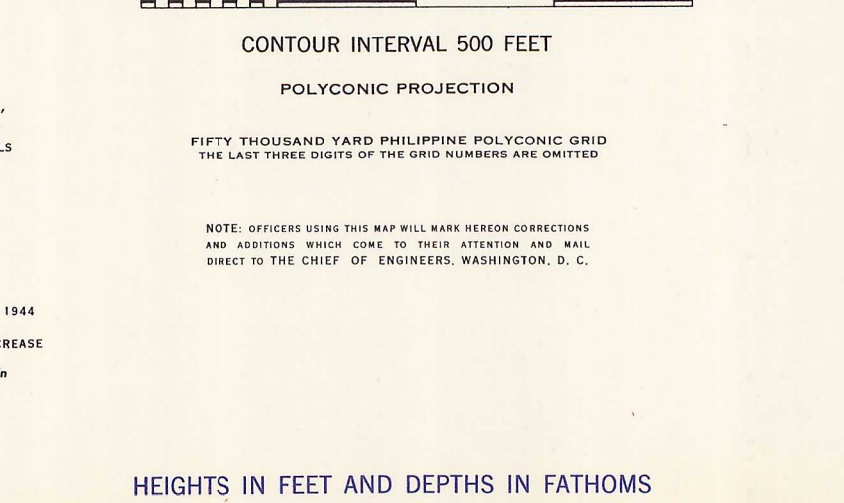
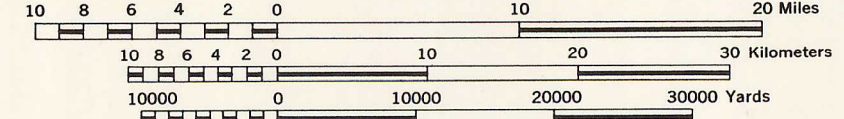
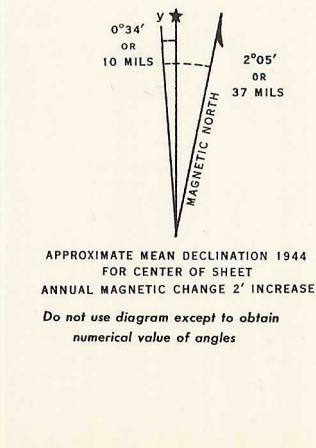
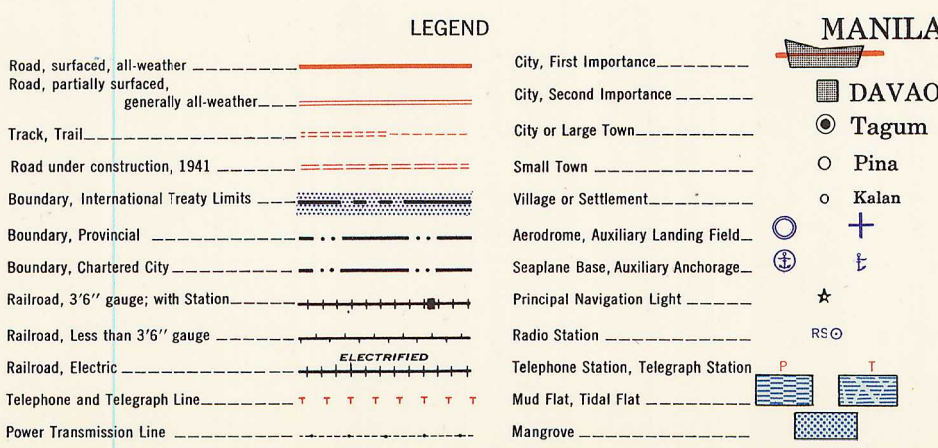
SECOND EDITION-AMS 2

NC 50-3

VEGETATION



A.M.S. S401
First Edition (AMS 1), 1943
Second Edition (AMS 2), 1944
Prepared under the direction of the Chief of Engineers, U. S. Army, by
the Army Map Service (AMS), U. S. Army, Washington, D. C., 1944.
Compiled from: Sectional Aeronautical Chart 1:500,000 USC & GS, No. 5, 1941. USC & GS Charts 4313, 1917;
4316, 1938; 4317, 1918; 4319, 1920; 4321, 1920; 4714, 1936; 4716, 1938.
Volumes I and V, Commission of the Census, Commonwealth of the Philippines, 1940. Intelligence Data, 1943.
Roads from: Official Road Map of the Philippines, 1:500,000 Bureau Public Works, No. 14, 1941.



Broken Shorelines Indicate Mangrove
SIBALTAN, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N1000-E11800/200

PHILIPPINE ISLANDS 1:500,000

PALAWAN PROVINCE (P.I.)

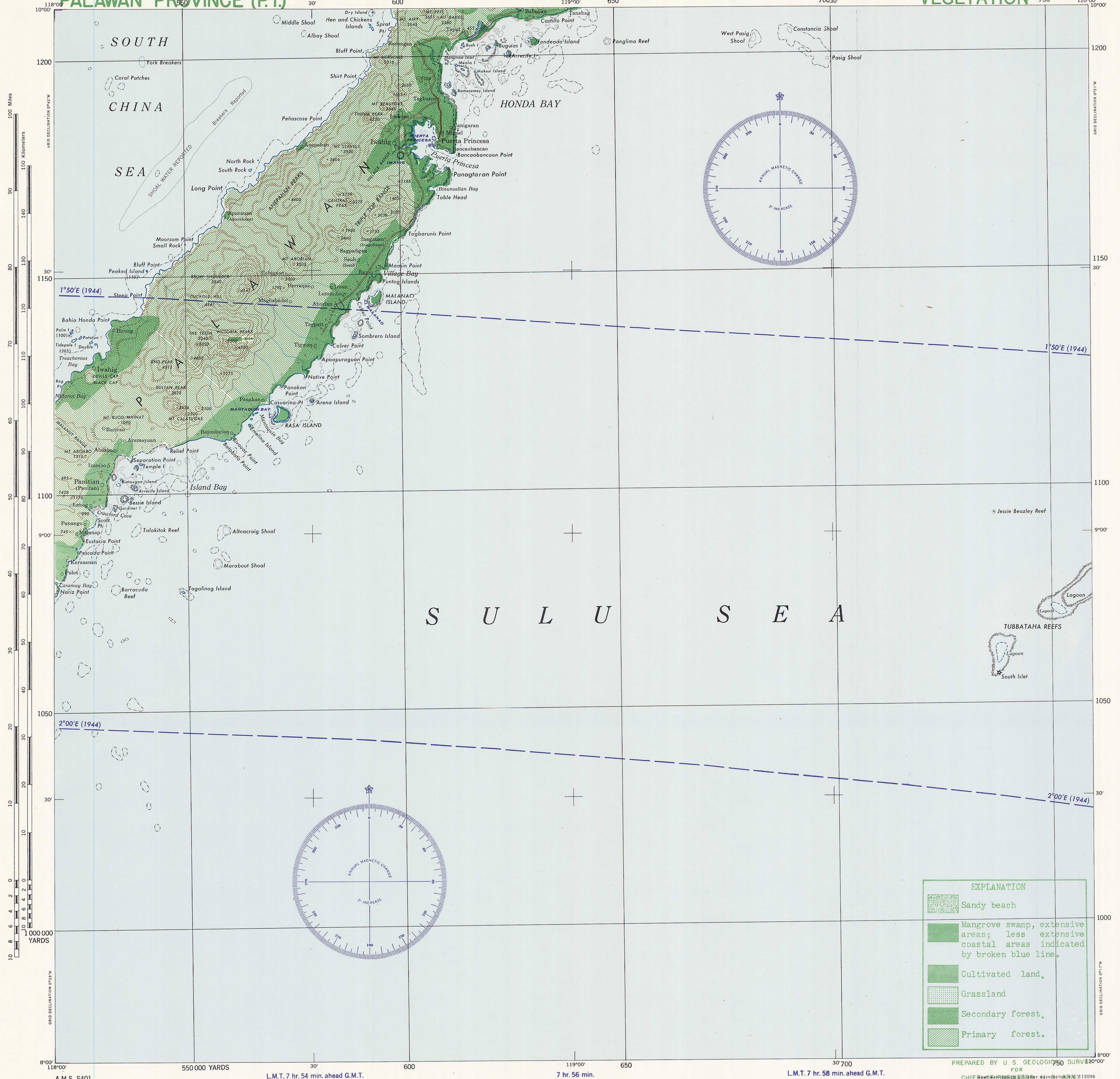
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PUERTA PRINCESA

SECOND EDITION - AMS 2

NC 50-6

VEGETATION



PUERTA PRINCESA, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N800-E11800/200

PHILIPPINE ISLANDS 1:500,000

PALAWAN PROVINCE (P.I.)

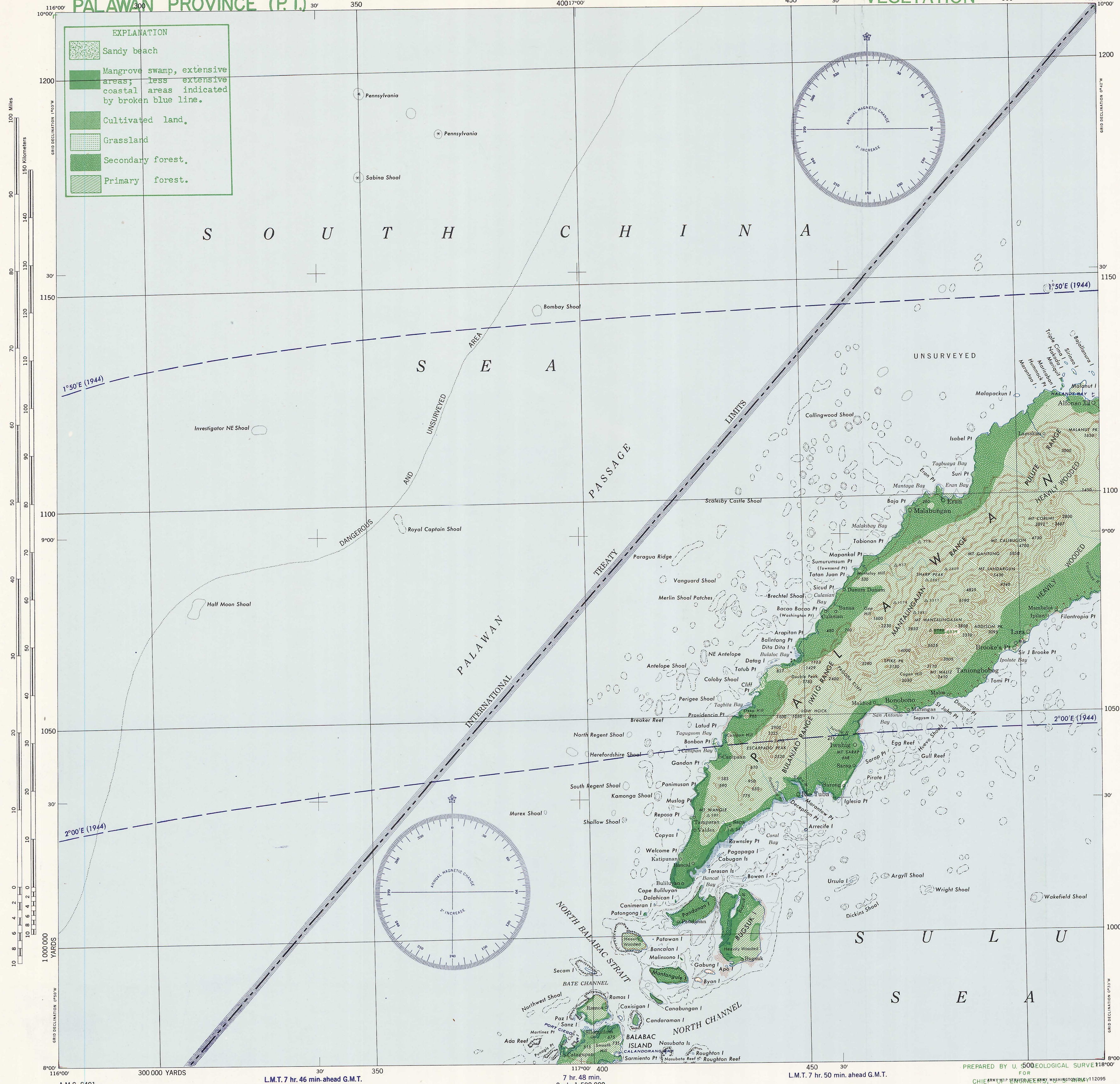
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SARAP

SECOND EDITION-AMS 2

NC 50-5

VEGETATION



A.M.S. S401.

L.M.T. 7 hr. 46 min. ahead G.M.T.

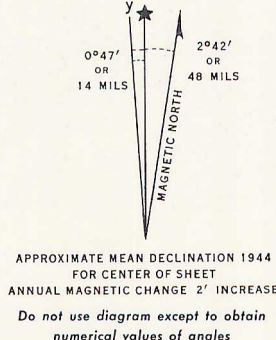
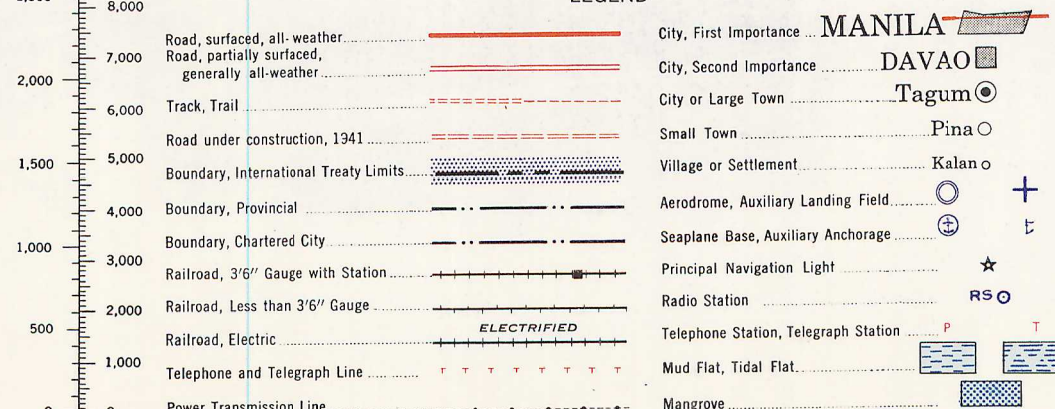
Scale 1:500,000

L.M.T. 7 hr. 50 min. ahead G.M.T.

PREPARED BY U. S. 5000 ECOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY, WASHINGTON, D. C. 112095
1944

CONVERSION
GRAPH
NOT at the scale
of the map.
Meters Feet
3,000 10,000
2,500 8,000
2,000 7,000
1,500 5,000
1,000 3,000
500 2,000
0 1,000
0 0

LEGEND

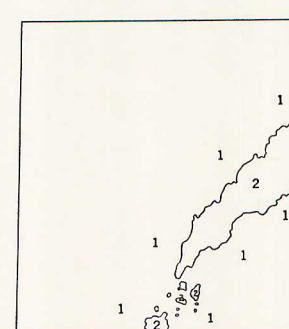


CONTOUR INTERVAL 500 FEET

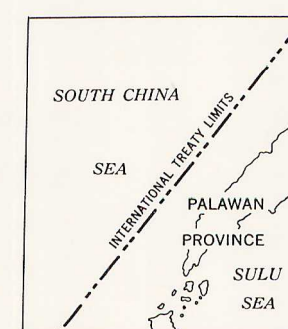
POLYCONIC PROJECTION
FIFTY THOUSAND YARD PHILIPPINE POLYCONIC GRID
THE LAST THREE DIGITS OF THE GRID NUMBERS ARE OMITTED

HEIGHTS IN FEET AND DEPTHS IN FATHOMS

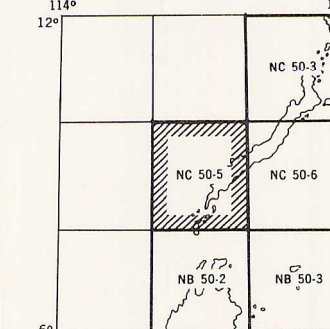
COVERAGE DIAGRAM



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INDEX TO ADJOINING SHEETS



1. USCG Charts (Reliable Surveys).
2. Sectional Aeronautical Chart, 1:500,000
(Compiled Map, Reliability Fair).

Broken shorelines indicate mangrove

SARAP, PHILIPPINE ISLANDS
N800-E1600/200

PHILIPPINE ISLANDS 1:500,000

PALAWAN PROVINCE (P. I.)

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BALABAC STRAIT

SECOND EDITION - AMS 2

NB 50-2

VEGETATION

AMS S401.
First Edition (AMS 1) 1943.
Second Edition (AMS 2) 1944.

Prepared under the direction of the Chief of Engineers, U. S. Army, by the Army Map Service (AM),
U. S. Army, Washington, D. C., 1944. Compiled from USCGS Charts 4309, 1921; 4326, 1940; 4720, 1936;
U. S. Hydrographic Chart 2119, 1938. North Borneo, 1:380,160, USGS 4311, 1942, reprint of LSD, East
and West Sheets, 1941. Kudat and Marudu Bay, 1:126,000, West Coast and Interior of North Borneo,
1:126,000, District Maps of North Borneo, Various Scales, 1928-39. Environs of Kudat, 1:34,290, Survey
of North Borneo, Sheet Brunei and Sarawak, WGS, 1943. Vols. I & V, Commission of the Census,
Commonwealth of the Philippines, 1940. Intelligence Data, 1943.

LEGEND

- | | | |
|---|------------------------------------|--------|
| Road, surfaced, all-weather | City, First Importance | MANILA |
| Road, partially surfaced, generally all-weather | City, Second Importance | DAVAO |
| Track, Trail | City or Large Town | Tagum |
| Road under construction, 1941 | Small Town | Pina |
| Boundary, International Treaty Limits | Village or Settlement | Kalan |
| Boundary, Provincial | Aerodrome, Auxiliary Landing Field | |
| Boundary, Chartered City | Seaplane Base, Auxiliary Anchorage | |
| Railroad, 3'6" Gauge, with Station | Principal Navigation Light | |
| Railroad, Less than 3'6" Gauge | Radio Station | |
| Railroad, Electric | Telephone, Telegraph Station | |
| Telephone or Telegraph Lines | Mud Flat, Tidal Flat | |
| Power Transmission Line | Mangrove | |

POINT MASIN		LETTERS C.W.	
Take West edge of square in which point lies, and read the figure printed opposite this line on the left margin or on the line itself on the face of the map.	Estimate Number Eastward	Take South edge of square in which point lies, and read the figure printed opposite this line on the left margin or on the line itself on the face of the map.	Estimate Number Northward
37	To nearest 1,000 yards	3	To nearest 1,000 yards

GLOSSARY

Batu: rock	Pulau: P. island
Besar: great	Sungai: S. river
Bukit: B. hill	Tanjung: T. cape
Gunung: Gn. mountain	Teluk: Tk. bay
Kechil: small	Trusan: Tr. channel, tributary
Kuala: Ka. river mouth	

 CONTOUR INTERVAL 500 FEET
 POLYCONIC PROJECTION
 U. S. YARD GRID
 N. E. 1, EQUATORIAL ZONE

Projection: Lambert Conical Orthomorphic
 Spheroid: Bessel
 Origin: Equator and 110°E
 False Co-ordinates: 4,265,095.6 yards East
 of Origin: 984,252.8 yards North
 Scale Factor: .997

FIFTY THOUSAND YARD PHILIPPINE POLYCONIC GRID
 THE LAST THREE DIGITS OF THE GRID NUMBERS ARE OMITTED

NOTE: OFFICERS USING THIS MAP WILL MAKE HEREON CORRECTIONS
 AND ADDITIONS WHICH COME TO THEIR ATTENTION AND MAIL
 DIRECT TO THE CHIEF OF ENGINEERS, WASHINGTON, D. C.

 HEIGHTS IN FEET AND
 DEPTHS IN FATHOMS

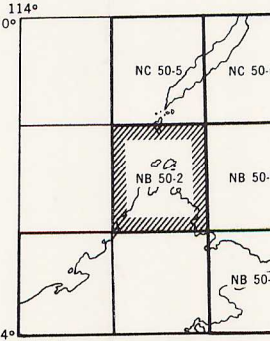
COVERAGE DIAGRAM



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 BALABAC STRAIT, PHILIPPINE ISLANDS
 N600-E11600/200

PHILIPPINE ISLANDS 1:500,000

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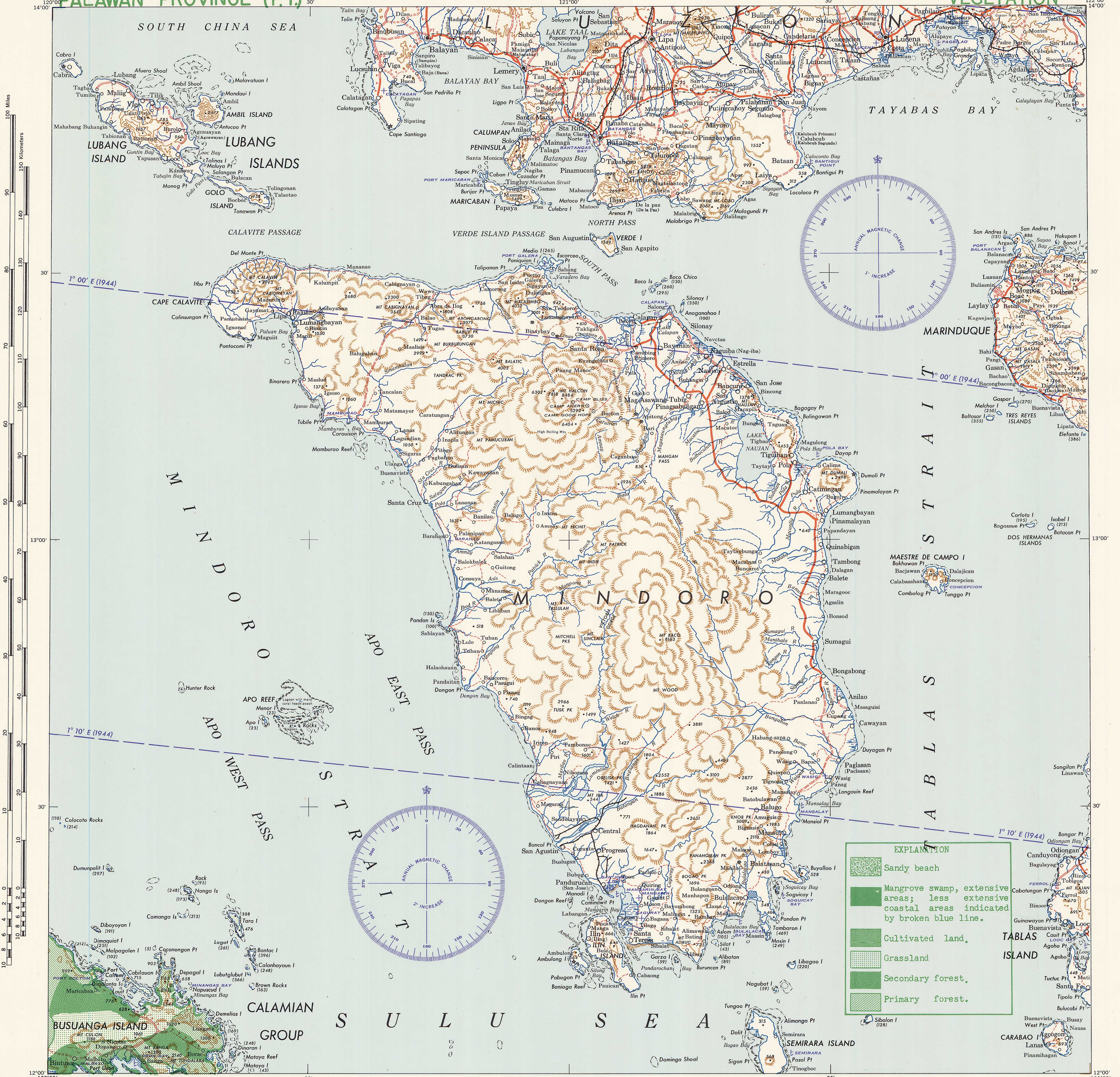
MINDORO ISLAND

SECOND EDITION-AMS 2

ND 51-4

PALAWAN PROVINCE (P.I.)

VEGETATION



A.M.S. 5401
First Edition (AMS 2) 1943.
Second Edition (AMS 2) 1944.
Prepared under the direction of the Chief of Engineers, U. S. Army, by the
Army Map Service (AMS), U. S. Army, Washington, D. C., 1944.
Compiled from: Luzon 1:63,360, AMS reprints 1942; and C.O.E. Phil. Dept. original 1913; Sec. Aero. Chart,
1:500,000, USC & GS, No. 2, 1941; USC & GS, Chart 4214, 1933; 4218, 1941; 4205, 1939; 4214, 1913;
4338, 1914; 4339, 1912; 4340, 1939; 4351, 1916; 4410, 1913; Philippine Islands, 1:200,000, USC & GS, No. 8,
1940; No. 10, 1935; Vols. I & V, Commission of the Census, Commonwealth of the Philippines, 1940; Intelligence
data, 1943; Roads from: Mobil Road Map of the Philippines, 1:1,100,000, Standard Vacuum Oil Co., P. I., 1941;
Philippine Islands, 1:200,000, USC & GS, 1935-1940; Official Road Map of the Philippines, 1:500,000, Bur. Pub.
Works, Nos. 4 and 6, 1941; Tel. & Tel. from: Communication Map of the P. I., 1:400,000, Hq. Mil. Int. Phil. Dept.
CM 14-3, 1931 (Corrected to 1940, AMS); Transmission Lines from: Philippine Islands, 1:1,000,000, USC & GS,
No. 100, 1933.

CONVERSION
GRAPH
NOT at the scale
of the map.

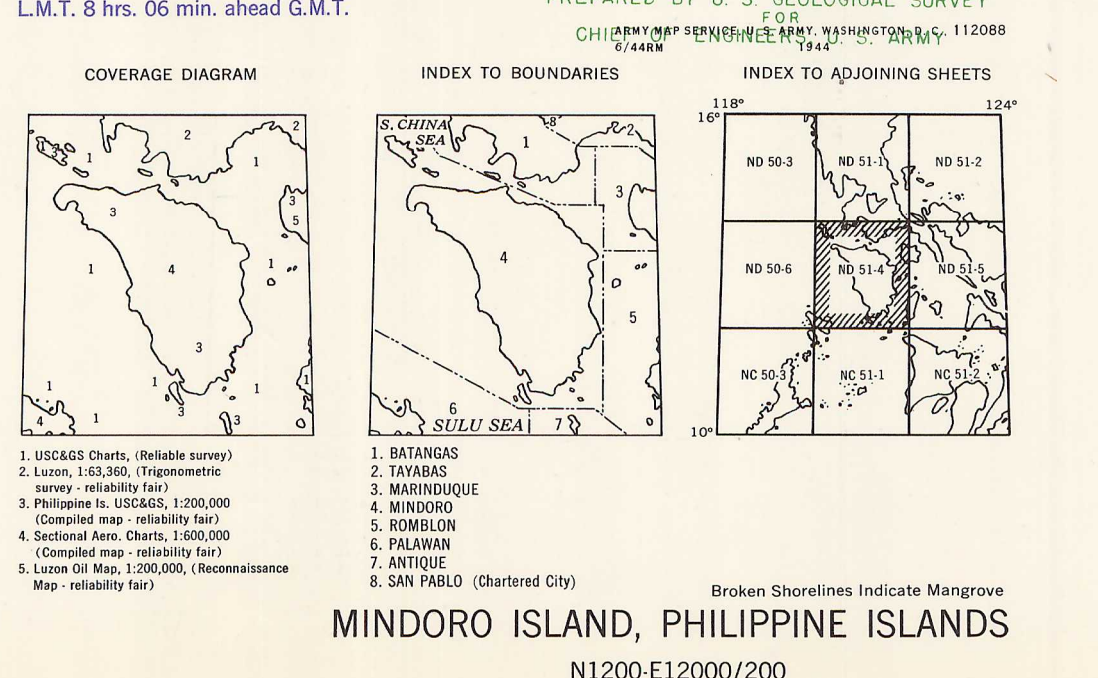
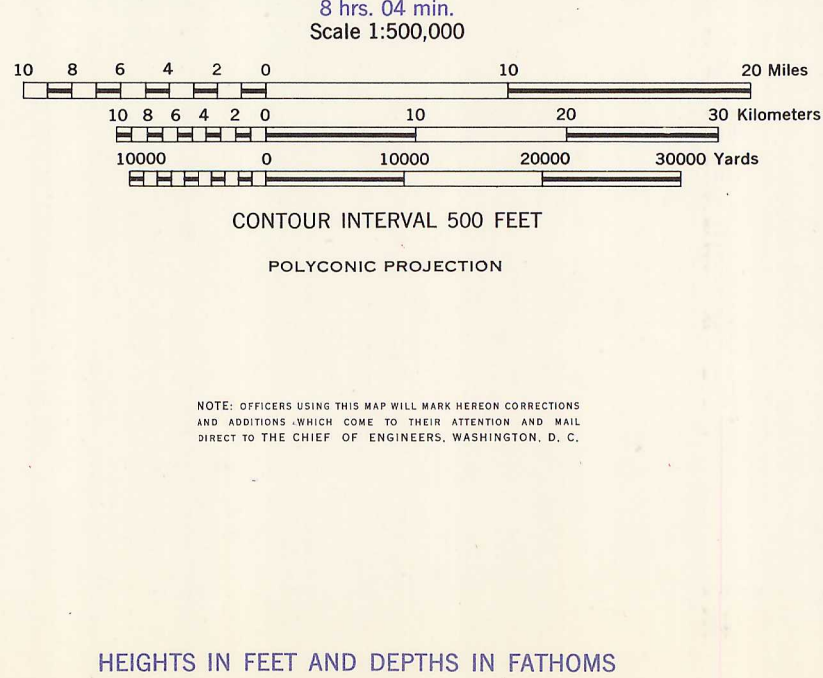
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
Meters
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
Feet

LEGEND

City, First Importance
City, Second Importance
City or Large Town
Small Town
Village or Settlement
Aerodrome, Auxiliary Landing Field
Seaplane Base, Auxiliary Anchorage
Principal Navigation Light
Radio Station
Telephone Station, Telegraph Station
Mud Flat, Tidal Flat
Mangrove

MANILA
DAVAO
Tagum
Pina
Kalan
Star
Mangrove

Road, surfaced, all-weather
Road, partially surfaced
generally all-weather
Track, Trail
Road under construction, 1941
Boundary, International Treaty Limits
Boundary, Provincial
Boundary, Chartered City
Railroad, 3'6" gauge, with Station
Railroad, Less than 3'6" gauge
Railroad, Electric
Telephone and Telegraph Line
Power Transmission Line



PHILIPPINE ISLANDS 1:500,000

PALAWAN PROVINCE (P.I.)

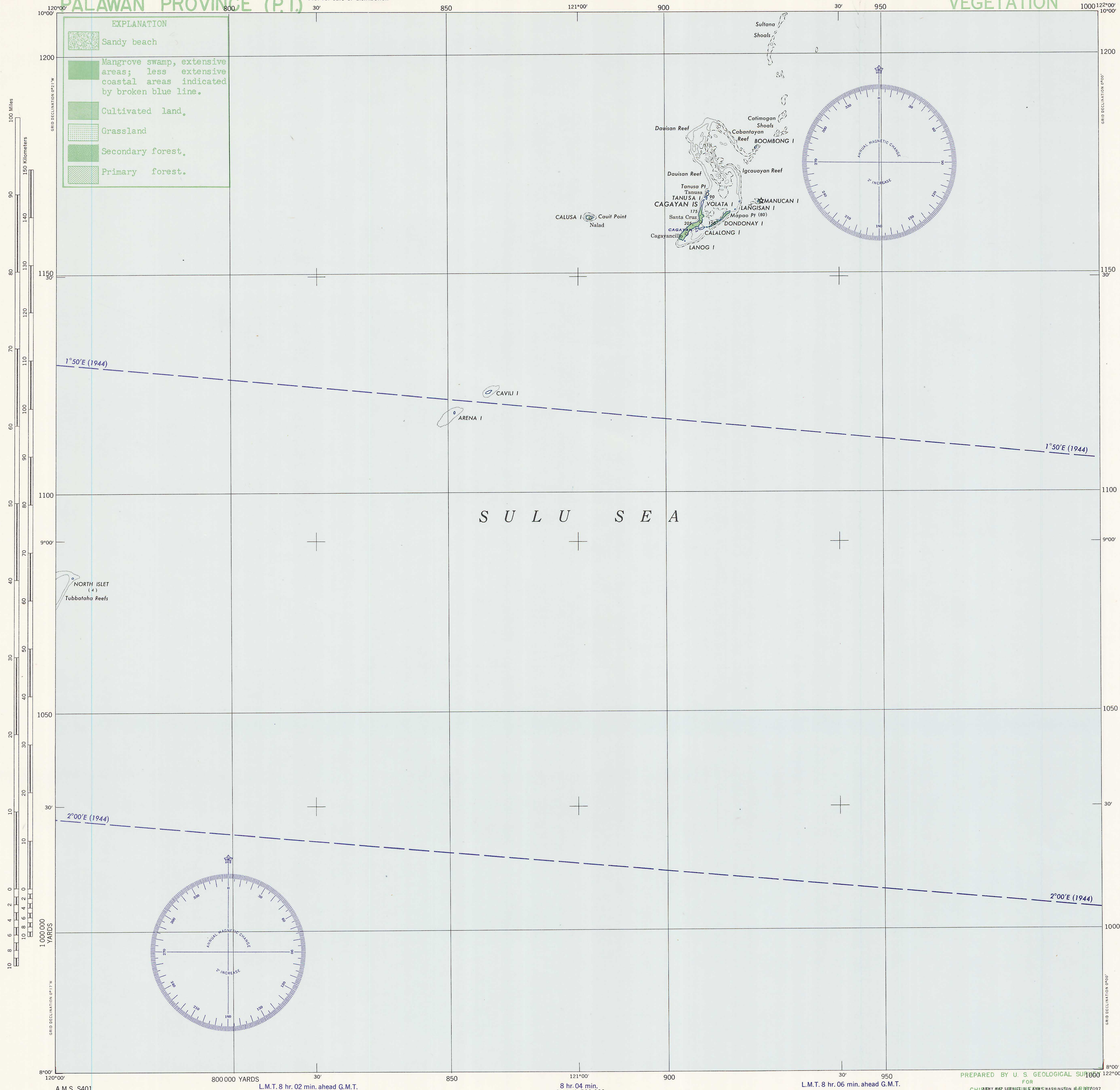
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CAGAYAN ISLANDS

SECOND EDITION - AMS 2

NC 51-4

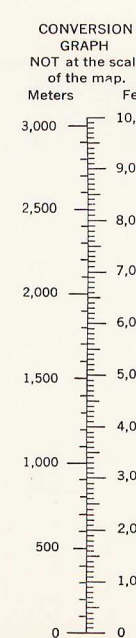
VEGETATION



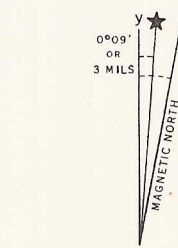
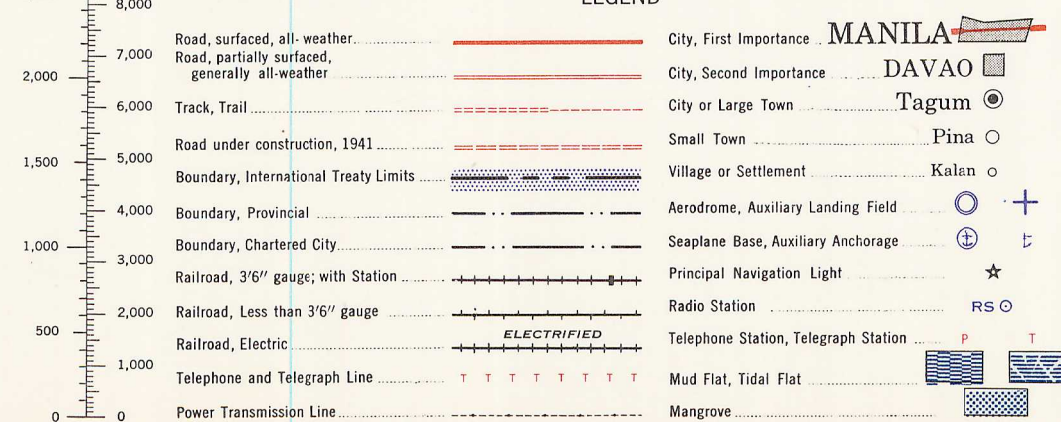
A.M.S. 5401.

First Edition (AMS 1) 1943.
Second Edition (AMS 2) 1944.

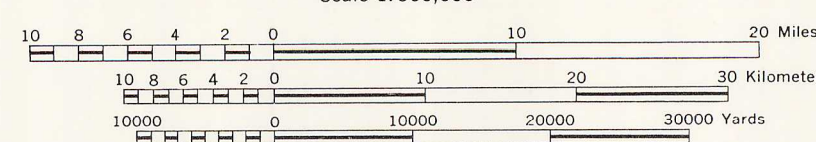
Prepared under the direction of the Chief of Engineers, U. S. Army,
by the Army Map Service (AMS), U. S. Army, Washington, D. C., 1944.
Compiled from Sectional Aeronautical Chart, 1:600,000, USC&GS, Number 4, 1941;
USC&GS Charts 4396, 1925; 4707, 1939; 4716, 1938;
Volumes I & V, Commission of the Census, Commonwealth of the Philippines, 1940.



LEGEND



APPROXIMATE MEAN DECLINATION 1944
FOR CENTER OF SHEET
ANNUAL MAGNETIC CHANGE 2" INCREASE
Do not use diagram except to obtain
numerical values of angles

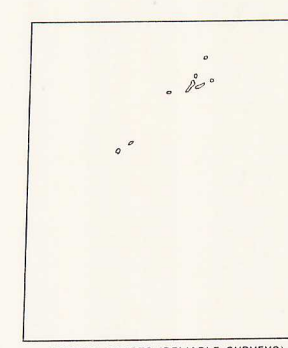


POLYCONIC PROJECTION

FIFTY THOUSAND YARD PHILIPPINE POLYCONIC GRID
THE LAST THREE DIGITS OF THE GRID NUMBERS ARE OMITTED

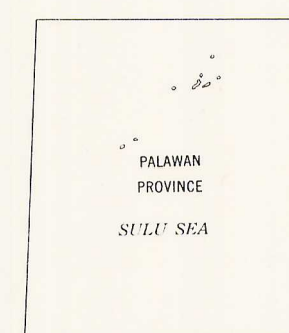
HEIGHTS IN FEET AND DEPTHS IN FATHOMS

COVERAGE DIAGRAM

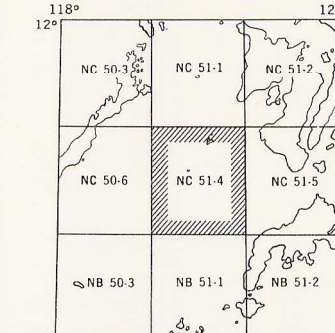


USC&GS CHARTS (RELIABLE SURVEYS)

INDEX TO BOUNDARIES



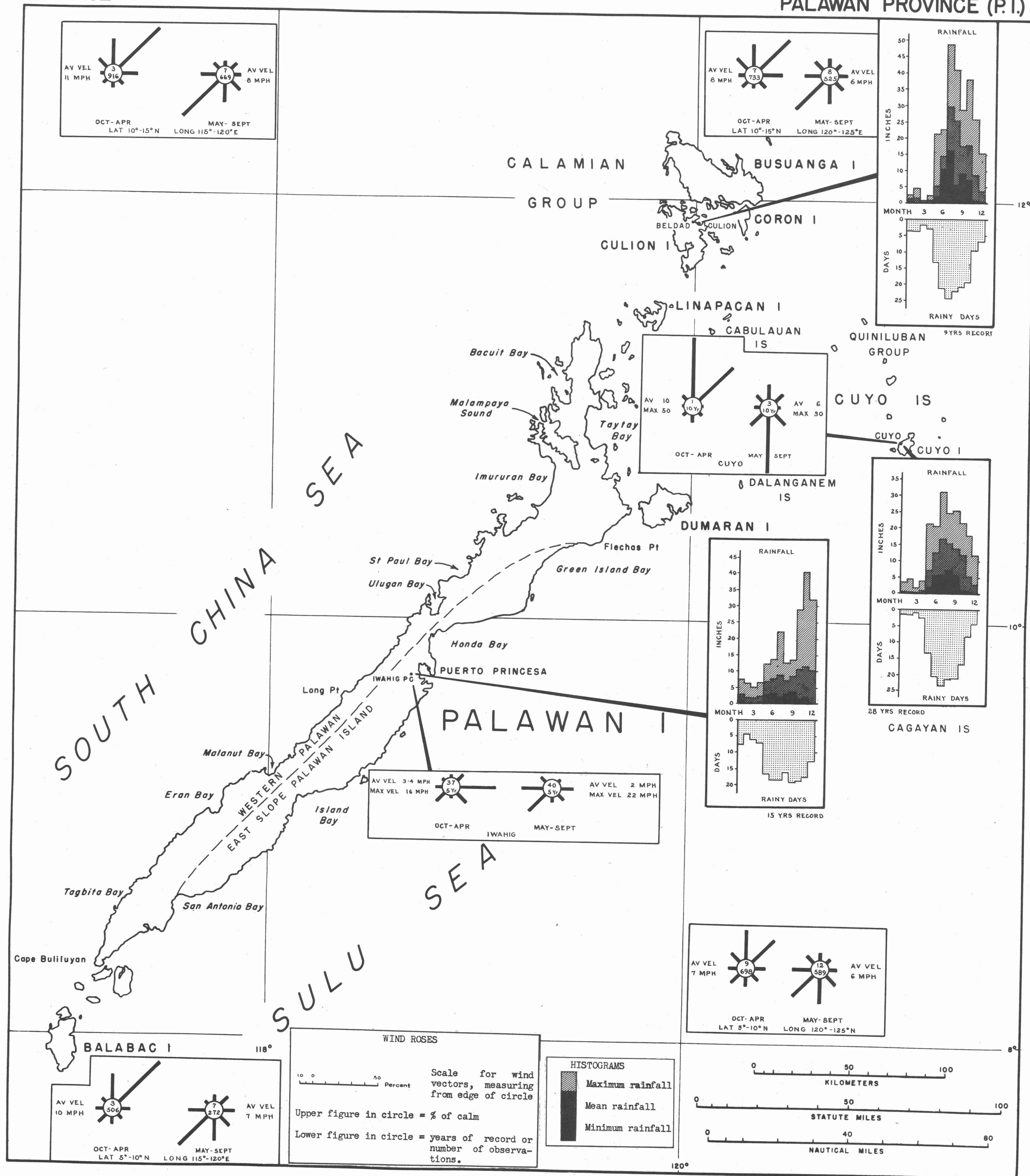
INDEX TO ADJOINING SHEETS



CAGAYAN ISLANDS, PHILIPPINE ISLANDS
PALAWAN PROVINCE
N800-E12000/200

CLIMATE

PALAWAN PROVINCE (P.I.)



PREPARED BY U. S. GEOLOGICAL SURVEY
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Sources: Climate and weather of the Philippines, 1907-1918;
Corona S. J., Jose, Rainfall records of Philippine Islands
through 1935; both published by Philippine Government.

INTRODUCTION

Climatic data for Palawan Province are based on observations at Iwahig Penal Colony (altitude 44 feet) on Palawan Island, at Cuyo (altitude 137 feet) on Cuyo Island, and on ships at sea between latitudes 5° and 15° north and longitudes 115° and 125° east. Records are for 5 to 15 years at Iwahig, 5 to 28 years at Cuyo, and from ships' observations made between 1880 and 1931. Only rainfall records are available from stations at Beldad and Culion on Culion Island. Because the stations were located close to each other and at similar sites, their data are combined in this summary. These records are for 9 years with no overlap and only a two-year break.

The weather records from Cuyo and Culion are probably representative of the smaller islands, and the northern and southern extremities of Palawan Island. Iwahig is representative of the eastern slope of Palawan Island between San Antonio Bay and Flechas Point. There is no weather station on the western slope of Palawan Island. The climate of this portion of the island is believed to differ somewhat from that in the rest of the area. Some estimates regarding climate in this section are based on data from stations in similar locations outside of the province.

WINDS

The controlling climatic factors of Palawan Province are the wind systems. The long axis of Palawan Island extends from northeast to southwest and corresponds approximately with the directions of the prevailing winds; northeast winds from October to April and southwest winds from May to September. These winds are fairly regular from year to year. The northeast winds are stronger and steadier than those from the southwest. Specific data in regard to the winds are given in the following table, and seasonal distribution is shown by wind roses on the Climate map.

Period of Northeast Winds			
	At sea and on smaller islands	At Iwahig	On west slope of Palawan
Percent of winds from NE quadrant (N, NE, and E)	70+	35	65-70 (estimated)
Percent calms	3+	37+	5-10 "
Average wind velocity (mph)	7-11	3-4	7-10 "
Maximum wind velocity (mph)	50	16	16-20 "
Period of Southwest Winds			
Percent of winds from SW quadrant (S, SW, and W)	55-65	38	25-30 (estimated)
Percent calms	3-7	40	40 "
Average wind velocity (mph)	6-8	2	3-4 "
Maximum wind velocity (mph)	35	22	35 "

Typhoon centers are practically unknown in the southern part of the region and occur only rarely in the north. However, typoons, passing to the north of the province, occasionally cause strong winds and unsettled weather. Between 1903 and 1918 there were four typhoons. The centers of three of them passed through the Calamian Islands and of the fourth through the northern third of Palawan Island. Two of the typhoons were in November, one in June and one in December.

RAINFALL

The amount, distribution, and frequency of rainfall in different areas varies; but all have distinct wet and dry seasons (see Rainfall Table). Precipitation in the dry season is usually confined to afternoon showers of small areal extent, although occasionally rain falls almost continuously for periods of a few hours to a day. In the wet season rains are fairly steady and often quite heavy over large areas. Storms may last from a few hours to several days. Thunderstorms are relatively rare; most frequent during period of southwest winds when they reportedly take place about 5% of the time.

Significant rainfall data are summarized in the following table. Monthly distribution, etc are shown by histograms on the Climate Map.

	Cuyo	Culion	Iwahig	Western Palawan (Estimated)
Years of record	28	9	15	
Average annual rainfall (inches)	87.0	126.1	79.9	110-115
Dry Season				
Months	Dec.-Apr.	Dec.-Apr.	Jan.-Apr.	Nov.-Apr.
Average seasonal rainfall (inches)	4.7	7.5	8.7	16-22
Percent of average annual rainfall	5.4	5.9	10.9	15-20
Average rainfall (inches), rainiest month	2.7 Dec.	3.6 Dec.	2.8 Jan	
Average rainfall (inches), driest month	0.2 Mar.	0.2 Mar.	1.8 Feb.-Mar.	
Heaviest recorded rainfall in 24 hours (inches) ^{a/}	11.6 Dec.		4.2 Feb.	
Average number of rainy days per month	1.0-2.5	1.8-6.8	4.7-7.6	3-10

^{a/} Records for 5 years only.

Cuyo

Culion

Iwahig

Western Palawan (Estimated)

Wet Season

Months	May-Nov.	May-Nov.	May-Dec.	May-Oct.
Average seasonal rainfall (inches)	82.3	118.6	71.2	
Percent of average annual rainfall	94.6	94.1	89.1	80-85
Average rainfall (inches), rainiest month	16.8 Jul.	29.6 Jul.	11.6 Nov.	
Average rainfall (inches), driest month	5.3 Nov.	5.2 May	6.6 May	
Heaviest recorded rainfall in 24 hours (inches) ^{a/}	8.4 Jul.		11.5 Nov.	
Average number of rainy days per month	8.3-21.6	9.7-24.4	12.7-19.2	14-25

^{a/} 5 year period

RELATIVE HUMIDITY

Relative humidity is highest in early morning and lowest in mid-afternoon. It is highest in the period of southwest winds. The available data are summarized below:

	Months with highest mean		Months with lowest mean		Annual mean		Years of record
	6:00am	2:00pm	6:00am	2:00pm	6:00am	2:00pm	
Iwahig	96% Nov. and June	71% Nov.	93% Sept.	63% April	95%	68%	5
Cuyo	89% May and Sept.	78% Aug.	83% Jan.	65% April	86%	73%	5

TEMPERATURE

Monthly mean temperatures at Iwahig range from 78 degrees F. (Feb.) to 82 degrees F. (April and May) and at Cuyo from 80 degrees F. (January and February) to 84 degrees F. (April and May). Temperatures are slightly higher in the period of southwest winds than during the rest of the year. Significant temperatures in degrees F. are summarized below.

	Maximum recorded temperature	Month with highest mean maximum	Annual mean	Month with lowest mean minimum	Minimum recorded temperature	Years of record
Iwahig	98 July	92 April	80	69 Feb.	56 Dec.	5
Cuyo	95 Apr. and May	91 April	82	78 Apr. and May	66 Feb. and Dec.	5

VISIBILITY

Available data on cloud conditions relate only to amount (0-10) of cloud cover. Due to topographic influences and radiation, cloudiness is generally greater over the islands than over the sea. Clouds begin to form over the islands in mid-morning and accumulate until late afternoon. They are usually dissipated in the early hours of the night. Strato-cumulus and cumulus clouds are the predominant forms.

Visibility is rarely obscured by fog or mist, but during season of northeast winds haze frequently limits visibility to less than 6 miles. Exceptionally good visibility is reported more than 10% of the time during all months. The most common limitation to visibility is rain which frequently reduces it to less than 1 mile. During the dry season limited visibility caused by rains will ordinarily last for only short periods of time, but during the wet season such conditions may persist for several hours or even days.