G09-40.201 a

SOUTHERN GUAM
FLOOD CONTROL MASTER PLAN

TASK 2

COMPUTER MODELING AND DATABASE DEVELOPMENT

DECEMBER 20, 1996

PREPARED FOR:

DEPARTMENT OF PUBLIC WORKS
GOVERNMENT OF GUAM
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CHAPTER I.
INTRODUCTION

A. Project Background

Guam is the largest and southernmost of the Marianas Islands. Excluding fringing reef areas, the island is approximately 30-miles long with an average width of 7-miles, and an area of 212-square miles. Refer to Figure I-1 for a Map of Guam. The eastern shores face the Pacific Ocean and the western shores front the Philippine Sea.

The island of Guam lies 13°28'29" North Latitude and 144°44'55" East longitude at the Capital city of Agana, on the central western coast.

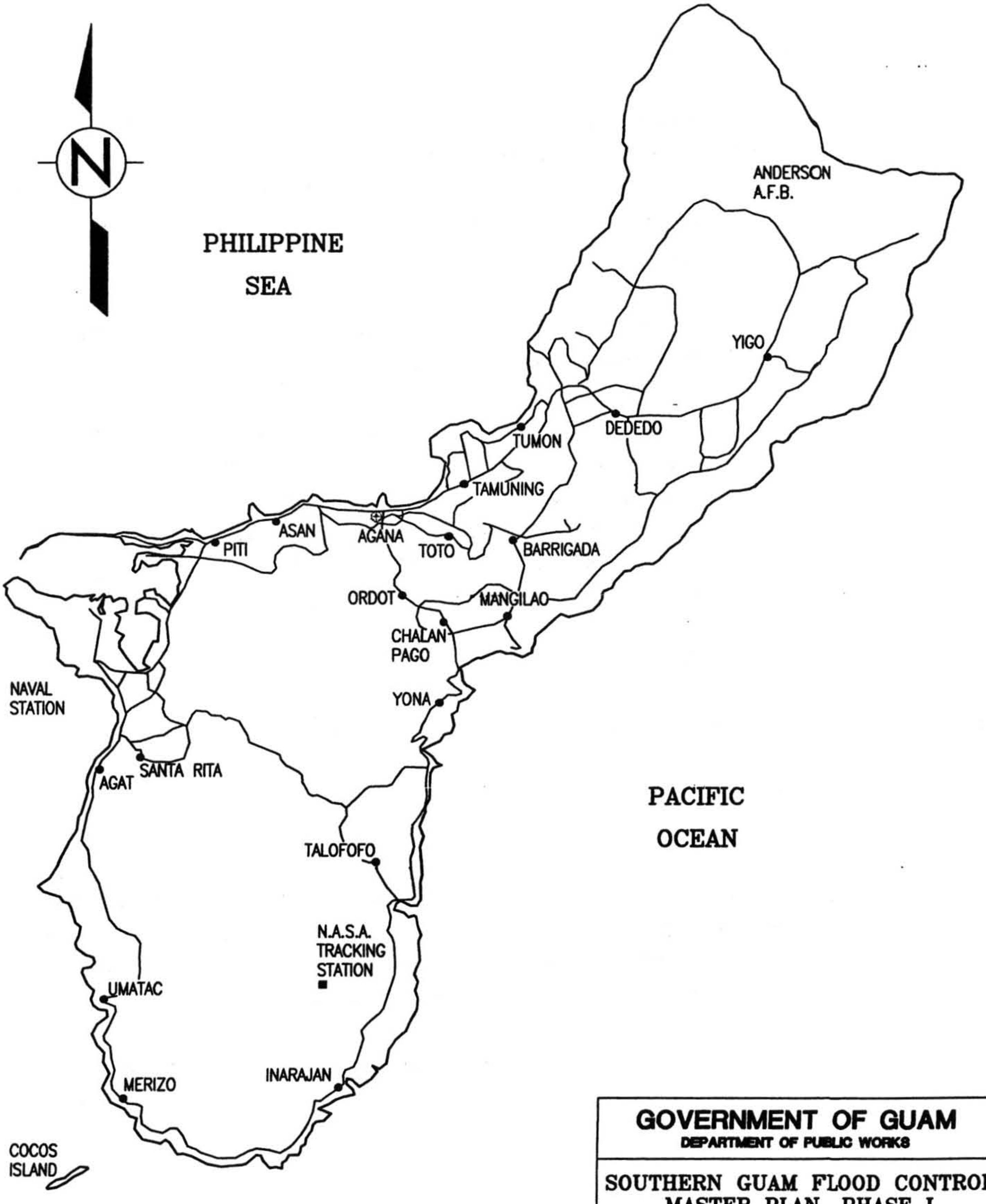
This project is a Flood Control Masterplan for Southern Guam, Phase I, and includes the Municipalities of Agat, Santa Rita, Piti, Asan and the southern part of Agana. The study area is bounded by the Philippine Sea, and in some areas U.S. Military property, to the west; Talafofo and Sinajana Municipalities to the east; the Agana River watershed to the north and Umatac Municipality to the south. Refer to Figure I-2 for the Location Map.

B. Historical Flood Planning

Since the 1970's the Department of the Army, Pacific Ocean Division, Corps of Engineers, Honolulu, Hawaii, has conducted numerous flood related studies and project on Guam. Several projects have been completed within the masterplan study limits.

Flood Hazard Studies were provided for the Agat and Asan areas in November 1976. The studies discuss the hydrology of the areas and present technical information on flood frequencies and discharges. Maps were completed showing the areas that would be inundated by 100-year flood events.

In 1982 the Army Corps of Engineers released the Alternative Solutions for Flood Prone Areas in Guam, which included the Agat Area.



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SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I

GUAM U.S.A.

DRAWING TITLE:
GUAM MAP

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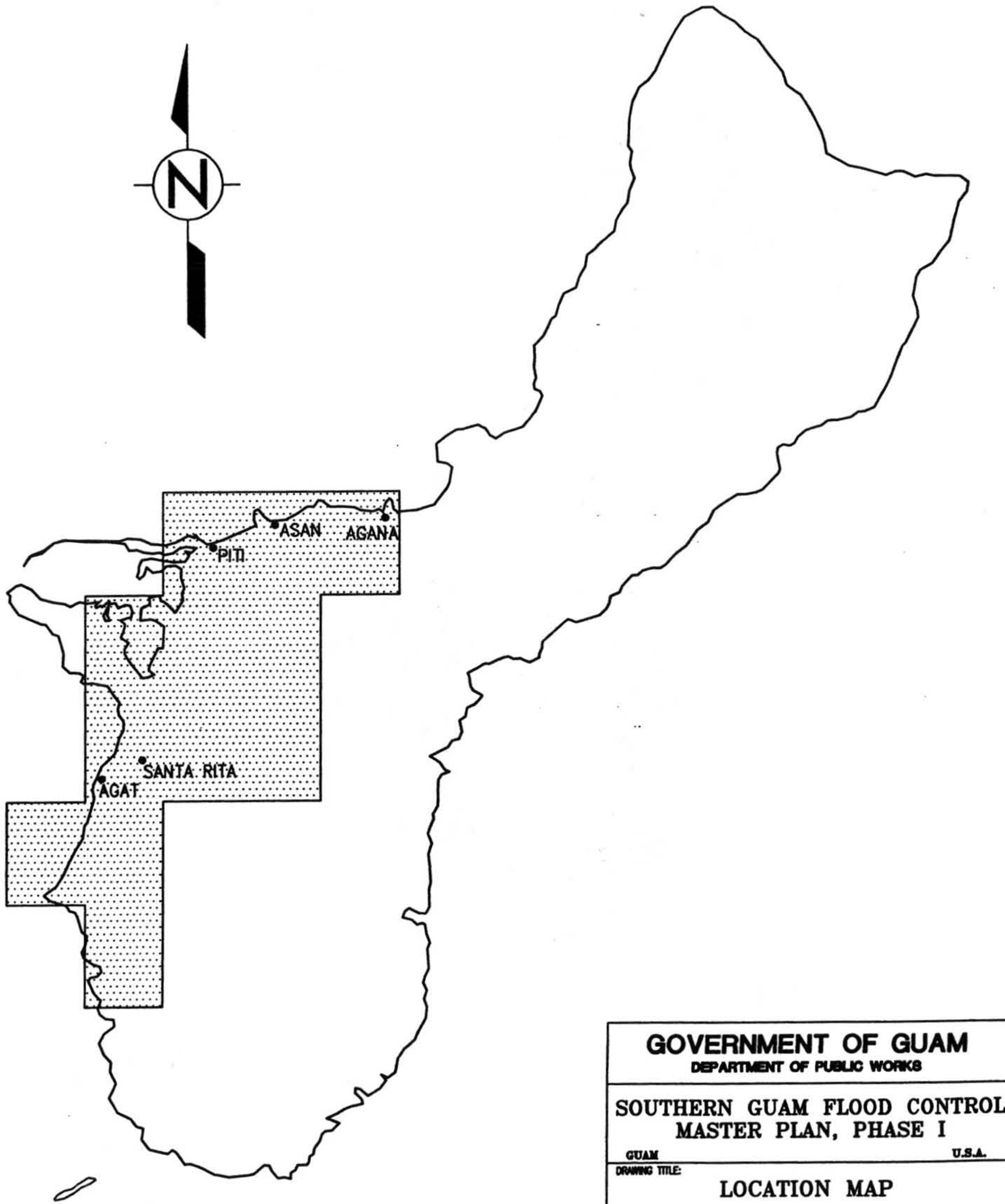
FIGURE I-1



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GUAM U.S.A.

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LOCATION MAP

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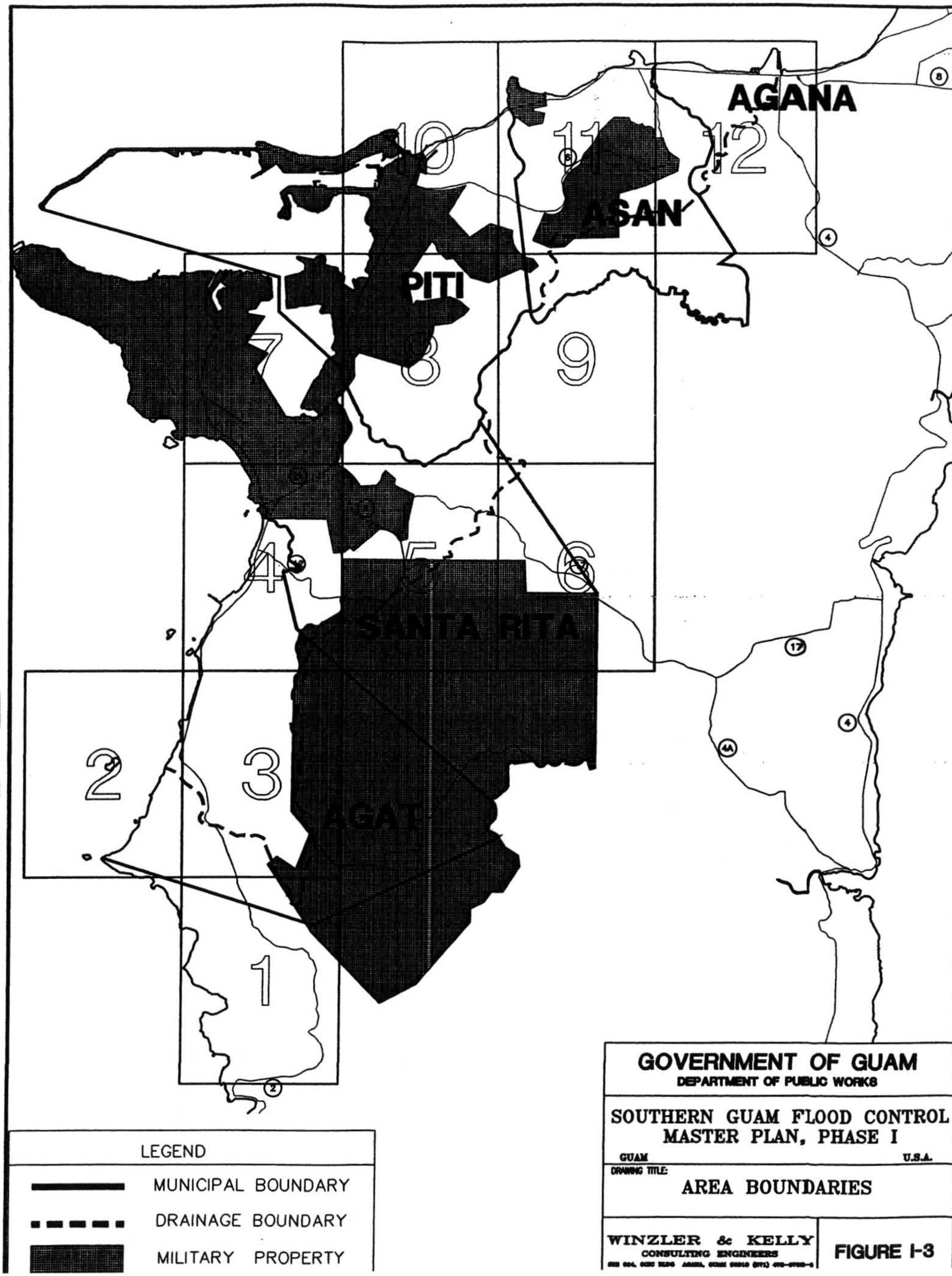
FIGURE I-2


AGANA
ASAN
PITI
SANTA RITA
AGAT
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LEGEND
MUNICIPAL BOUNDARY
DRAINAGE BOUNDARY
MILITARY PROPERTY
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AREA BOUNDARIES
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FIGURE I-3

The Government of Guam and the Army Corps of Engineers have also completed the Namo River Flood Control Project in Agat and the Asan River Flood Control Project in Asan. Both projects were designed for the 100-year flood event.

The Federal Emergency Management Agency (FEMA) prepared the FEMA Flood Insurance Study, Territory of Guam in November 1985. The maps included with this study indicate the 100 year Flood Plan Island Wide associated with both stream flooding and storm surge.

C. Purpose of the Flood Control Masterplan

Based on the detailed Scope of Services of the Engineering Agreement, the purpose of the Flood Control Masterplan is the following:

1. Identify existing flooding problem areas and develop a prioritized list of facility improvements.

2. Develop policies and guidelines for future development to follow in order to eliminate village flooding problems and maintain working storm water drainage systems.

Specifically, the project will develop a comprehensive flood management strategy. A masterplan document will be created by which the Department of Public works can implement policies, guidelines and capital improvement programs for eliminating seasonal flood damage to public and private properties.

CHAPTER II.
CONCLUSIONS AND RECOMMENDATIONS (Executive Summary)

A. General

1. Masterplan Area Boundries

The limits of the masterplan study area include the five municipalities of Agat, Santa Rita, Piti, Asan and the Southern portion of Agana in south and central western Guam. The area is approximately 19 square miles and includes about 9% of the land area of Guam.

2. Land Use

Land use patterns have been relatively consistent on Guam for the past 20+ years. The significant tourism related development on the island has occurred in the Tamuning and Tumon Bay villages while the general expansion of residential housing has been most significant in the Dededo area.

The trend occurring now is for tourism related development to occur in other areas around the island. Military downsizing is also affecting Guam and could have an affect on the type and rate of development within the study area limits.

The study area includes the Municipality of Agat which could be greatly affected by tourism development and military downsizing within the projected 20-year build-up period.

Santa Rita Municipality includes large areas of military land and could also be significantly affected if military land is released to the Government of Guam.

The Municipalities of Piti and Asan appear less susceptible to land use changes. The two villages have experienced the least change in the past 15-years.

Agana is the capital of Guam and a commercial center. It has been outpaced by development in Tamuning and Tumon Bay but may become revitalized following steady tourism related development further away from the Tumon Bay area.

3. Population and Projected Growth

The last census was taken on Guam in 1990, the population of permanent residents was approximately 133,000. Extrapolation was provided to correlate with the horizon year of 2015, used in the I Tano'-ta, Land Use Plan, 1994. The projected growth indicates the population is expected to approximately double to 263,000, by the year 2015.

4. Flood Control and Drainage Policies

a. Planning and Engineering Policy

The following existing policies guide planning and engineering practices in southern Guam.

i. Planning and engineering considerations for storm drainage are a prerequisite to designating areas for future development. Storm drainage facilities shall be provided as an integral part of basic infrastructure required for the approval of development.

ii. Runoff from development in Guam's southern watersheds generally shall be routed to natural waterways in accordance with the design standards prescribed by the Guam Storm Drainage Manual and to protect against erosion, sedimentation and other forms of pollution. Exceptions to this general routing policy include cases where excessive costs preclude such routing plans and where stormwater disposal in a low-flow stream will cause adverse impacts.

b. Environmental Protection Policy

The 208 Water Quality Management Plan, prepared by the Guam Environmental Protection Agency (GEPA) has been adopted by the Government of Guam as the official planning document for water.

5. Flooding and Drainage Laws and Regulations

a. Government of Guam Legislation

21 GCA Chapter 62 - Subdivision Law, §62501. Required Improvements., (c) Storm Water Drainage, reads, "Storm drainage facilities shall be provided in all subdivisions in accordance with plans prepared by the subdivider conforming to criteria established by the commission. These facilities shall be designed to dispose of normal storm waters falling on the subdivision without hazard of flooding, inconvenience of ponding and the erosion of public or private lands".

b. Government of Guam Regulations

"Flood Hazard Area Rules and Regulations", promulgated under Executive Order 78-20, include all areas which have a one percent or greater chance of flooding in any given year. This flooding may be due to either abnormally high coastal water, overflow of streams, rivers and wetlands, or excessive rainfall drainage into sinkholes or low-lying basins. The areas are to be delineated in an official Map of Flood Hazard Areas.

The major intent of these regulations is to qualify for the federally-subsidized National Flood Insurance Program. The procedures and standards for the management of flood hazard areas must be followed in order to be issued a Flood Hazard Area Building Permit for a proposed development.

c. Federal Regulations

Executive Order 11988, effective May 24, 1977, outlines the responsibilities of Federal agencies in the role of flood plain management.

CHAPTER III.
EXISTING AND FUTURE AREA CHARACTERISTICS

A. Introduction

The intent of this chapter is to describe pertinent physical, demographic, environmental and economic characteristics of the study area to provide a basis for development of the Flood Control Masterplan. Included are descriptions of the geographical setting, land-use patterns, economic activity, population and environmental setting within the study area. Some characteristics can be related to the study area, while others are best described on a broader island-wide basis.

B. Study Area

1. General

The project study area is located in Southwest Guam, as shown on Figure I-2. The area encompasses approximately 19 miles in the Municipalities of Agat, Santa Rita, Piti, Asan, and Southern Agana.

2. Watersheds

The areas tributary to major waterways (rivers and streams) within the study limits have been defined to delineate the watersheds. There are a total of 38 watersheds identified, that were studied and modeled as part of the project effort.

3. Coastal Areas

The western boundary limit follows the coastline of the island through Agat, Piti, Asan and Agana.

The limit of flooding in the coastal areas was assumed to follow the appropriate "A" and "V" Zone areas delineated on the Federal Emergency Management Agency (FEMA), Flood Insurance Rate Maps (FIRM's). Refer to Site Maps I-12 for the coastal flood area limits.

4. Flood Plain (100-year storm event)

The limits of flooding from the 100-year storm event, as defined by the study is indicated for each watershed in the study area. Refer to Site Maps I-12 for the limits of the 100-year flood plains.

5. Wetlands

Wetlands are areas that are periodically or permanently inundated by surface or ground water and support vegetation adapted for life in saturated soil. Wetlands include swamps, marshes, bogs and similar areas.

C. Geographical Setting

1. Topography

The elevation of the study area varies from 0.0 (MSL) along the coast, up to the highest elevations of (850) feet in the Santa Rita and Asan Municipalities. In Agat, Piti, Asan and Agana there is a coastal plain area, generally sloping up from the coast to a few feet above MSL. The developed part of Santa Rita is located at higher elevations above the village of Agat, and extends north towards Military property. In general, the villages are developed into the foothills with undeveloped jungle areas extending to the upper reaches of the watersheds.

The 300-foot contour was generally identified as the upper elevation limit for future development. Exceptions were found primarily in the villages of Santa Rita, and Asan.

2. Soils

The study area covers part of central and southern Guam. The GENERAL SOIL MAP for the Territory of Guam, compiled in 1985, indicates varied soil types in the study area.

Central Guam consists of rolling limestone hills and plateaus. Southern Guam has mountainous uplands that are mostly volcanic in nature. In each of the villages bordering the coast, the coastal plain has the "Inarajan-Inarajan Variant" soil type. This soil type is characteristically deep, poorly drained and level on the coastal plains. In the upper reaches of the watersheds, the soil types are typical for volcanic uplands, very shallow to very deep; poorly drained to well drained; moderately steep to extremely steep; on strongly dissected mountains and plateaus. Although the soil types varied within the study area, as an average they match Hydrologic Soil Group C as defined in the SOIL Survey of Territory of Guam, 1984-1985.

3. Climate

Generally, the climate on Guam is warm and humid regardless of the time of year. The daytime temperatures are commonly between 83°F and 88°F, with night temperatures falling to the mid-seventies.

The two distinct climatic seasons on Guam are the wet and dry seasons. The dry season is generally from January to April and the wet season from July to November. The mean annual rainfall ranges from 85-inches to 95-inches along the central and southern coasts of the study area. The annual rainfall distribution is approximately 20-24% in the dry season and 63-66% in the wet season with the rest falling in the transition periods between seasons.

D. Land Use

1. General

Land use patterns have remained relatively stable on Guam over the past 20-years. Significant development has occurred in several central and northern villages while the southern villages have experienced less change.

The tourism industry has caused development in the past and will continue to drive development and land use patterns on Guam. Recent studies have noted that development is spreading out away from the main tourism districts of Tamuning and Tumon Bay. Within the study limits, the Municipalities of Agat, Asan and Agana are expected to have new tourism related development in the near future.

Tabulated in the Land Use Plan, 1994, is the "GUAM HOTEL AND CONDOMINIUM UNITS INVENTORY". The table indicates 440 units had been approved for Agana, with more development currently in the Territorial Land Use Commission process. There are 800 approved units for Agat with another 580 units pending approval. For Asan there are another 48 units approved and 680 pending.

The return of excess U.S. Military land to the Government of Guam appears likely to impact several areas of Guam. Within the study area limits, the municipalities of Agat, Santa Rita and Piti are the most likely to be affected.

2. Study Area

a. Agat

Agat has been a mix of Commercial and Residential land uses for many years. The village proximity to Naval Station has drawn commercial businesses to the area.

Agat is expected to be developed with hotel and condominium projects. The village is also directly affected by changes in the military presence at Naval Station.

b. Santa Rita

Santa Rita is primarily a residential community. Little tourism related development is currently planned for the Municipality. The land surrounding Naval Magazine and other military property south of Piti are located within Santa Rita. As the U.S. Military returns excess land to the Government of Guam, commercial activity in the village may develop from the use of this land. Without military land use it is unlikely that Santa Rita will change from its present residential use.

c. Piti

Piti is a residential community with a strip of commercial businesses fronting Marine Drive. Excess military property south of the village and nearby the Cabras Island area could become a busy industrial and commercial area if the land is returned to the Government of Guam. The Fish-Eye Marine Park opened in Piti in early 1996, however not much other tourism related development is currently planned.

d. Asan

Asan is a residential community with a strip of commercial businesses fronting Marine Drive. The commercial activity in the village has dropped off with the departure of several businesses in recent years. A Guam Housing and Urban Renewal Authority (GHURA) housing project in the village can be expected to bring a revitalization of the commercial businesses in the area. Tourism related development is planned for Asan.

e. Agana

The southern part of Agana, south of the Agana River watershed, is included in the study area limits. This area is primarily a commercial district with occasional residential development found at the inland side of Marine Drive. Revitalization of the commercial district appears to be beginning. Federal Government office space is planned to occupy some areas.

3. Zoning

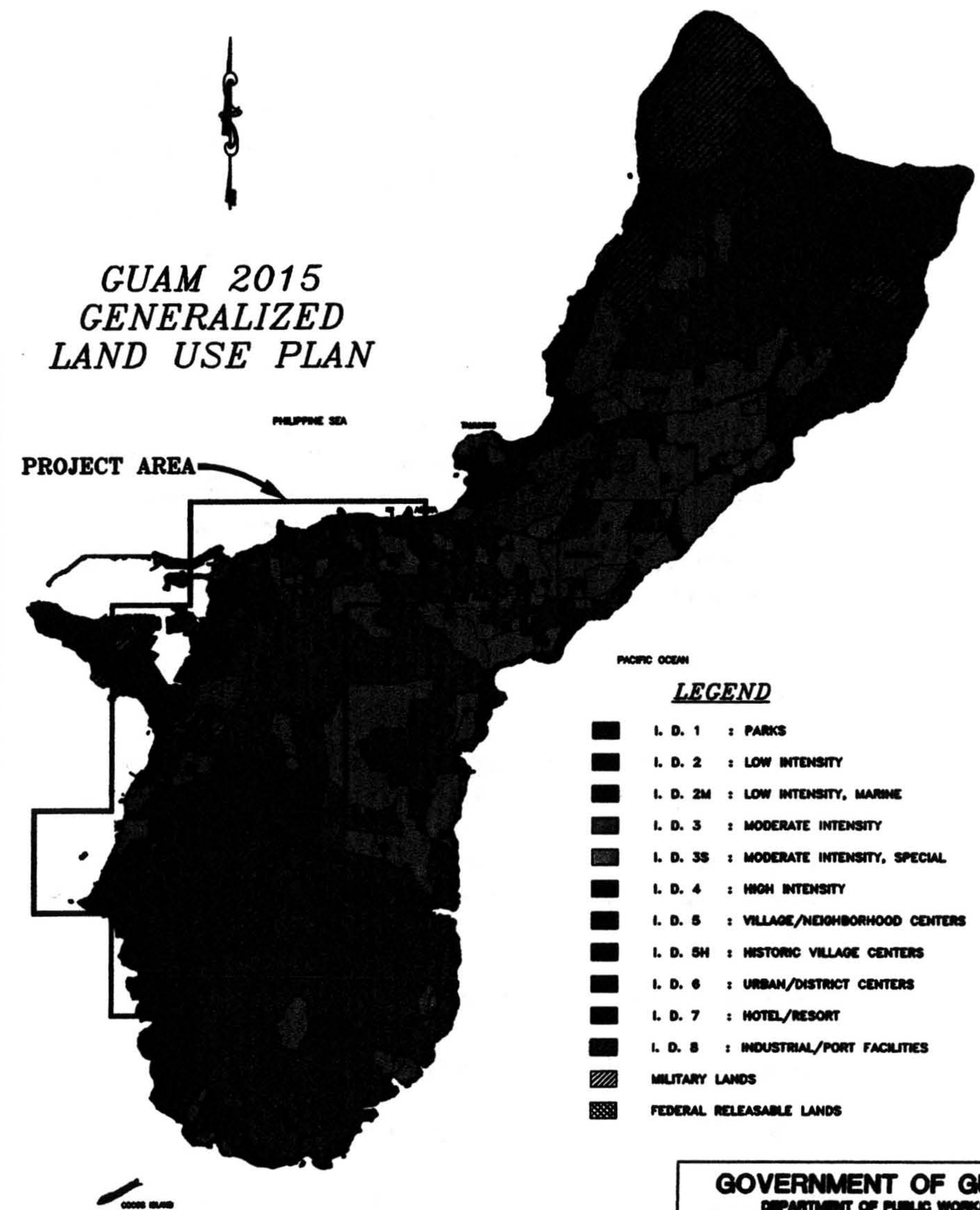
A Zoning Code has been developed as part of the 1994, I Tano'-ta, Land Use Plan. Refer to Figure III-1. Eleven zoning districts are provided. The study area is zoned mostly for "Low Intensity" and "Moderate Intensity" residential development. Agat, Santa Rita and Piti also have areas zoned for "Urban/District Centers", "Village/Neighborhood Centers" and "Industrial Port Facilities".

The zoning definitions are as follows:

A. ZONING DISTRICT 2: Low Intensity

1. General Description of Character and Intent of District

This District includes undeveloped and sparsely-developed areas and outlying subdivisions that are located outside the service districts for existing sewer and/or water lines. District 2 accommodates low-density residential neighborhoods with active and passive recreational facilities and neighborhood-oriented commercial activities. This District also encourages



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ZONING MAP

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FIGURE III-1

agriculture and aquaculture activities and provides for a range of public services. Performance Standards to ensure that the natural functions of environmentally sensitive areas such as very steep slopes, wetlands, beaches, flood plains, limestone forests, and potable water wellfield areas are maintained will be enforced. The ranges and types of activities that are proposed for inclusion in the District are listed below:

B. ZONING DISTRICT 3: Moderate Intensity

1. General Description of Character and Intent of District

This District primarily includes areas that are serviced by current or planned public sewer and potable water lines. Larger residential subdivisions and limited commercial development are permitted in these areas. This District accommodates medium-density residential development, limited offices, active and passive recreational facilities, smaller-scale hotels, as well as community-and neighborhood-oriented commercial facilities. This District is served by both public sewer and potable water facilities or have planned expansions thereto programmed within five (5) years from the date of adoption of this Zoning Code.

C. ZONING DISTRICT 5: Village/Neighborhood Centers

1. General Description of Character and Intent of District

This District encompasses the existing nucleated villages in the southern sector of Guam, as well as proposed new neighborhood center areas. It is characterized by small-scale retail outlets to meet the daily needs of the people residing in its environs. The intent is to enhance the character of the existing villages and to promote the development of new areas that will be of a scale to encourage social interaction. To that end, Attached Dwellings and small-scale multiple-family dwellings developments are to be encouraged. However, projects of this type will have to be especially sensitive to the environment in which they are proposed to be built, so that the existing character and charm are not destroyed. These areas are serviced by both public sewer and potable water facilities or have planned expansions thereto programmed within five (5) years from the date of the adoption of this Zoning Code.

D. ZONING DISTRICT 6: Urban/District Center

1. General Description of Character and Intent of District

This District includes downtown Agana and is characterized by high-intensity residential, commercial and other central business district functions that provide a full range of pedestrian-oriented commercial activities and urban services. This District does not include highway-oriented commercial activities such as supermarkets and shopping centers, which would be counter-productive in terms of trying to establish a pedestrian-oriented, close-knit urban center.

E. Economic Activity

1. Employment

The 1990 statistics indicated there were 64,924 employed persons on Guam. The private sector was the largest of the three major employment sectors with approximately 58.3% of the employed population. The public sector followed at 28.2% and active duty military trailed at 13.5%. Tourism related jobs dominate the private sector market and will continue to do so with the tourism driven economy.

2. Masterplan Area Employment

The municipalities within the study limits had the following employment characteristics, in accordance with the 1990 statistics.

MASTERPLAN AREA EMPLOYMENT CHARACTERISTICS			TABLE III-1
Municipality	**Government**	**Private**	**Military**
Agat	221	239	0
Santa Rita	4,452	220	2,834
Piti	1,254	829	0
Asan	167	227	216
Agana	2,333	7,457	0
TOTAL	**8,427**	**8,972**	**3,050**

The villages of Agat and Santa Rita have a dropping military work force as the military downsizes its work force across the island. This may be balanced by tourism related development in these areas.

The Agana, Government of Guam, work force was substantially reduced with the relocation of many Government offices to the Tiyan area. Agana is targeted for private development which will introduce new private sector jobs.

Piti and Asan have remained similar to the 1990 statistics with small work forces. As private development projects reach completion there may be increases, such as the Fish-Eye Marine Park in Piti.

F. Population and Population Characteristics

1. General

The national census conducted by the Bureau of the Census, Department of Commerce, in 1990, provided a population count for each election district on Guam. The population total in 1990 was 133,152. In comparison, the total population on Guam in 1960 and 1980 was 67,000 and 105,979 respectively.

2. Growth and Population Projections

The increase in population on Guam from 1980 to 1990 calculates to an average annual growth rate of 2.31% and a total growth factor of 26%. Extrapolation of these numbers was provided for the horizon year of 2015 in the I Tano'-ta, Land Use Plan, 1994. The extrapolation indicates the permanent resident population of Guam in 2015 is expected to be approximately 263,000. This demonstrates an increase of approximately 130,000, over the next 20 years, about doubling the current population. The population model developed for the Land Use Plan was based on several assumptions, the primary assumption being that the current focus on tourism as a major economic driving force on the island will continue for a number of years.

For the municipalities within the study boundaries, the following table identifies population growth characteristics:

MASTERPLAN AREA POPULATION CHARACTERISTICS			TABLE III-2
MUNICIPALITY	POPULATION 1980	POPULATION 1990	GROWTH FACTOR
Agat	3,999	4,960	1.24
Santa Rita	9,183	11,024	1.22
Piti	2,866	2,480	0.87
Asan-Maina	2,034	2,070	1.02
Agana	896	1,139	1.27
TOTALS	18,978	21,673	1.14

The villages of Agat, Santa Rita and Agana have experienced similar growth in the range of 22% - 27%. Asan-Maina has seen very little growth, totaling just 2%. Piti has experienced a reduction in population of 13%.

G. Environmental Setting

1. On ridges and hills to the southwest of Agana lies a mixture of disturbed and formerly planted forests and native limestone forest. The limestone forest in this area is mostly found in the steepest areas from Anigua to the Fonte River.

From the Fonte River to the western edge of the War in the Pacific National Park in Piti lies a mixture of disturbed upland forests on the slopes of Nimitz hill to grasslands and riverain forests. Much of the upland areas in this village have been greatly altered by World War II. The grasslands or savannah in Asan lies below the limestone ridge of Nimitz Hill. Springs form at the base of this formation and combine with runoff into small streams. Associated with these streams are small patches of riverain forest and alluvial wetland areas. The wetlands in this area are a mixture of Pago and Karisu, although Pandanus and Coconut are also present.

As one progresses through Piti village and moves to Turner Drive, the inland landform gradually shifts from limestone cliffs to the edges of a volcanic formation. At the western extreme of the village proper, a small stream runs northward from the volcanic mountains to the southwest. The ridges above Piti contain both intentionally planted forests of coconut and mahogany and mixed disturbed limestone forests.

Agat village is located predominantly in coastal lowlands and low hills to the west. Where no modern housing is located lie scattered Ironwood and Tangantangan trees with an occasional cluster of Coconut Palms. To the southwest can be seen the rolling hills which separate the volcanic portion of the lowlands and savannah from the high limestone cap of the Mount Lamlam ridge. On ridges above the rivers lie areas of exposed badlands and savannah. This upland savannah is characterized by exposed volcanic soil and hardy savanna vegetation. Swordgrass, Dimeria, Sedges, and occasional Ironwood trees are located here. As in Asan, springs form streams which work their way down to the sea. These streams are bordered by thin bands of riverain forests and eventually contribute water to low alluvial areas that contain wetlands. Most of the wetland area is located from the old cemetery to just beyond the Nimitz Beach Park.

Santa Rita is basically a converted savannah area. Prior to World War II the area consisted of the same types of mixed riverain forests, savannahs and wetland ecosystems as non-populated western Agat. The population of Sumay village was moved by the U.S. Navy to the Santa Rita area immediately after the war. They have planted trees, farmed and cared for the land since then.

CHAPTER IV
DESIGN CRITERIA

A. INTRODUCTION

One of the purposes of this study is to develop criteria applicable to the design of the drainage facilities. This chapter reviews existing data including mapping and planning documents and establishes pertinent design criteria. It is recommended that the design criteria be adopted as official policy for the future design of storm drainage facilities.

B. EXISTING FACILITIES

1. Water System

The masterplan study area is served by the Guam Waterworks Authority (GWA) water system. The island is divided into 4 main water service regions and the study area spans into 2 regions identified as Region "B" and Region "C". Region "B" is serviced by the Asan Springs Facility and Region "C" by the Santa Rita Springs.

A large portion of the present service system is old and as much as 30 - 40 percent of the total water production is thought to be lost through deteriorated lines. The GWA is developing new water sources and working to upgrade existing facilities and reduce losses.

The island water resources exceed projected future demand and it is not expected that the water system capacity would be a determining factor in limiting growth potential in the foreseeable future.

2 Sewer System

A gravity sewer collection system is provided within the village areas of each municipality, in the study limits. To some extent the collection system extends beyond the village areas.

The expansion and upgrade of the wastewater collection and treatment system has not been able to keep pace with the development on the island. As the island continues to grow, upgrading the overall system is going to be increasingly important. It is possible that delayed improvements to the wastewater system could limit growth potential in parts of the study area.

3. Storm Drainage System

The existing storm drainage system consists of a series of open channels and closed conduits varying in size and age. The policy presently used in designing facilities is the Guam Storm Drainage manual. Much of the system is undersized and poorly maintained. Siltation of many pipes and culverts is evident and can greatly restrict the capacity of these structures, further exacerbating an already serious flooding threat to the communities.

C. HYDROLOGY COMPUTER MODELING

1. General

In designing drainage facilities, it is important to develop accurate design flood information to properly size the facilities. This section outlines the method used for developing these flood flows.

2. HEC-1/SCS Hydrography method

There are a number of methods available to develop flood flows. The Rational Formula is the most widely used method and is generally adopted by the Guam Storm Drainage Manual. This method does not easily develop a hydrography. Rather, it only develops estimated peak flood flows. In discussions with DPW staff, it was decided that developing flood hydrographs would be useful in future design of drainage facilities, and this masterplan recommends a hydrography model to be used for the study area.

The U. S. Army Corps of Engineers has developed a flood hydrography package called HEC-1. There are a number of Synthetic Unit Hydrography models available in HEC-1, including the Clark Unit Hydrography, the Snyder Unit Hydrography and the SCS Dimensionless Unit Hydrography. The SCS (Soil Conservation Service) hydrography is perhaps the most used hydrography and is discussed in detail in the Guam Storm Drainage Manual.

The SCS hydrography, unlike the others available in HEC-1, can easily be defined by a single parameter, TLAG, which is equal to the lag (hours) between the center of mass of rainfall excess and the peak of the unit hydrography. The lag can be related to the time of concentration which is a measurable value related to the basin characteristics. Some of the parameters defining other synthetic unit hydrogaphs in HEC-1 are much more esoteric and much more difficult to define. It was therefore decided that the SCS Unit Hydrography would be used to develop the design flood hydrographs.

HEC-1 requires additional input data besides a unit hydrography model to develop a flood hydrography. HEC-1 requires precipitation data and a method of estimating Interception/Infiltration. Both of these input criteria were carefully reviewed to calibrate the model. They are described in detail below.

3. Design Rainfall Storm

In evaluating the existing facilities, the design storm event criteria used was as follows:

* Storm drainage facilities will pass a 20-year, 24-hour storm event without flooding

* Storm drainage facilities will pass a 100-year, 24-hour storm event with no serious flooding of residences and other important structures.

The rainfall totals for the design storms were taken from the Guam Storm Drainage Manual.

HEC-1 requires a rainfall distribution as well as rainfall totals. The Natural Resources Conservation Service, formerly the Soil Conservation Service (SCS) developed a series of synthetic storm events to characterize design rainfall events in various parts of the country. In this study, a Type III synthetic rainfall distribution is assumed. (Refer to Section 6 <u>Hydrology Computer Model Calibration</u>)

4. Runoff Curve Number, CN

HEC-1 has several methods available for estimating interception/infiltration losses. One of the most common and easiest to use is the Soil Conservation Service (SCS) Curve Number, CN. The SCS has instituted a soil classification system for use in soil survey maps across the county. These maps have also been developed for Guam. Based on experimentation and experience, the agency has been able to relate the drainage characteristics of soil groups to a curve number, CN. The SCS provides information on relating soil group type to the curve number as a function of soil cover, land use type and antecedent moisture conditions.

The SCS Curve Number, CN, was used to define the interception/infiltration losses in the HEC-1 hydrography model. The SOIL SURVEY OF TERRITORY OF GUAM, 1984 - 1985 along with the I Tano'-Ta, Land Use Plan for Guam, 1994, GUAM 2015 GENERALIZED LAND USE PLAN was used in determining soil classification and land use in the project area. Based on this information, CN values as shown in Table IV–1, were determined for future conditions to be used in the HEC-1 model.

TABLE IV-1: Cn VALUES

NODE	LAND USE	AREA Sq. Feet	Sq. Miles	Cn Value	Weighted Cn Product	Sum of Area	Weighted Average
1	Moderate	4,803,611	0.1723	87	14.9906077	1.9828	76.00
	Low	16,642,068	0.5970	83	49.5470201		
	Undeveloped	33,830,501	1.2135	71	86.1586594		
2	Moderate	2,824,200	0.1013	87	8.81346849	0.1013	87.00
3	Moderate	816,028	0.0293	87	2.54657498	0.0293	87.00
4	Moderate	4,776,586	0.1713	87	14.9062709	0.9489	75.12
	Low	1,064,348	0.0382	83	3.16879319		
	Village Center	861,279	0.0309	94	2.90404851		
	Undeveloped	19,750,551	0.7085	71	50.3002009		
5	Moderate	2,382,357	0.0855	87	7.43461099	0.1164	84.51
	Low	377,379	0.0135	83	1.12353855		
	Village Center	52,330	0.0019	94	0.17644556		
	Undeveloped	433,977	0.0156	71	1.10524158		
6	Moderate	2,936,641	0.1053	87	9.16436262	0.3377	79.85
	Low	3,023,880	0.1085	83	9.00274191		
	Undeveloped	3,453,678	0.1239	71	8.79573928		
7	Moderate	3,215,344	0.1153	87	10.0341098	0.3617	78.50
	Low	2,017,839	0.0724	83	6.00754121		
	Undeveloped	4,851,434	0.1740	71	12.3555087		
8	High	1,108,862	0.0398	90	3.57974561	0.1621	84.47
	Moderate	1,839,468	0.0660	87	5.74041968		
	Low	863,375	0.0310	83	2.57045329		
	Undeveloped	706,461	0.0253	71	1.79919691		
8a	High	306,518	0.0110	90	0.98953383	0.1333	83.28
	Moderate	1,839,468	0.0660	87	5.74041968		
	Low	863,375	0.0310	83	2.57045329		
	Undeveloped	706,461	0.0253	71	1.79919691		
8b	Moderate	113,685	0.0041	87	0.35477628	0.0594	78.16
	Low	835,773	0.0300	83	2.48827619		
	Undeveloped	706,461	0.0253	71	1.79919691		
9	High	891,882	0.0320	90	2.87926782	0.0358	89.68
	Moderate	105,035	0.0038	87	0.32778226		
10	High	562,580	0.0202	90	1.81618027	0.0683	87.58
	Moderate	1,197,715	0.0430	87	3.73770392		
	Low	145,153	0.0052	83	0.43215174		
10a	Moderate	852,751	0.0306	87	2.66117629	0.0358	86.42
	Low	145,153	0.0052	83	0.43215174		
11	High	1,177,660	0.0422	90	3.80184659	0.0455	89.79
	Moderate	90,351	0.0032	87	0.28195797		
12	High	897,732	0.0322	90	2.89815341	0.0410	89.35
	Moderate	246,648	0.0088	87	0.76971333		
13	High	1,459,311	0.0523	90	4.71110214	0.5639	83.04
	Moderate	7,596,463	0.2725	87	23.7062486		
	Low	3,332,032	0.1195	83	9.92017677		
	Undeveloped	3,332,032	0.1195	71	8.48593434		
13a	High	690,580	0.0248	90	2.22940341	0.4576	82.63
	Moderate	7,596,463	0.2725	87	23.7062486		

TABLE IV-1: Cn VALUES

NODE	LAND USE	AREA Sq. Feet	Sq. Miles	Cn Value	Weighted Cn Product	Sum of Area	Weighted Average
	Low	1,136,788	0.0408	83	3.38446267		
	Undeveloped	3,332,032	0.1195	71	8.48593434		
13b	High	263,902	0.0095	90	0.85195635	0.4422	82.37
	Moderate	7,596,463	0.2725	87	23.7062486		
	Low	1,136,788	0.0408	83	3.38446267		
	Undeveloped	3,332,032	0.1195	71	8.48593434		
13c	Moderate	1,668,164	0.0598	87	5.20583204	0.1313	78.29
	Undeveloped	1,991,409	0.0714	71	5.07166979		
14	High	897,489	0.0322	90	2.89736893	0.0666	88.45
	Moderate	958,017	0.0344	87	2.98967943		
15	High	152,635	0.0055	90	0.49275245	1.4877	86.66
	Moderate	20,737,937	0.7439	87	64.7167886		
	Low	5,348,679	0.1919	83	15.9241691		
	Industrial	12,533,349	0.4496	91	40.9110551		
	Undeveloped	2,701,501	0.0969	71	6.88011403		
15a	Moderate	3,151,290	0.1130	87	9.83421681	0.1317	87.57
	Industrial	520,431	0.0187	91	1.6987783		
15b	Moderate	730,894	0.0262	87	2.28089768	0.0262	87.00
15c	Moderate	13,188,521	0.4731	87	41.1573594	0.9647	86.30
	Low	5,348,679	0.1919	83	15.9241691		
	Industrial	6,812,939	0.2444	91	22.2386309		
	Undeveloped	1,542,839	0.0553	71	3.92926312		
15d	Moderate	353,986	0.0127	87	1.10468255	0.2425	82.47
	Low	4,685,704	0.1681	83	13.9503498		
	Industrial	782,505	0.0281	91	2.55423392		
	Undeveloped	938,982	0.0337	71	2.39137547		
15e,f	Low	1,084,689	0.0389	83	3.22935272	0.0942	80.55
	Industrial	603,702	0.0217	91	1.97058949		
	Undeveloped	938,982	0.0337	71	2.39137547		
15g	Low	178,803	0.0064	83	0.53233503	0.0543	78.78
	Industrial	481,218	0.0173	91	1.57078017		
	Undeveloped	853,707	0.0306	71	2.17419927		
15h	Low	175,241	0.0063	83	0.52173019	0.0127	87.04
	Industrial	178,803	0.0064	91	0.58364443		
15i	Moderate	1,212,130	0.0435	87	3.78268875	0.0850	79.18
	Undeveloped	1,158,662	0.0416	71	2.95085091		
15j	Moderate	597,701	0.0214	87	1.86524288	0.0630	76.44
	Undeveloped	1,158,662	0.0416	71	2.95085091		
16	High	1,987,398	0.0713	90	6.41592846	4.4706	82.47
	Moderate	11,744,562	0.4213	87	36.6512029		
	Low	38,441,354	1.3789	83	114.448189		
	Undeveloped	35,306,253	1.2664	71	89.9170671		
	Industrial	37,154,361	1.3327	91	121.278368		
16a	Low	1,698,931	0.0609	83	5.05808343	0.6844	83.53
	Undeveloped	6,446,350	0.2312	71	16.4174002		
	Industrial	10,934,218	0.3922	91	35.6912103		
16b	High	112,423	0.0040	90	0.36293582	2.2830	81.53

TABLE IV-1: Cn VALUES

NODE	LAND USE	AREA Sq. Feet	Sq. Miles	Cn Value	Weighted Cn Product	Sum of Area	Weighted Average
	Moderate	11,744,562	0.4213	87	36.6512029		
	Low	20,590,174	0.7386	83	61.3013818		
	Undeveloped	19,544,424	0.7011	71	49.7752419		
	Industrial	11,653,743	0.4180	91	38.0398665		
16c	Moderate	116,926	0.0042	87	0.36489045	0.4520	80.23
	Low	9,534,314	0.3420	83	28.3857059		
	Undeveloped	2,950,836	0.1058	71	7.51511407		
16d	Low	2,208,324	0.0792	83	6.57465608	0.1338	78.10
	Undeveloped	1,522,322	0.0546	71	3.87701095		
16e	Low	1,216,832	0.0436	83	3.62277089	0.0788	77.65
	Undeveloped	979,023	0.0351	71	2.49335087		
16f	Low	1,625,412	0.0583	83	4.83920153	0.0744	80.40
	Undeveloped	449,491	0.0161	71	1.14475225		
25	Moderate	681,595	0.0244	87	2.12705051	0.0244	87.00
25a	Moderate	373,330	0.0134	87	1.16504929	0.0134	87.00
26	Moderate	5,397,321	0.1936	87	16.8433959	0.7821	84.09
	Low	16,134,576	0.5787	83	48.0361071		
	Industrial	272,164	0.0098	91	0.88839116		
26a	Moderate	353,725	0.0127	87	1.10386805	0.0248	85.05
	Low	336,372	0.0121	83	1.00145188		
26b	Moderate	4,338,583	0.1556	87	13.5393968	0.7239	83.97
	Low	15,570,303	0.5585	83	46.3561449		
	Industrial	272,164	0.0098	91	0.88839116		
26c	Moderate	3,772,215	0.1353	87	11.7719347	0.6549	83.95
	Low	14,213,897	0.5099	83	42.3178321		
	Industrial	272,164	0.0098	91	0.88839116		
27	Moderate	641,665	0.0230	87	2.00244114	0.0374	85.46
	Low	401,293	0.0144	83	1.19473567		
27a	Moderate	224,095	0.0080	87	0.69933228	0.0224	84.43
	Low	401,293	0.0144	83	1.19473567		
28	Moderate	436,345	0.0157	87	1.36169992	0.1273	83.49
	Low	3,112,643	0.1117	83	9.26700847		
28a	Moderate	436,345	0.0157	87	1.36169992	0.1072	83.58
	Low	2,551,363	0.0915	83	7.59595705		
29	Moderate	1,679,058	0.0602	87	5.2398289	0.0649	86.71
	Low	130,472	0.0047	83	0.38844324		
30	Moderate	697,875	0.0250	87	2.17785544	0.0559	84.79
	Low	860,635	0.0309	83	2.56229572		
31	Moderate	1,109,351	0.0398	87	3.46194678	0.0591	85.69
	Low	539,400	0.0193	83	1.60590995		
32	Moderate	4,035,713	0.1448	87	12.5942318	0.3769	84.54
	Low	6,472,354	0.2322	83	19.2695916		
32a	Moderate	3,138,350	0.1126	87	9.79383501	0.1402	86.21
	Low	770,873	0.0277	83	2.29505492		
32b	Moderate	546,164	0.0196	87	1.70441159	0.0196	87.00
32c	Moderate	699,686	0.0251	87	2.18350702	0.0251	87.00
33	Moderate	9,983,707	0.3581	87	31.1561104	0.8050	84.78

TABLE IV-1: Cn VALUES

NODE	LAND USE	AREA Sq. Feet	Sq. Miles	Cn Value	Weighted Cn Product	Sum of Area	Weighted Average
	Low	12,459,579	0.4469	83	37.0948497		
33a	Moderate	6,991,923	0.2508	87	21.8196633	0.5861	84.71
	Low	9,347,196	0.3353	83	27.8286153		
33b	Moderate	293,657	0.0105	87	0.91641411	0.0130	86.23
	Low	69,867	0.0025	83	0.2080091		
33c	Moderate	1,484,961	0.0533	87	4.63411125	0.1624	84.31
	Low	3,042,516	0.1091	83	9.05822529		
33d	Moderate	1,434,926	0.0515	87	4.47796724	0.1606	84.28
	Low	3,042,516	0.1091	83	9.05822529		
34	Moderate	2,480,511	0.0890	87	7.74091974	0.1935	85.30
	Low	2,636,976	0.0946	83	7.85084539		
	V.Center	276,475	0.0099	92	0.91238019		
34a	Moderate	1,114,845	0.0400	87	3.47909188	0.1234	85.02
	Low	2,048,017	0.0735	83	6.09738762		
	V. Center	276,475	0.0099	92	0.91238019		
34b	Moderate	523,390	0.0188	87	1.63334087	0.0335	85.24
	Low	410,981	0.0147	83	1.22357894		
34c	Moderate	1,008,982	0.0362	87	3.14872568	0.1097	84.32
	Low	2,048,017	0.0735	83	6.09738762		
34d	Moderate	656,470	0.0235	87	2.04864304	0.0885	84.06
	Low	1,812,043	0.0650	83	5.39484221		
34e	Moderate	71,557	0.0026	87	0.22330761	0.0110	83.93
	Low	235,974	0.0085	83	0.70254541		
34f	Moderate	516,655	0.0185	87	1.61232298	0.0835	83.89
	Low	1,812,043	0.0650	83	5.39484221		
34g	Moderate	291,750	0.0105	87	0.91046294	0.0168	85.48
	Low	177,978	0.0064	83	0.52987883		
35	Moderate	1,033,517	0.0371	87	3.22529195	0.0727	85.04
	Low	993,698	0.0356	83	2.95845292		
35a	Moderate	420,619	0.0151	87	1.31262386	0.0366	84.65
	Low	599,600	0.0215	83	1.78513831		
35b	Moderate	148,540	0.0053	87	0.46354812	0.0268	83.79
	Low	599,600	0.0215	83	1.78513831		
36	Moderate	362,037	0.0130	87	1.12980727	0.0314	84.66
	Low	512,412	0.0184	83	1.52556086		
37	Moderate	41,068	0.0015	87	0.12816073	0.0378	83.16
	Low	1,013,299	0.0363	83	3.01680932		
38	Low	185,624	0.0067	83	0.55264262	0.0067	83.00
39	Low	257,294	0.0092	83	0.76601964	0.0092	83.00
40	High	4,545,154	0.1630	90	14.673147	2.3432	84.78
	Moderate	32,663,764	1.1717	87	101.933664		
	Low	23,419,355	0.8401	83	69.7244628		
	Undeveloped	3,044,112	0.1092	71	7.75266701		
	Parks	1,651,803	0.0593	77	4.56227154		
40a	High	1,504,725	0.0540	90	4.85771242	0.3804	86.50
	Moderate	6,647,151	0.2384	87	20.7437348		
	Low	2,452,810	0.0880	83	7.30254355		

TABLE IV-1: Cn VALUES

NODE	LAND USE	AREA Sq. Feet	Sq. Miles	Cn Value	Weighted Cn Product	Sum of Area	Weighted Average
40b	High	1,813,214	0.0650	90	5.85360925	1.9188	84.31
	Moderate	26,016,613	0.9332	87	81.1899295		
	Low	20,966,545	0.7521	83	62.4219193		
	Undeveloped	3,044,112	0.1092	71	7.75266701		
	Parks	1,651,803	0.0593	77	4.56227154		
Pump	High	411,401	0.0148	90	1.32812823	0.0240	88.38
	Moderate	178,379	0.0064	87	0.55666656		
	Low	78,478	0.0028	83	0.23364591		
41	High	846,294	0.0304	90	2.73209582	0.0359	89.25
	Moderate	84,722	0.0030	87	0.26439157		
	Low	70,762	0.0025	83	0.21067371		
42	High	437,186	0.0157	90	1.41137009	0.0157	90.00
43	High	1,116,293	0.0400	90	3.60373515	0.0650	88.31
	Moderate	452,019	0.0162	87	1.4106137		
	Low	243,706	0.0087	83	0.72556524		
44	High	240,188	0.0086	90	0.77540031	0.0333	89.77
	Moderate	340,500	0.0122	87	1.06259685		
	Low	53,148	0.0019	83	0.15823304		
	Urban	294,348	0.0106	94	0.99247848		
44a	High	9,707	0.0003	90	0.03133716	0.0157	87.12
	Moderate	340,500	0.0122	87	1.06259685		
	Low	53,148	0.0019	83	0.15823304		
	Urban	33,883	0.0012	94	0.11424623		
45	Moderate	200,063	0.0072	87	0.62433572	0.0362	90.68
	Low	177,191	0.0064	83	0.52753576		
	Urban	630,825	0.0226	94	2.12700693		
45a	Moderate	200,063	0.0072	87	0.62433572	0.0191	87.70
	Low	177,191	0.0064	83	0.52753576		
	Urban	154,121	0.0055	94	0.51966304		
46	Moderate	12,794	0.0005	87	0.03992618	0.0340	91.84
	Low	177,935	0.0064	83	0.52975081		
	Urban	756,348	0.0271	94	2.55024363		
46a	Moderate	12,794	0.0005	87	0.03992618	0.0108	87.23
	Low	177,935	0.0064	83	0.52975081		
	Urban	111,405	0.0040	94	0.37563382		
47	Moderate	157,464	0.0056	87	0.49139721	0.0946	90.46
	Low	747,389	0.0268	83	2.22513799		
	Urban	1,731,184	0.0621	94	5.83718205		
47a	Low	143,254	0.0051	83	0.42649801	0.0054	83.54
	Urban	7,411	0.0003	94	0.02498831		
47b	Moderate	157,464	0.0056	87	0.49139721	0.0308	84.98
	Low	604,135	0.0217	83	1.79863999		
	Urban	97,735	0.0035	94	0.32954151		

5. Lag Analysis

As is mentioned above, the SCS unit hydrography model is defined by a single parameter, Lag. Lag is defined as the time in hours from the center of mass of rainfall excess to the peak discharge and can be related to the individual basin characteristics by the following formula:

$$L = l^{0.8}(S+1)^{0.7}/1900Y^{0.5}$$

where:
Y = slope of basin in percent
l = hydraulic length of the basin in feet
S = the maximum retention which is related to the curve number, CN by the following formula:
S = 1000/CN - 10
The above formula is used in this study to calculate the lag for the individual nodes where design storm flows need to be estimated.

6. Hydrology Computer Model Calibration

There are few gauging stations on any of the streams within the project boundary. However, regional equations were developed for peak discharges on Guam in the FEMA Flood Insurance Study, Territory of Guam, November 1985. The SCS hydrography model in HEC-1 was run for several of the basins where FEMA 100-year flood flows were given in the above referenced study. The object was to try to calibrate the hydrography model to match the 100-year flood flows. CN values were developed for the basin based on the soil classification and land use (zoning).

The Corps of Engineers in Hawaii have adopted the Type IA SCS synthetic storm event to be used not only on Hawaii but in the Marianas. This synthetic storm event was developed for Hawaii, and the Pacific coast. The local branch office of the Natural Resources Conservation Service (formerly SCS) indicate that until recently, they also have assumed a type IA synthetic rainfall event for the Marianas. However, they recently changed policy and have decided to use a type III event which represents hurricane type rainfall on the Atlantic coast. They believe this more closely represents intense typhoon events.

Both rainfall distributions were used during the calibration of the SCS hydrography model. The type IA distribution underestimated the peak runoff when compared to the results from the Regional Equations developed for the FEMA study. The type III distribution overestimated the peak flows by approximately 20 percent.

It was decided that the type III rainfall distribution be adopted in this study to develop estimated design storm runoff. This allows a somewhat conservative estimate of runoff and will help protect facilities. Drainage structures designed under this criteria should still function properly even if moderate siltation or debris buildup occurs.

D. HYDRAULIC COMPUTER ANALYSIS

1. General

Many of the drainage facilities in the project area consist of open channel sections. Using the Manning's equation to determine channel capacity may, in some cases, provide erronious results, if, for instance, the system is operating under backwater conditions. A method of calculating channel capacity that takes into account potential backwater conditions would provide more accurate results. In this study, The U. S. Corps of Engineers program, HEC-RAS will be used for analyzing open channel capacities.

2. HEC-RAS River Analysis System Computer Model

The U. S. Army Corps of Engineers developed a Water Surface Profile package called HEC-2 that calculates water surface profiles for steady gradually varied flow in natural and man-made channels. Recently, the Corps developed a new program that essentially upgrades the HEC program. This new program called HEC-RAS, River Analysis System presently analyzes steady flow water surface profiles much as HEC-2 does.

The program allows the user to define a particular reach of open channel and input cross section data and other pertinent information such as manning's n values, estimated storm design flows and beginning water surface elevation. The model will allow analysis of both subcritical and supercritical flow conditions

E. HYDRAULIC DESIGN CRITERIA

1. Channel Design

There are several reasons for using open channels instead of closed conduits to carry storm water runoff. Probably the biggest consideration is that construction costs are significantly lower. Another major consideration is that velocities are generally lower in channels which in turn increases the time of concentration, thus decreasing the required design flow downstream. Channels also allow overland flow to enter at almost any location along their reach, and if the groundwater table is low enough, some water may saturate into the soil.

Perhaps their main drawback is space requirement. A channel designed for even moderate flow can occupy considerable space. This may require obtaining substantial drainage easements, often in excess of 20 feet wide. This may not be feasible in many locations, thus requiring the use of closed conduits or steeper side slopes that may require channel lining.

Where feasible, open channels will continue to be used throughout the project area. HEC-RAS will be used to size the channel for the design flows. Hydraulic calculations for the various open channels being investigated are included in Appendixes C to F.

2. Conduit Design

Throughout this report the following standard abbreviations will be used to designate pipe material:

RCP	-	Reinforced Concrete Pipe
RCB	-	Reinforced Concrete Box
CMP	-	Corrugated Metal Pipe
PLP	-	Plastic Pipe
HDPE	-	High Density Polyethylene Pipe

In many circumstances it is not feasible to use open channels. Conduits, if required, should be reinforced concrete (RCP) or plastic pipe as opposed to corrugated metal pipe (CMP). The concrete pipe has a substantially larger capacity per diameter over the CMP and has a longer service life. The Mannings friction factor, "n", generally used for RCP is 0.013 and for CMP is 0.024 which equates to an 85 percent increase capacity for RCP, all other factors being equal.

In this study, RCP is assumed for cost estimate purposes. However, during the design stage a determination of conduit material should be made, taking into account not only capacity, but costs. It is possible to have CMP coated which helps the hydraulic capacity significantly. PVC and HDPE is being used more frequently for storm drainage facilities in certain sizes. In sizing the storm drainage systems, single circular RCP, or box culverts RCB are assumed. No attempt was made to determine flow lines of pipes or if adequate cover exists. The actual size and shape of a storm drain will need to be determined during the actual design phase and is dependent on a number of factors, including utility conflicts, that are beyond the scope of this study.

Inlet control is normally assumed in sizing culverts. Information on roughness, length and slope is required for outlet control calculations and is not always easily obtainable. Care must be taken at the design stage to design the drain so that it operates under inlet control during a 20-year storm if at all possible. In this study inlet control has been assumed along with the assumption that headwater depth (the actual depth of the water entering the pipe) is equal to the pipe diameter. The nomograph used to calculate the capacities of pipes and box culverts based on the headwater depth is shown in Figures IV-1 and IV-2. By using these as the criteria for the 20-year storm design, when a 100-year storm occurs, the headwater will generally be deeper, which increases the capacity of the pipes, often allowing the 100-year storm to pass through the same system with no major flooding damage. For culvert design the culvert capacity at maximum headwater depth was checked to ensure that the 100-year storm will pass with minimal flooding.

The Mannings Formula is used in sizing conduits and calculating conduit capacities. Street slopes are used to estimate conduit slopes unless actual pipe slopes are available. Conduits are generally designed to flow full during a 20-year storm event. The capacities of the existing storm drainage facilities are included in Appendixes C to F, with the hydraulic calculations.

In tidally influenced areas, conduits are sized to pass a 20-year storm event assuming Mean Sea Level(MSL) as a beginning water surface

FIGURE IV-1

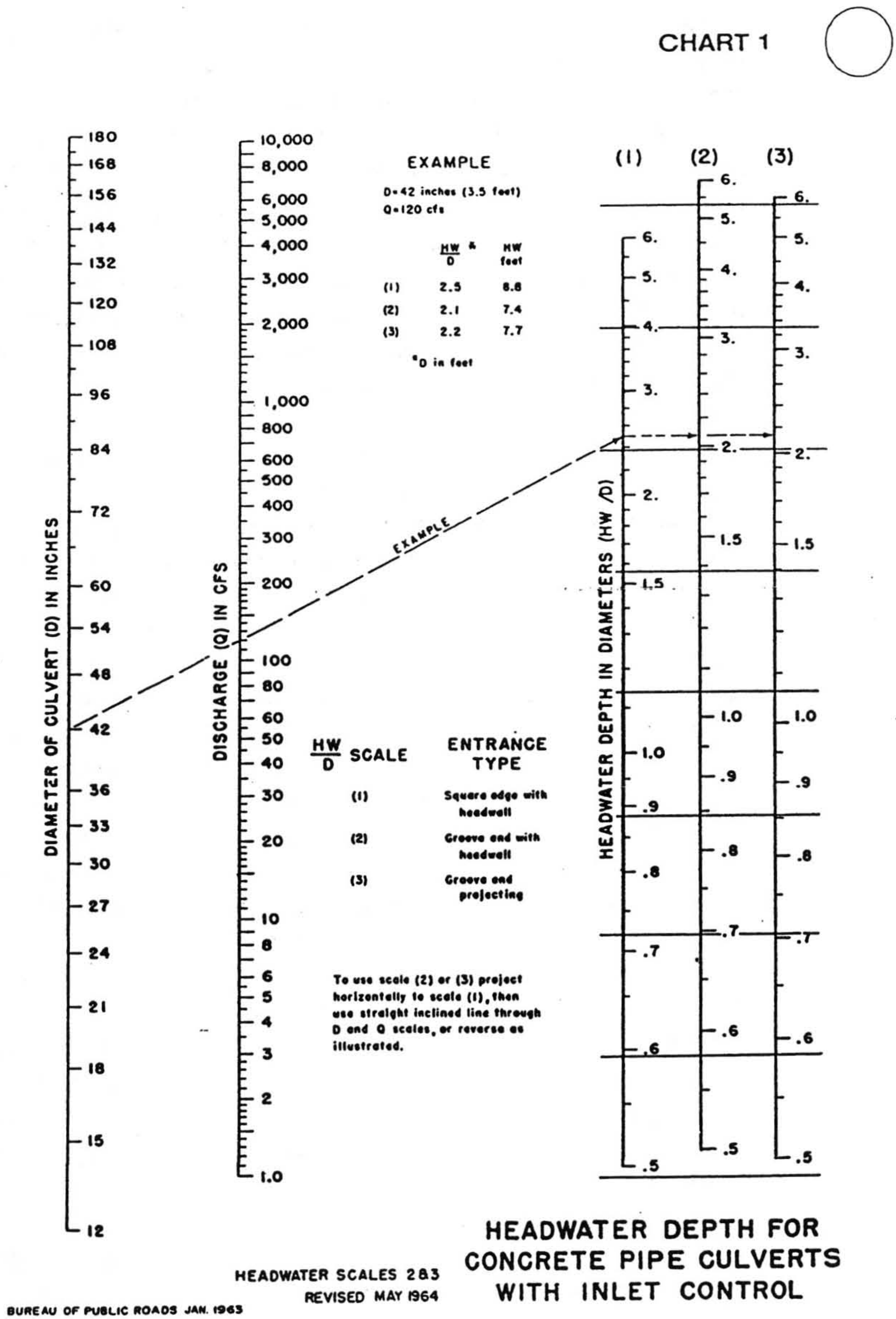
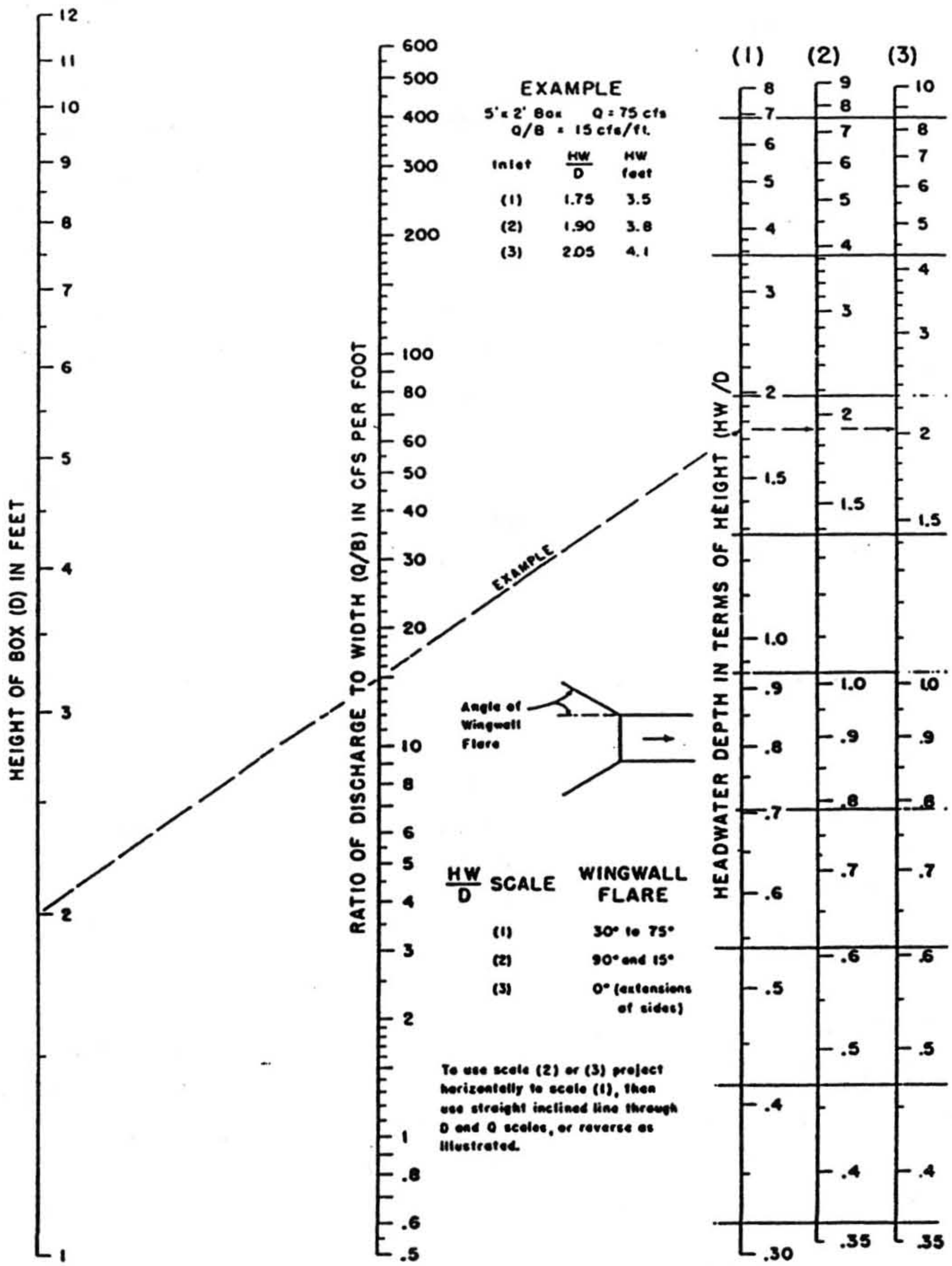


CHART 1
DIAMETER OF CULVERT (D) IN INCHES
DISCHARGE (Q) IN CFS
HEADWATER DEPTH IN DIAMETERS (HW/D)
(1)
(2)
(3)
EXAMPLE
D=42 inches (3.5 feet)
Q=120 cfs
HW/D* HW feet
(1) 2.5 8.8
(2) 2.1 7.4
(3) 2.2 7.7
*D in feet
EXAMPLE
HW/D SCALE
ENTRANCE TYPE
(1) Square edge with headwall
(2) Groove end with headwall
(3) Groove end projecting
To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through D and Q scales, or reverse as illustrated.
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL
HEADWATER SCALES 2&3 REVISED MAY 1964
BUREAU OF PUBLIC ROADS JAN. 1963

FIGURE IV-2

CHART 8



HEADWATER DEPTH
FOR BOX CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

elevation. The conduit capacity is checked against the 100-year flood, assuming a beginning water surface elevation defined in the FEMA Flood Maps.

3. Tide Gates

Tide gates are recommended to be installed on all outfalls that discharge to the ocean where tidal influence or storm surge can cause a backup of runoff. Rather than typical steel of cast iron tide gates, it is recommended that tide gates constructed of a flexible rubber material be used with fewer parts that can corrode. One such gate is manufactured by Ashbrook-Simon-Hartley and operates under lower head conditions than a typical iron tide gate.

Another viable option that should be investigated at the time of design would be the TIDEFLEX check valves produced by Red Valve Company. This is a true check valve made of rubber that can seal drop tight even around entrapped solids and debris. They operate under extremely low head loss. While more expensive than most other tide gates, the increased costs, when compared with the overall cost of the project should be minimal, and reduced maintenance would likely more than offset the increased construction costs.

4. Detention Reservoirs and Basins

Detention reservoirs are ponds with a normal low water level. They provide additional storage capacity during periods of high flows to act as storage for excess runoff. Detention basins, on the other hand, are normally dry areas that act as storage facilities for excess water during periods of high runoff.

Both serve to decrease peak discharge flows downstream by acting as storage basins, effectively limiting the amount of flow that is released to less than the inflow. This is generally done by restricting the pipe outlet size. It is imperative that a safety bypass system be designed should flows exceed the capacity of the storage facility.

Both systems work better in undeveloped areas where development can be built around the proposed sites. These basins can decrease the required storm drainage facility improvements downstream and their associated costs. However, the cost of the basin including any potential land costs can, at times, outweigh the costs of downstream improvements.

CHAPTER V.
SPECIAL CONSIDERATIONS

A. EXISTING DEFICIENCIES

1. Agat Municipality

a. Node 1 - Taleyfac River (Refer to Site Map 3)

The 15' x 7' triple RCB culvert crossing Route 2 is adequate to handle the 20-year and 100-year storm flows. The RCB culvert capacity is 1,530-cfs and the runoff volummes are 549-cfs (20-year flood) and 845-cfs (100-year flood).

The HEC-RAS model indicates that the main channel banks of the river contain the 20-year storm runoff. The 100-year storm causes culvert over-topping and flooding of the river overbank areas. Flooding of nearby residences will occur, approximately within 1,000-feet of Route 2, during the 100-year storm.

b. Node 2 - Pagachao Subdivision, 36" RCP (Refer to Site Map 3)

The 36" diameter RCP conduit that discharges the storm water runoff generated for most of the Pagachao subdivision is undersized for the 20-year flood. Based on Manning's equation for full flow, the capacity of the storm drain is 26-cfs. The runoff volummes are 56-cfs (20-year flood) and 100-cfs (100-year flood).

There are several drain inlets within the Pagachao Subdivision that were filled with debris, causing blockage and storm water flooding on the road surface.

c. Node 3 - A 36" diameter RCP Culvert Crossing Route 2 (Refer to Site Map 3)

The 36" diameter culvert is at capacity for the 20-year storm event. The capacity of the culvert is 37-cfs based on inlet control using the banks of the channel as the headwater depth. The runoff volummes are 37-cfs (20-year flood) and 54-cfs (100 year flood). Residences and commercial buildings approximately within 500-feet of Route 2 will be flooded during the 100-year storm.

The culvert is commonly blocked at the downstream side with debris and sand from storm surge, causing flooding of the channel overbanks.

d. Node 4 - Chaligan Creek (Refer to Site Map 3)

The 11' x 6' RCB culvert crossing Route 2 is undersized. The capacity of the culvert is 242 cfs based on inlet control analysis, using the height of the channel bank as the headwater depth. The runoff volumes are 539-cfs (20-year flood) and 829-cfs (100-year flood).

The HEC-RAS model indicates that the channel size is not adequate to contain the runoff volumes. In the event of a 20-year storm, flooding occurs in the overbank area. Flooding of residences will occur, within approximately 300-feet of Route 2, during the 100-year storm.

e. Node 5 - Auau Creek (Refer to Site Map 4)

The 6' x 4.25' RCB culvert crossing Route 2 is adequately sized for the 20-year storm. The capacity of the RCB culvert is 120-cfs using inlet control analysis. The runoff volumes are 108-cfs (20-year flood) and 159-cfs (100-year flood).

The HEC-RAS model indicates that there is some minor channel over-topping during the 20-year storm in some of the upstream reaches of the main river channel. Elsewhere, and for most of the river reach, the model indicates that the main river channel contains the 20-year storm. The 100-year storm will cause flooding of residences within approximately 1,000-feet of Route 2.

Node 6 - Gaan River (Refer to Site Map 4)

The 6'x 5' double RCB culvert crossing Route 2 is adequately sized for the 20-year storm. The capacity is 336-cfs and runoff volumes are 196-cfs (20-year flood) and 295-cfs (100-year flood).

The HEC-RAS model indicates flooding of residences will occur to approximately 1,700 feet upstream from Route 2, during the 100-year storm event.

f. Node 7 - Finile River (Refer to Site Map 4)

The 11'x 6' RCB culvert crossing Route 2 is adequately sized. The capacity of the culvert is 418-cfs based on inlet control analysis. The runoff volumes are 215-cfs (20 year flood) and 325-cfs (100-year flood).

The HEC-RAS model indicates that the main channel banks contain the 20-year storm runoff without any flooding. Flooding of the overbanks, and nearby residences, is expected during the 100-year storm, within approximately 1,400-feet upstream of Route 2.

The condition of the underground conduit drainage system within the Node 7 watershed boundary is poor. There are several drainage inlets that are filled with heavy debris causing blockage and flooding of the roads.

g. Node 8 - Salinas River (Refer to Site Map 4)

The 5'x 4' RCB culvert crossing Route 2 is adequately sized for the 20-year storm. The capacity of the 5'x 4' RCB culvert is 160-cfs based on inlet control analysis. The runoff volumes are 150-cfs (20-year flood) and 220-cfs (100-year flood).

The HEC-RAS model indicates that the 20-year flood tops the main channel banks in the areas just upstream of the 5'x 4' RCB culvert. For the upstream areas, the natural channel appears to be adequate for containing the 20-year storm runoff without flooding into the overbanks.

The 100-year storm will cause culvert over-topping and flooding of the overbanks and nearby residences within approximately 700-feet upstream of Route 2.

The condition of the underground conduit drainage system within the Node 8 watershed boundary is poor. There are several drain inlets that are routinely blocked with debris and silt. Also, there are long steep sloping streets that have ineffective drain inlets or no inlets at all, that could cause problems with sheet flow on the road surface due to the steep slopes.

h. Node 9 - 24" Diameter RCP Conduit (Refer to Site Map 4)

The 24" diameter RCP conduit is undersized. Based on Manning's equation for full flow, the capacity of the storm drain is 26-cfs. The runoff volumes are 56-cfs (20-year flood) and 100-cfs (100-year flood). Minor flooding of Route 2 will occur during the 20-year storm and Route 2 plus nearby residences will be flooded during the 100-year storm.

The storm drain discharges into an earth channel that is overgrown with heavy vegetation and small trees.

i. Node 11 - 36" Diameter RCP Culvert (Refer to Site Map 4)

The 36" diameter culvert is undersized. The capacity of the culvert is 35-cfs. The runoff volumes are 95-cfs (20-year flood) and 136-cfs (100-year flood). The storm drain discharges into a natural earth/sand channel that is routinely overgrown with heavy vegetation.

j. Node 12 - 36" Triple Barrel RCP Culvert (Refer to Site Map 4)

The triple barrel pipe culvert crossing Route 2 is adequately sized. The capacity of the culvert is 180 cfs. The runoff volumes are 58-cfs (20-year flood) and 84-cfs (100-year flood).

The HEC-RAS model indicates that the channel leading up to the culvert barely contains the 20-year storm within the channel banks.

The 100-year storm model indicates culvert over-topping and flooding of the overbanks for an approximate distance of 1,000-feet upstream of Route 2.

k. Node 13 - Togcha River (Refer to Site Map 4)

The Togcha River contains three main culverts within the Node 13 watershed boundary. All three culverts are adequately sized.

The HEC-RAS model indicates that the 20-year storm is barely contained within the main river channel and at several locations there is some minor flooding into the overbank region. The main channel is routinely filled with heavy debris. At one particular location, banana stalks and other debris built up forming a minor dam and causing major blockage within the channel banks.

Flooding of residences will occur approximately 1,100-feet upstream of Route 2 during the 100-year storm.

The Node 13 watershed area also drains part of the Santa Rita village. The 36" diameter RCP located in Santa Rita is undersized. The capacity of the 36" drainage pipe is 145 cfs based on Manning's Equation for full pipe flow. The runoff volumes are 221-cfs (20-year flood) and 332-cfs (100-year).

The Santa Rita village contains a network of earth & concrete ditches and small culverts along the roads. In general, the concrete channels are fairly clean. In one particular location, close to the Santa Rita baseball field, the channel is filled with debris, blocking the culvert entrance and diverting storm runoff onto the road. Several earth channels contain overgrown vegetation that also diverts runoff onto the road.

l. Node 14 - 36" Triple Barrel RCP Culvert (Refer to Site Map 4)

The 36" diameter, triple barrel, RCP culvert crossing Route 2 is adequately sized. However, the channel upstream and downstream contains debris and vegetation. The HEC-RAS model indicates that the upstream reaches of the channel barely contain the 20-year storm.

The 100-year storm model indicates culvert over-topping and flooding of residences approximately 1,200-feet upstream of Route 2.

m. Node 15a - Santa Rosa Subdivision, 24" RCP Conduit (Refer to Site Map 4)

The 24" diameter RCP conduit that discharges the Santa Rosa Subdivision runoff is undersized. Based on Manning's equation for full flow, the capacity of the 24" diameter conduit is 47 cfs. The runoff volumes are 142-cfs (20-year flood) and 207-cfs (100-year flood).

It appears the drain inlet manhole is regularly filled with debris and would reduce the capacity of the pipe.

In general, the condition of the underground drainage network for Santa Rosa Subdivision is in good shape. There were a few drain inlets that were completely covered with silt.

2. Santa Rita

a. Node 15d - 40" Double Barrell RCP Culvert (Refer to Site Map 5)

The 40" diameter, double barrel, RCP culvert near the Southern High School is undersized. The capacity of the culvert is 94-cfs based on inlet control. The headwater depth is limited to the height of the open channel leading to the culvert. The runoff volumes are 155-cfs (20-year flood) and 232-cfs (100-year flood).

The HEC-RAS model indicates over-topping of the channel banks upstream and downstream during a 20-year storm event. The channel is routinely blocked with banana stalks and debris from the surrounding overbank areas.

b. Node 15f - 36" Diameter, Double Barrel, RCP, Culvert (Refer to Site Map 5)

The 36" double barrel culvert near Route 5 (Roberto Drive) is adequately sized for the 20-year storm. The capacity of the culvert is 130-cfs based on inlet control. The headwater depth is limited to the height of the open channel leading to the culvert. The runoff volumes are 113-cfs (20-year flood) and 170-cfs (100-year).

Flooding of 1 nearby residence is possible during the 100-year storm event.

c. Node 15g - 36" & 24" RCP Culverts (Refer to Site Map 5)

The 36" and 24" diameter RCP culverts near J. Sarmiento Street in Santa Rita are undersized. The capacity of the combined culvert is 93-cfs based on inlet control. The headwater depth is limited to the height of the open channel leading to the culvert. The runoff volumes computed are 113-cfs (20-year flood) and 169-cfs (100-year flood).

d. Node 15h - 30" Double Barrel RCP Culvert (Refer to Site Map 4)

The 30" diameter, double barrel, RCP culvert crossing Pale Roman St. in Santa Rita is adequately sized. The channel upstream and downstream contains debris and vegetation. The HEC-RAS model indicates that the upstream channel reach does not contain the 20-year storm runoff within the channel banks.

Node 15i - 30" x 30" Double RCB Culvert (Refer to Site Map 4)

The double RCB (30"x 30") culvert near Chalan Obispo Road (Route 12) in Santa Rita is undersized. The capacity of the culvert is 135 cfs based on inlet control. The headwater depth is limited to the height of the ditch at the upstream end of the culvert. The runoff volumes computed using HEC-1 analysis are 209-cfs (20-year flood) and 312-cfs (100-year flood).

The HEC-RAS model indicates that the upstream channel reach does not contain the 20-year storm runoff. The downstream reach contains debris and vegetation which cause blockage and minor buildup.

3. Piti

a. Node 16 - Atantano River Bridge at Marine Drive

The HEC-RAS model of the lower reaches of the Atantano River will flood during the 20-year flood. Businesses near the intersection of Marine Drive and Route 2 will be flooded during the 20-year flood.

b. Node 16d - 2-36" Diameter RCP Culverts at J.C. Diaz (Refer to Site Map 5)

The 36" double barrel culvert near J.C. Diaz Drive in Santa Rita is undersized. The capacity of the culvert is 84-cfs based on inlet control. The headwater depth is limited to the height of the open channel leading to the culvert. The runoff volumes are 167-cfs (20-year flood) and 252-cfs (100-year flood).

The HEC-RAS model indicates over-topping the channel banks in the upstream reaches of the channel during the 20-year storm.

c. Node 25A - 18" RCP Culvert (Refer to Site Map 10)

The 18" diameter RCP culvert crossing Assumption Drive at the intersection with Route 6 is undersized for the . The capacity of the culvert is 14 cfs. The calculated runoff volumes are 25-cfs (20-year flood) and 36-cfs (100-year flood). Flooding at this location would be minor as water would rise in the ditch and overflow over Assumption drive and continue in the ditch adjacent to Route 6.

Other culverts in this node are sized properly but are commonly plugged with debris. Minor flooding may occur due to the debris and blockage of the culverts.

d. Node 26A - 27" Diameter RCP Culvert (Refer to Site Map 10)

The 27" RCP culvert crossing Assumption Drive is undersized. The capacity is 36-cfs based on inlet control. Runoff volumes are 56-cfs (20-year flood) and 82-cfs (100-year flood). Flooding caused by this culvert overflowing will flow over Assumption Drive and into the Masso River. No residential flooding is expected to occur.

e. Node 27 - 36" Diameter, Double Barrel, RCP Culvert (Refer to Site Map 10)

The RCP culvert at Marine Drive has adequate capacity for the 20-year storm event. Based on inlet control, the capacity is 96-cfs. The runoff volumes are 73-cfs (20-year flood) and 106-cfs (100-year flood).

It was noted that the culvert was partially blocked with debris. Residences upstream from the culvert, between Marine Drive and Assumption drive, will be flooded during the 100-year flood.

The double barrel, 27" diameter culvert upstream from Node 27 is partially collapsed and obstructed.

f. Node 27A - (3'-4"x 1'-7") RCB Culvert (Refer to Site Map 10)

The RCB culvert crossing Assumption Drive is undersized. The capacity is 14-cfs based on inlet control. Runoff volumes are 69-cfs (20-year flood) and 101 cfs (100-year flood).

Hydraulic analysis of the existing channel using Manning's equation indicates that it will overflow its banks during both the 20-year and 100-year events.

Residences and commercial buildings between Marine Drive and Assumption Drive will be flooded during these storm events.

g. Node 28 - 10'x5' RCB Culvert (Refer to Site Map 10)

The RCB culvert is adequately sized for the 20-year event. The capacity calculated is 240-cfs. Runoff volumes are 126-cfs (20-year flood) and 186-cfs (100-year flood).

HEC-RAS analysis of the river channel upstream from the culvert indicates that the existing channel will contain the 20-year storm but the 100-year storm will overtop the channel by approximately 1-foot. This will flood residences between Marine Drive and Assumption Drive.

Two 36" Diameter RCP culverts at Quenga Street have a capacity of 72 cfs, based on inlet control. Interpolation between Node 28 and Node 28A indicates this culvert is undersized.

h. Node 28A - 36" Diameter, Dual RCP Culvert (Refer to Site Map 10)

The culvert is adequately sized for the 20-year storm. The calculated capacity is 160-cfs. The runoff volumes are 133-cfs (20-year flood) and 196-cfs (100-year flood).

Residences will be flooded in the Quenga Street area during the 100-year storm event.

i. Node 29 - 24" Diameter, Triple Barrel, RCP Culvert (Refer to Site Map 10)

The existing RCP culvert is undersized. The capacity of the culvert is 66 cfs based on inlet control. The calculated runoff volumes are 168-cfs (20 year flood) and 244-cfs (100-year flood).

HEC-RAS analysis indicates this channel will overflow its banks by approximately 5-feet during the 20-year storm and by approximately 7-feet during the 100-year storm. Residential flooding will occur.

j. Node 30 - 36" Diameter, Dual RCP Culvert (Refer to Site Map 10)

The 2-36" RCP culvert is undersized. The capacity is 70-cfs based on inlet control and the calculated runoff volumes are 140-cfs (20-year flood) and 204-cfs (200-year flood).

The downstream outfall is subject to tidal influence and the capacity will be reduced by storm surge during a major storm. In addition, this facility is routinely partially blocked with debris.

HEC-RAS analysis indicates the existing channel is undersized. The channel will overflow during both the 20-year and 100 year events, causing flooding of residences.

k. Node 31 - (2-36") Diameter, RCP Culvert (Refer to Site Map 10)

The 36" diameter, double barrel RCP culvert is undersized. The capacity is 70-cfs based on inlet control and the calculated runoff volumes are 144-cfs (20-year flood) and 210-cfs (200-year flood). The downstream outfall is subjected to tidal influence and the capacity will be reduced by storm surge during a major storm. The low capacity of this culvert will exacerbate flooding caused by inadequate capacity of the channel.

HEC-RAS analysis indicates the existing channel is undersized and will overflow during both the 20-year and 100-year events. In both events nearby residences will be flooded.

4. Asan

a. Node 33B - 30" Diameter, RCP Conduit (Refer to Site Map 11)

The 30" diameter RCP conduit is adequately sized for the 20-year storm. The calculated capacity is 33-cfs using Manning's equation with the pipe flowing full. The runoff volumes are 31-cfs (20-year flood) and 46-cfs (100-year flood). Residences will be flooded at the west end of Monsignor Jose Leon Guerrero Street during the 100-year event.

b. 34D - 18" Diameter, RCP Conduit (Refer to Site Map 11)

The analysis, using Manning's equation, shows that this section of the drainage system is undersized. The calculated capacity is 18 cfs. The runoff volumes are 144-cfs (20-year flood) and 212-cfs (100-year flood).

c. Node 34G - 24" Diameter RCP, Conduit (Refer to Site Map 11)

The conduit is undersized. The calculated capacity of the existing 24" diameter RCP conduit, using Manning's equation, is 35 cfs. The calculated runoff volumes are 37-cfs (20-year flood) and 54-cfs (100-year flood).

d. Node 35 - 3'x 4' RCB Culvert (Refer to Site Map 11)

The culvert is undersized. Analysis of the existing culvert using inlet control indicate that its capacity is 120-cfs. The calculated runoff volumes are 132-cfs (20-year flood) and 190-cfs (100-year flood).

e. Node 35B - 30" Diameter, Dual RCP Culvert (Refer to Site Map 11)

The RCP culvert has adequate capacity for the 20-year storm. The capacity of this culvert is 110 cfs based on inlet control. The calculated runoff volumes are 84-cfs (20-year flood) and 123-cfs (100-year flood). Flooding in some residences will occur during the 100-year storm.

5. Agana

a. Node 40 (Fonte River) 67' x 10', Triple Barrel, RCB Culvert (Refer to Site Map 11)

Hec-RAS analysis of the river channel indicates that the river will overflow its banks within the study area during both the 20-year and 100-year storms. Flooding during the 20-year storm could flood some residences and the Pigo Cemetery. The 100-year storm will cause significant flooding to businesses, residences and the Pigo Cemetery.

The residential area just north of the Pigo Cemetery, within the Node 40 watershed, drains to a pump station. Storm drain inlets and the pump station have been added but there are no appurtenances such as gutters to carry the water to the inlets.

b. Node 40A - Triple Barrel, RCB Culvert (Refer to Site Map 11)

The RCB culvert crosses Route 6 and discharges to the Fonte River. The culvert is undersized for the 20-year storm event. The calculated capacity of the culvert is 328-cfs. The computed runoff volumes are 364-cfs (20-year flood) and 532-cfs (100-year flood).

c. Node 41 - 12' x 2' RCB Conduit (Refer to Site Map 12)

The RCB conduit is undersized for the 20-year storm event. The calculated capacity is 328-cfs. The runoff volumes are 364-cfs (20-year flood) and 532-cfs (100-year flood).

There very few curbs or gutters to direct flows to drainage inlets and the existing inlets are not adequately spaced.

d. Node 42 - 24" Diamter, RCP Conduit (Refer to Site Map 12)

The 24" diameter conduit is undersized for the 20-year storm event. The calculated capacity of this facility is 23-cfs based on Manning's equation with the pipe flowing full. The computed runoff volumes are 43-cfs (20-year flood) and 62-cfs (100-year flood).

This area is located between Marine Drive and Agana Bay and is likely to experience flooding from storm surge.

e. Node 43 - 30" Diameter, Triple Barrel, RCP Conduit (Refer to Site Map 12)

The RCP conduit is adequately sized for the 20-year storm event. The computed capacity of this node is 147-cfs using Manning's formula. The computed runoff volumes are 136-cfs (20-year flood) and 197-cfs (100-year flood).

The 100-year storm will flood residences.

f. Node 44 - 18" Diameter, RCP Conduit (Refer to Site Map 12)

The conduit at the intersection of O'Brian Drive and 5th Street is undersized. The calculated capacity of the conduit is 13-cfs. The computed runoff volumes are 73-cfs (20-year flood) and 106-cfs (100-year flood).

g. Node 45 - 24" Diameter, Dual RCP Conduit

The dual conduit is undersized for the 20-year storm. The calculated capacity is 46-cfs using Manning's equation with the pipe flowing full. The computed runoff volumes are 94-cfs (20 year flood) and 124-cfs (100-year flood).

h. Node 45A - 18" Diameter, RCP Conduit (Refer to Site Map 12)

The conduit is undersized for the 20-year event. The calculated capacity of the pipe is 11-cfs. The computed runoff volumes are 93-cfs (20-year flood) and 134-cfs (100-year flood).

i. Node 46 - 24" Diameter, Dual RCP, Conduit (Refer to Site Map 12)

The calculated capacity of this facility 43 cfs using Manning's formula with the conduit flowing full. The computed runoff volumes are 78 cfs (20 yr) and 112 cfs (100 yr).

j. Node 46A - 12" Diameter RCP Conduit (Refer to Site Map 12)

The conduit is undersized for the 20-year. The calculated capacity is 3-cfs. The computed runoff volumes are 56-cfs (20-year flood) and 81-cfs (100-year flood).

k. Node 47 - 36" Diameter, Dual RCP Conduit (Refer to Site Map 12)

The conduit is undersized for the 20-year event. The calculated capacity of the facility is 127-cfs using Manning's equation with the pipes flowing full. The computed runoff volumes are 147-cfs (20-year flood) and 212-cfs (100-year flood).

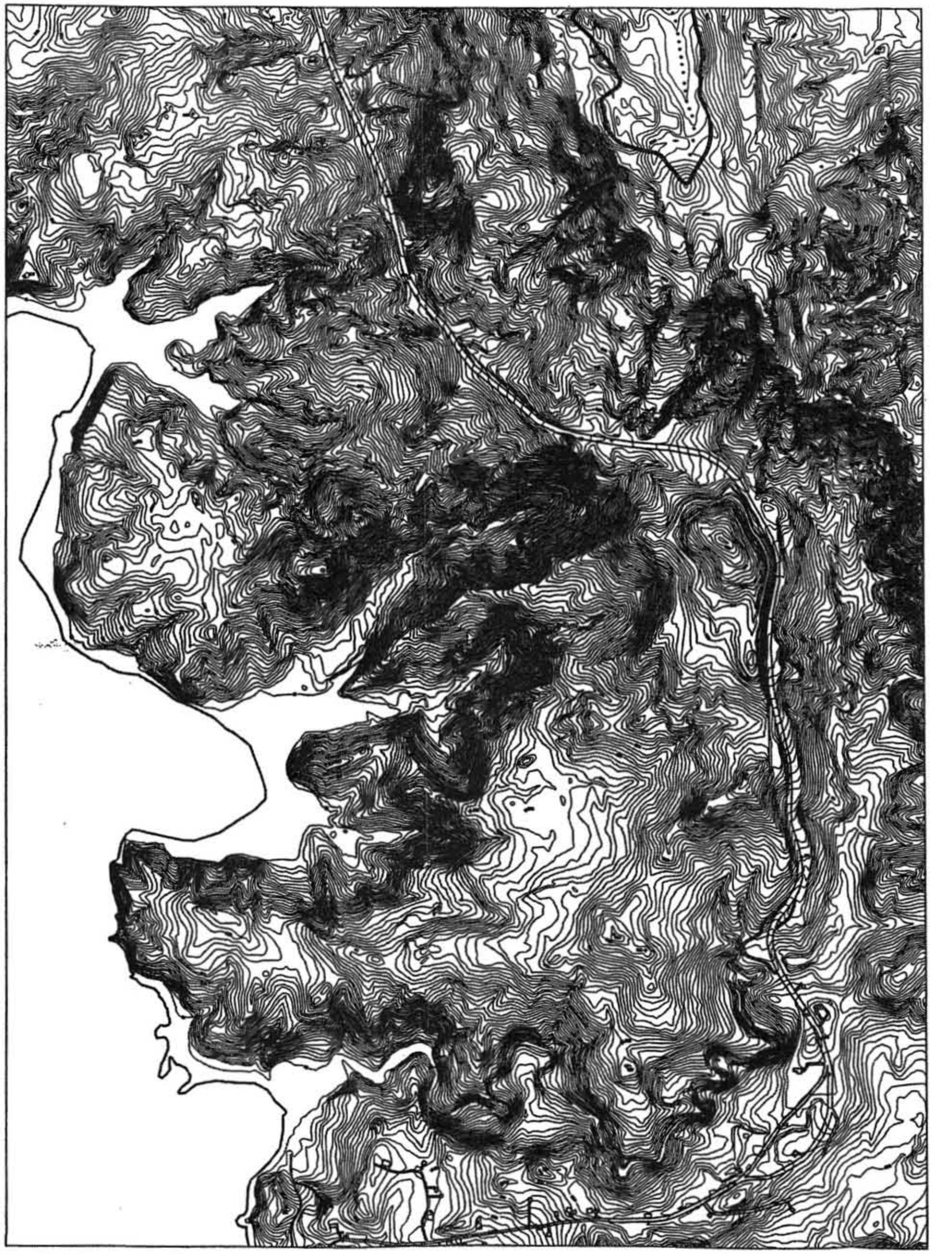
l. Node 47A - 12" Diameter, RCP Conduit (Refer to Site Map 12)

The conduit is undersized. The calculated capacity is 4-cfs using Manning's Equation with the pipe flowing full. The computed runoff volumes are 13-cfs (20-year flood) and 20-cfs (100-year flood). This area regularly experiences minor flooding during the rainy season.

m. Node 47B - 12" Diameter RCP Conduit (Refer to Site Map 12)

The conduit is undersized for the 20-year event. The calculated capacity is 3-cfs using Manning's Equation with the pipe flowing full. The computed runoff volumes are 129-cfs (20-year flood) and 187-cfs (100-year flood). This area regularly experiences minor flooding during the rainy season.

APPENDIX A



LEGEND

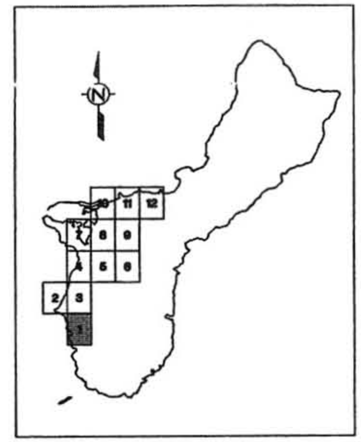
A – Areas of 100–year flood

V – Areas of 100–year coastal flood with velocity (wave action)

Node Area Boundary

Hydraulic Lines

Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

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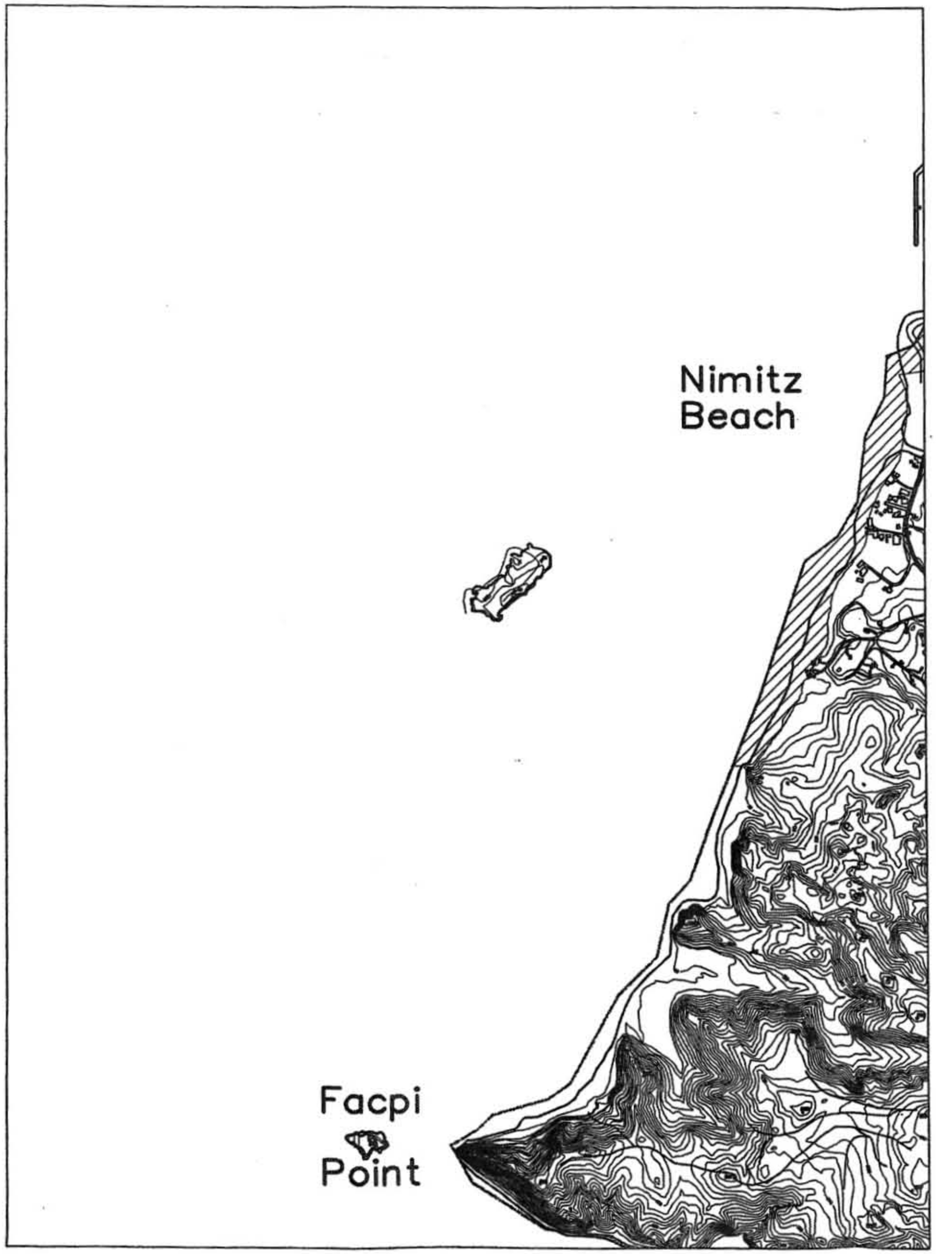
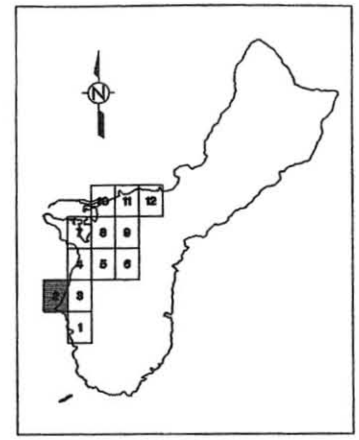
CONTRACT NO. –	
DESIGNED BY: TG	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: RS	
CHECKED BY: TG	
SUPV. BY: TG	GUAM U.S.A.
DATE: 12-20-96	DRAWING TITLE: SITE MAP 1
PROJECT ENGINEER DATE	
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS
SCALE: 1"=650'	DRAWER NO. DRAWING NUMBER



LEGEND

- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

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DRAWN BY: MP	
CHECKED BY: TG	
SUPV. BY: TG	
DATE: 12-20-96	DRAWING TITLE: SITE MAP 2
PROJECT ENGINEER DATE	
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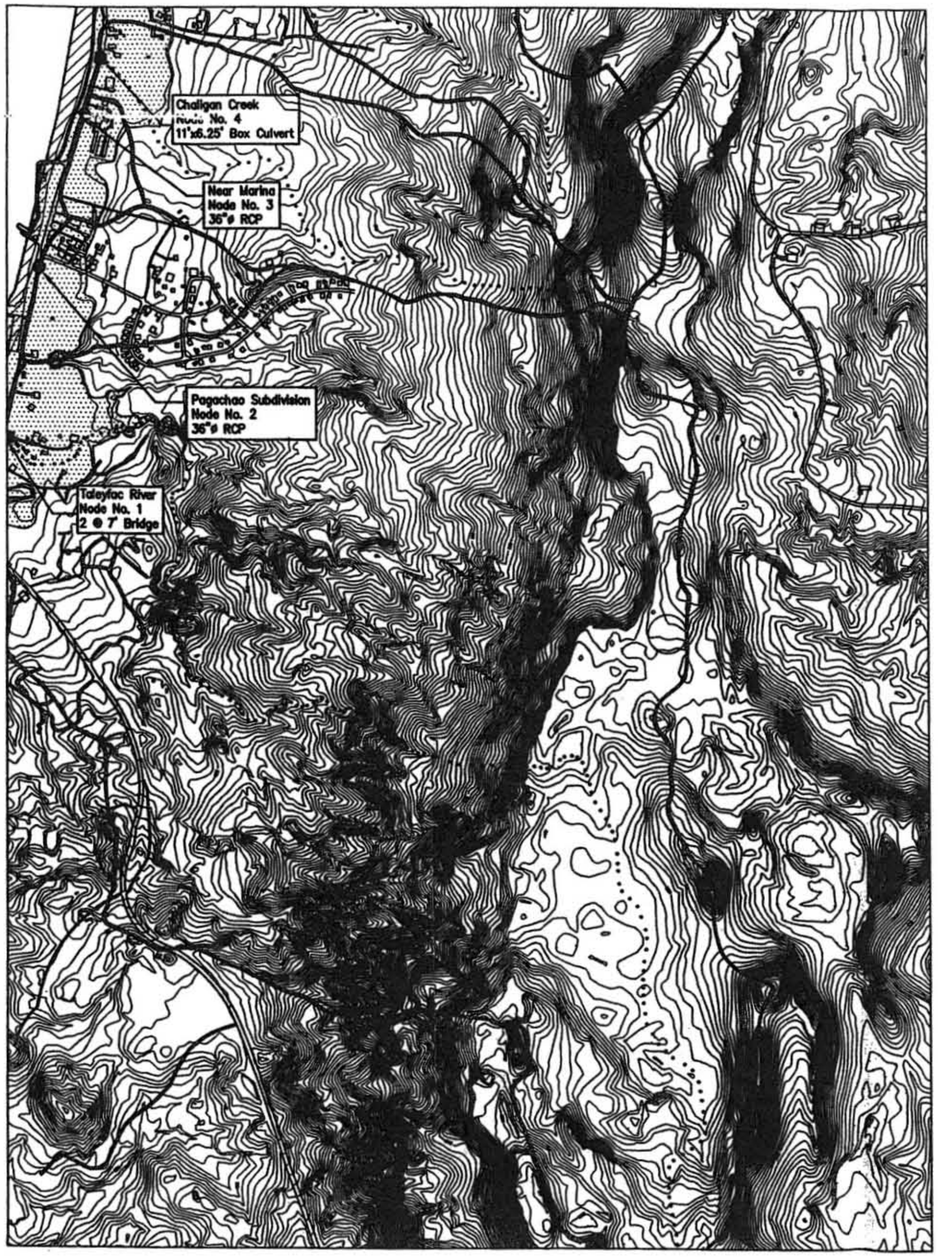
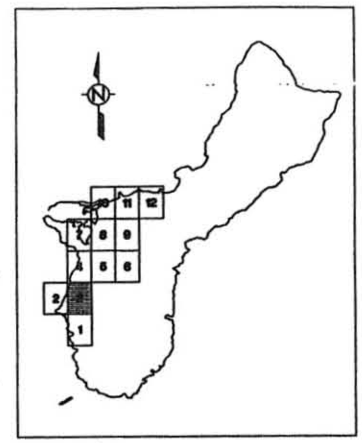
	DRAWER NO.
	DRAWING NUMBER



LEGEND

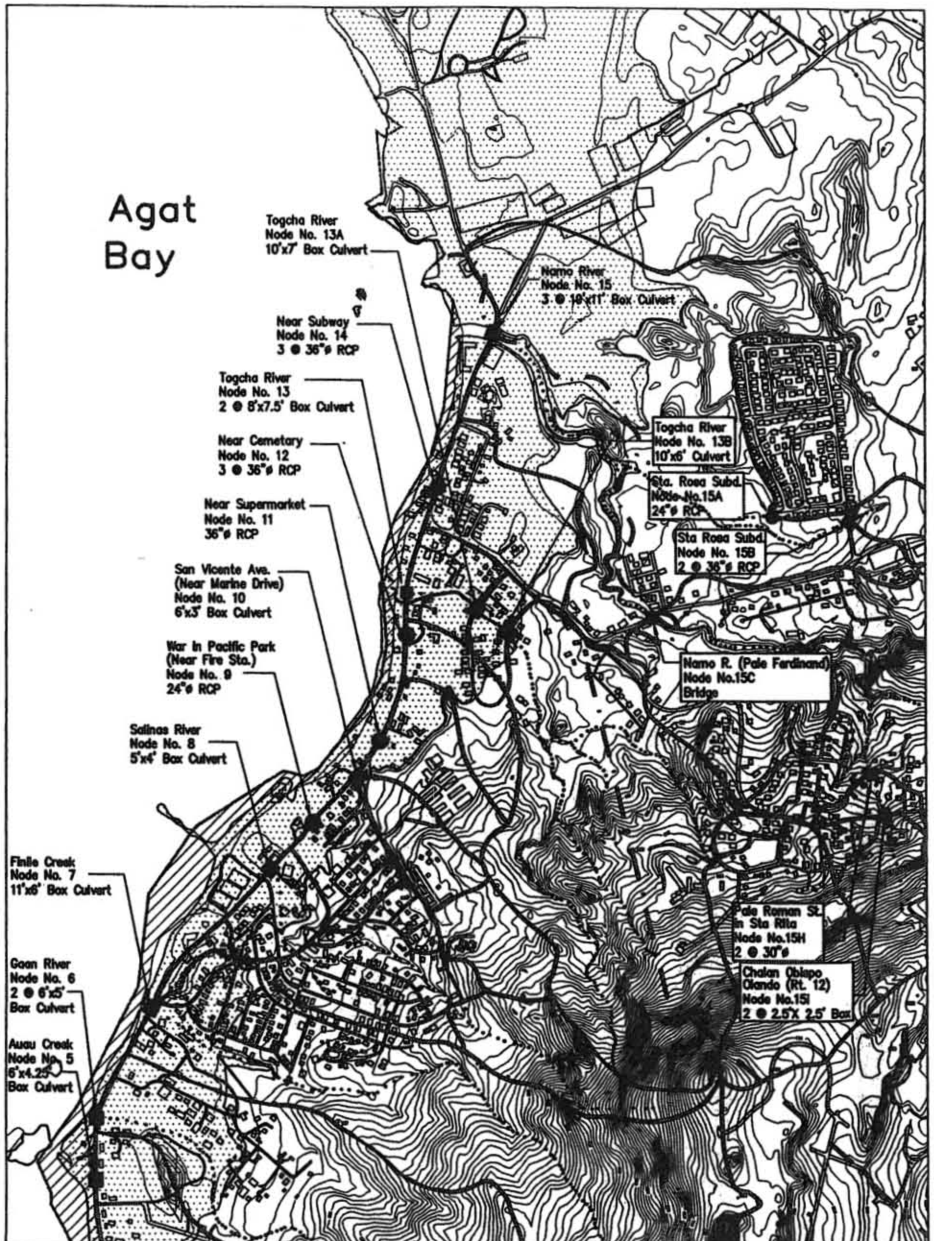
- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

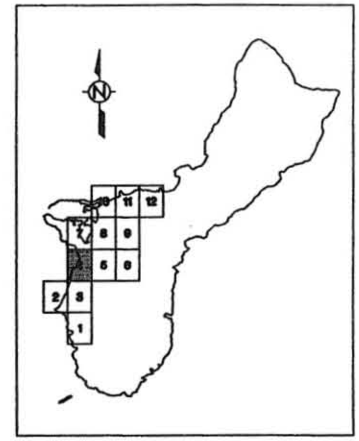
TASK 2 SUBMITTAL

WBK PROJECT NO. 94405228	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TC	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: MP	
CHECKED BY: TC	
SUPV. BY: TC	GUAM U.S.A.
DATE: 12-20-88	DRAWING TITLE: SITE MAP 3
PROJECT ENGINEER DATE	DRAWER NO.
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS
	DRAWING NUMBER



LEGEND

- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO.	94400228
CONTRACT NO.	–
DESIGNED BY:	TG
DRAWN BY:	MP
CHECKED BY:	TG
SUPV. BY:	TG
DATE:	12-20-95
PROJECT ENGINEER	DATE
SECTION MANAGER	DATE

GOVERNMENT OF GUAM
DEPARTMENT OF PUBLIC WORKS

SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I

GUAM U.S.A.

DRAWING TITLE:

SITE MAP 4

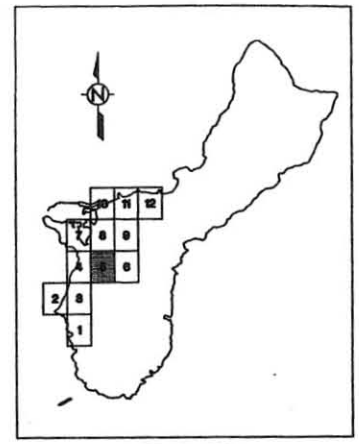
DRAWER NO.

DRAWING NUMBER

WINZLER & KELLY
CONSULTING ENGINEERS

LEGEND

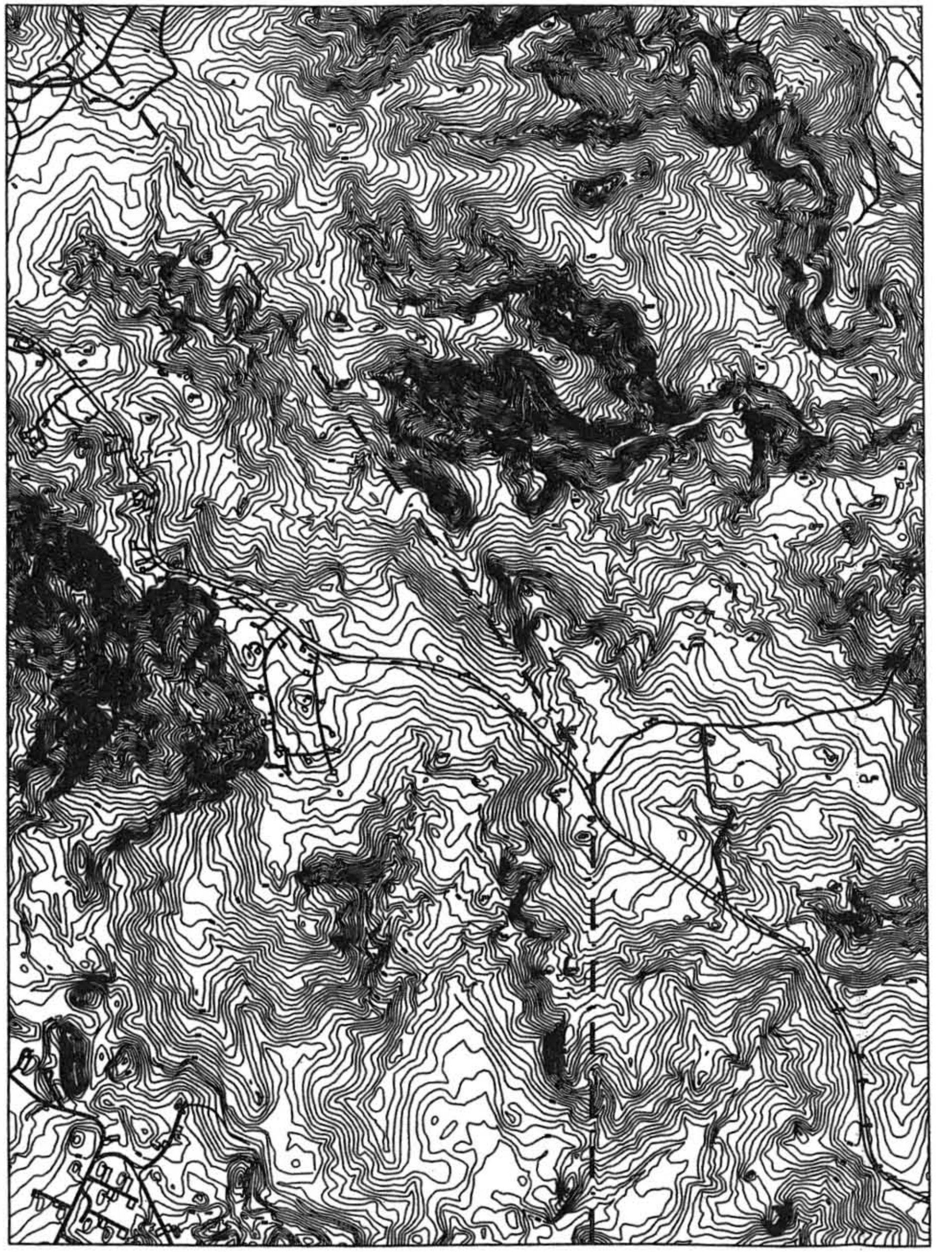
- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

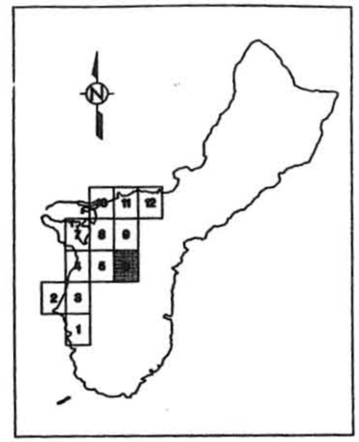
TASK 2 SUBMITTAL

W&K PROJECT NO. 94405220	**GOVERNMENT OF GUAM** DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TC	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: MP	
CHECKED BY: TC	
SUPV. BY: TC	GUAM U.S.A.
DATE: 12-20-96	DRAWING TITLE: SITE MAP 5
PROJECT ENGINEER DATE	DRAWER NO.
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS — DRAWING NUMBER



LEGEND

- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



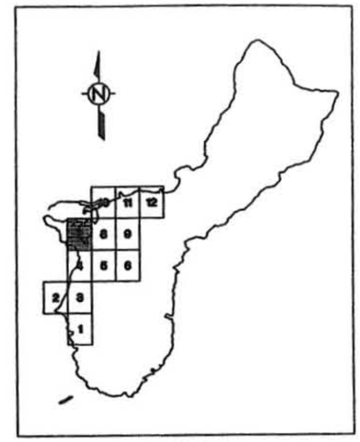
KEYMAP

TASK 2 SUBMITTAL

WKK PROJECT NO. 94405220	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS	
CONTRACT NO. –		
DESIGNED BY: TC	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I GUAM U.S.A.	
DRAWN BY: RS		
CHECKED BY: TC		
SUPV. BY: TC		
DATE: 12-20-95	DRAWING TITLE: SITE MAP 6	
PROJECT ENGINEER DATE		
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS	DRAWER NO.
SCALE: 1"=650'		DRAWING NUMBER

LEGEND

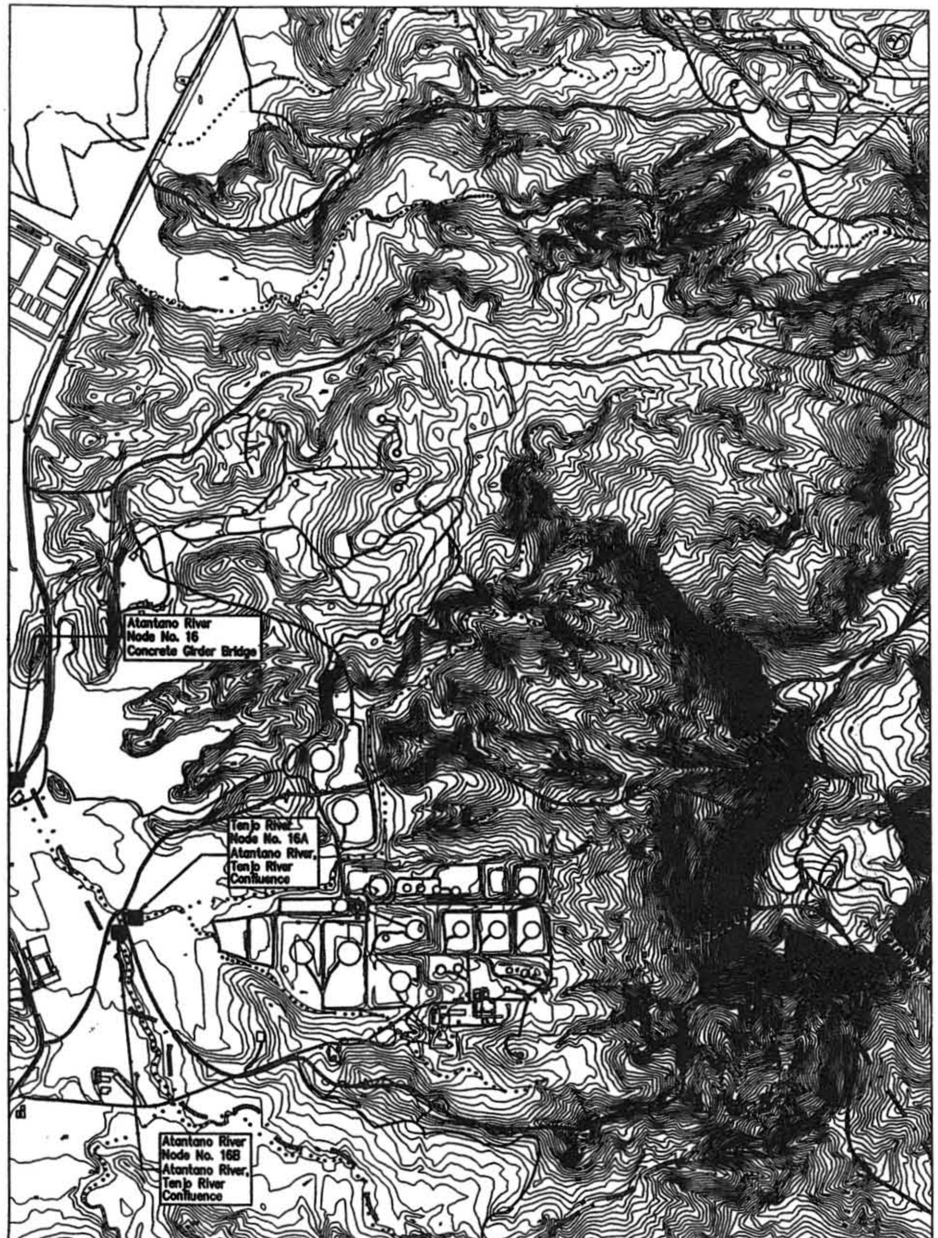
- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO. 94405228	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TC	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: RS	
CHECKED BY: TC	
SUPV. BY: TC	GUAM U.S.A.
DATE: 12-20-95	DRAWING TITLE: SITE MAP 7
PROJECT ENGINEER DATE	DRAWER NO.
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS — DRAWING NUMBER



LEGEND

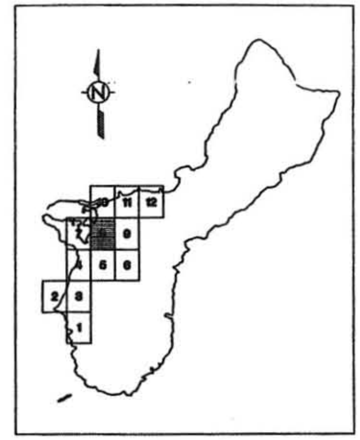
A – Areas of 100–year flood

V – Areas of 100–year coastal flood with velocity (wave action)

Node Area Boundary

Hydraulic Lines

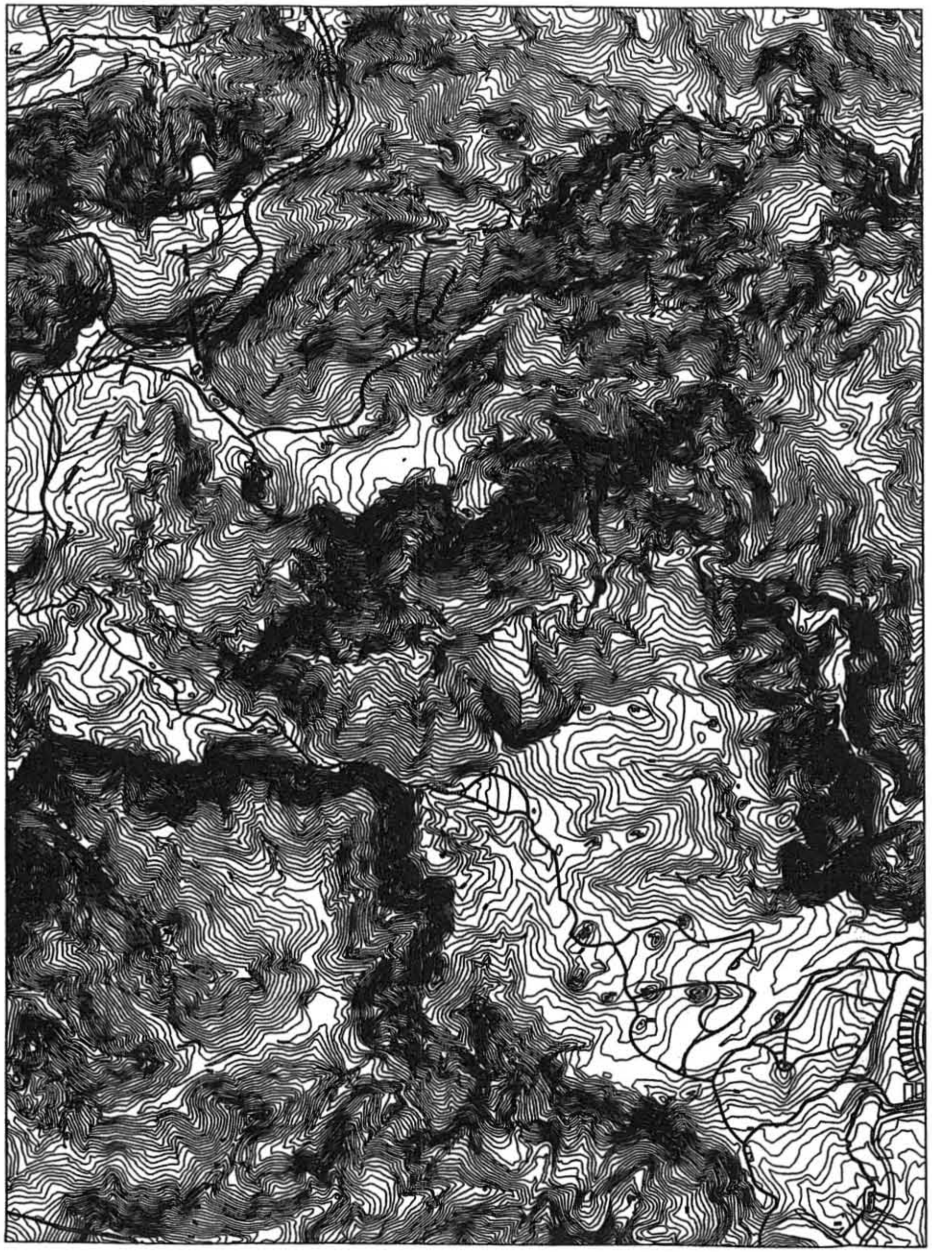
Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO. 94405228	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TC	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: RS	
CHECKED BY: TC	
SUPV. BY: TC	GUAM U.S.A.
DATE: 12-20-95	DRAWING TITLE: SITE MAP 8
PROJECT ENGINEER DATE	
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS
	DRAWER NO.
	DRAWING NUMBER



LEGEND

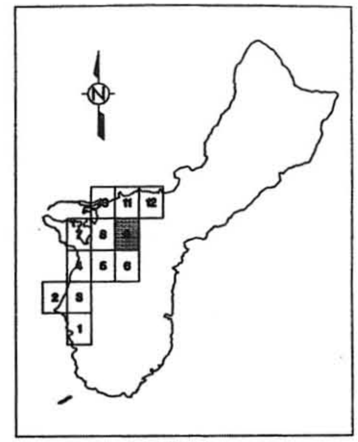
A – Areas of 100–year flood

V – Areas of 100–year coastal flood with velocity (wave action)

Node Area Boundary

Hydraulic Lines

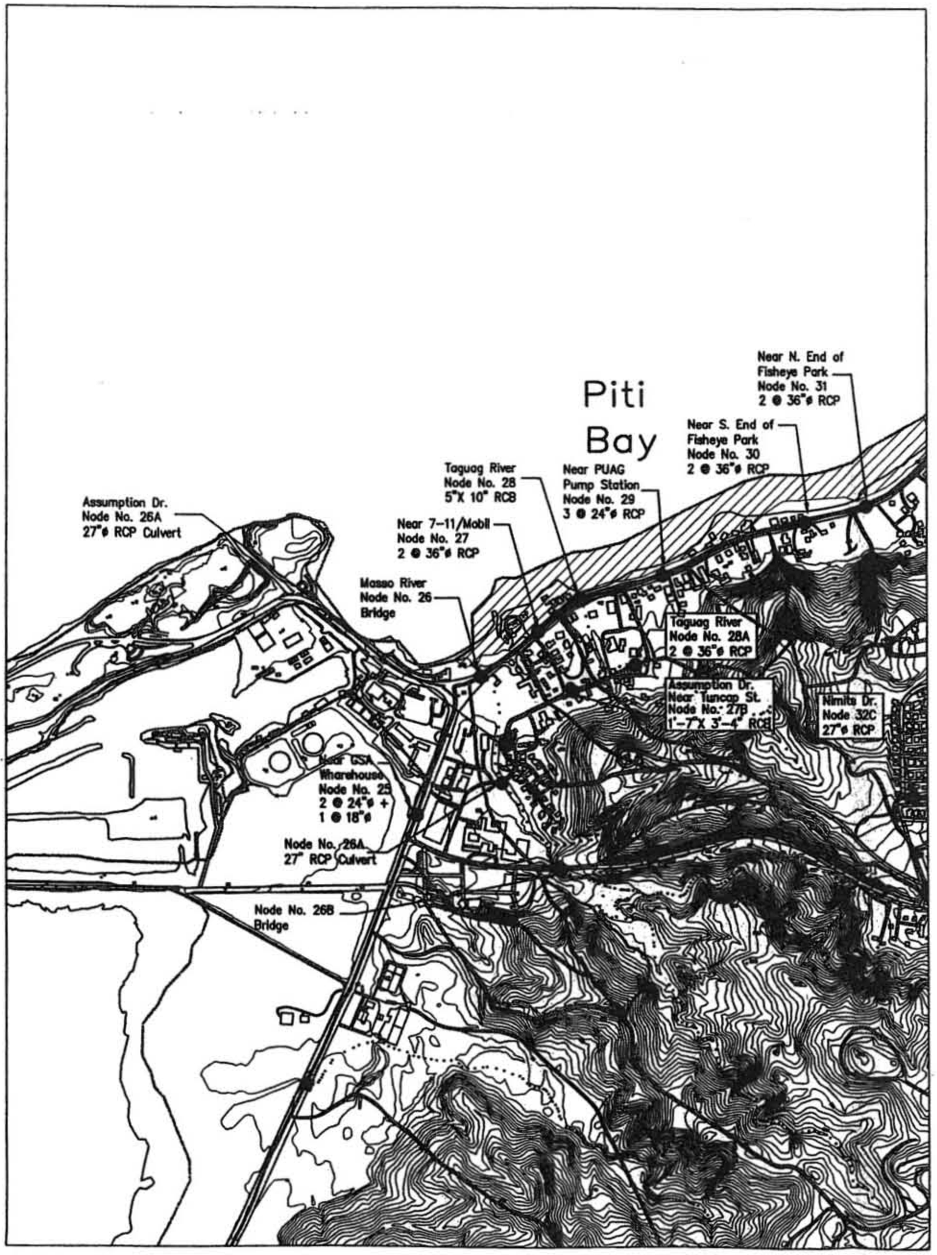
Municipal Boundary



KEYMAP

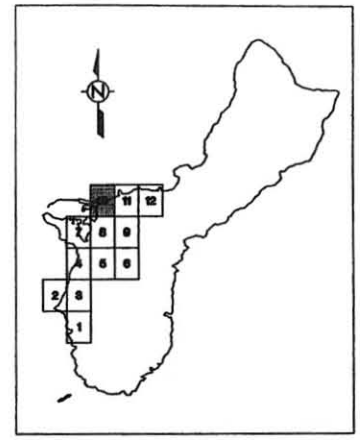
TASK 2 SUBMITTAL

W&K PROJECT NO. 94405228	**GOVERNMENT OF GUAM** DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TG	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: RS	
CHECKED BY: TG	
SUPV. BY: TG	GUAM U.S.A.
DATE: 12-20-96	DRAWING TITLE: SITE MAP 9
PROJECT ENGINEER DATE	
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS — DRAWER NO. — DRAWING NUMBER
SCALE: 1"=250'	



LEGEND

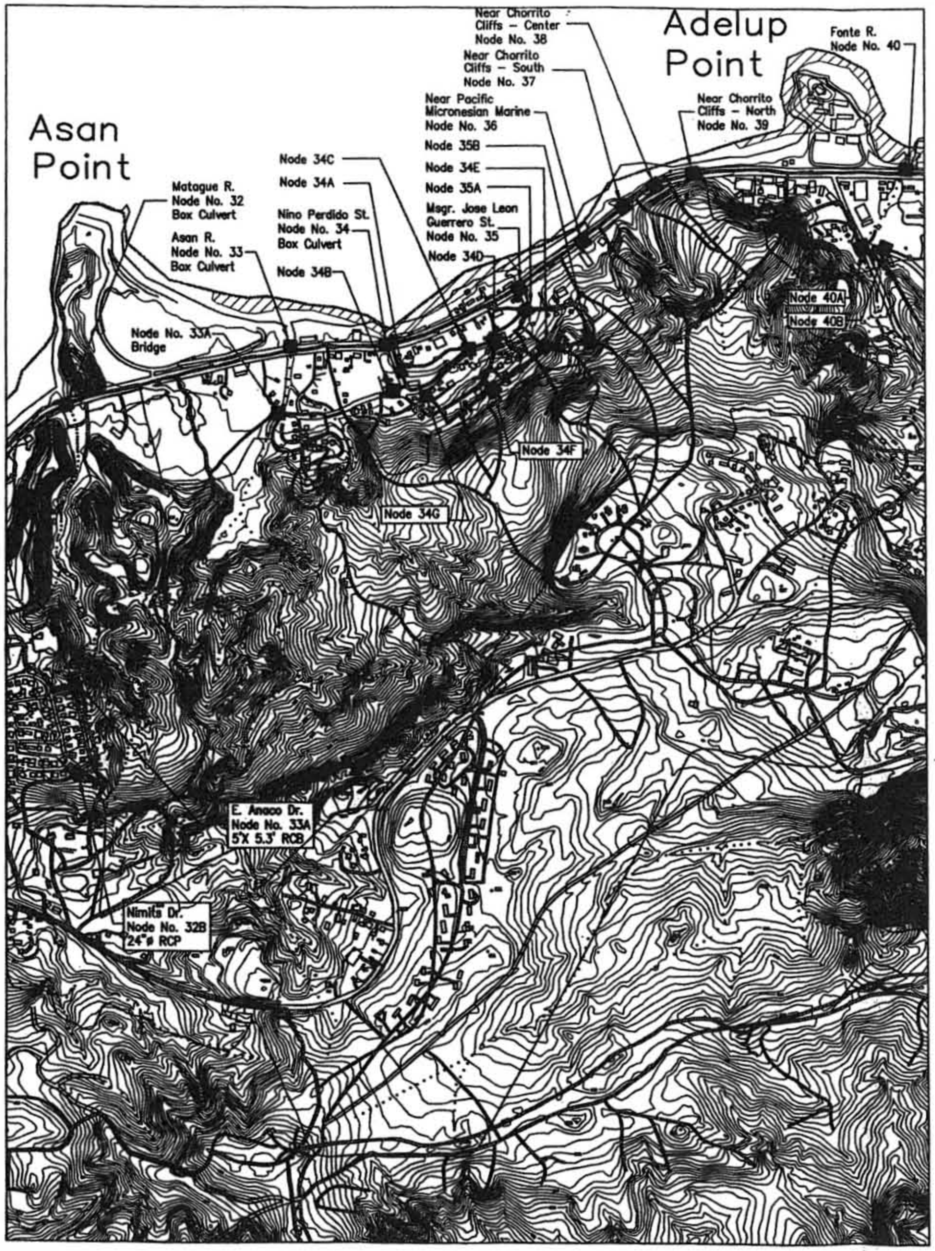
- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO.	94405220	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO.	–	
DESIGNED BY:	TC	SOUTHERN GUAM-FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY:	RS	
CHECKED BY:	TC	
SUPV. BY:	TC	GUAM U.S.A.
DATE:	12-20-95	DRAWING TITLE: SITE MAP 10
PROJECT ENGINEER	DATE	DRAWER NO.
SECTION MANAGER	DATE	WINZLER & KELLY CONSULTING ENGINEERS
SCALE:	1"=650'	DRAWING NUMBER



LEGEND

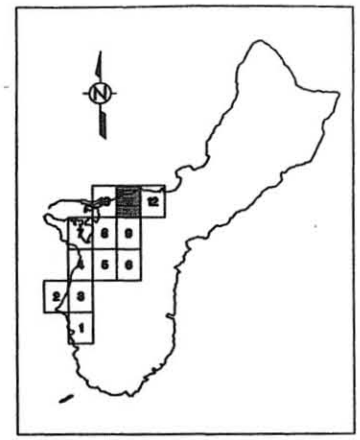
A - Areas of 100-year flood

V - Areas of 100-year coastal flood with velocity (wave action)

Node Area Boundary

Hydraulic Lines

Municipal Boundary



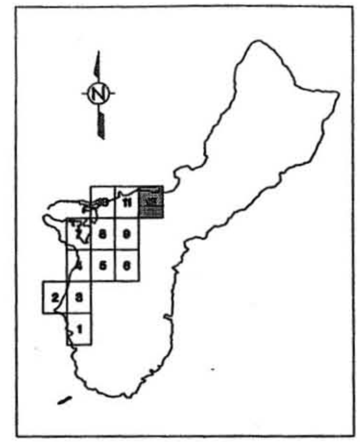
KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO. [illegible]	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. -	
DESIGNED BY: TG	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I GUAM U.S.A.
DRAWN BY: RS	
CHECKED BY: TG	
SUPV. BY: TG	
DATE: 12-20-96	DRAWING TITLE: SITE MAP 11
PROJECT ENGINEER DATE	
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS
SCALE: 1"=650'	DRAWER NO. DRAWING NUMBER

LEGEND

- A – Areas of 100–year flood
- V – Areas of 100–year coastal flood with velocity (wave action)
- Node Area Boundary
- Hydraulic Lines
- Municipal Boundary



KEYMAP

TASK 2 SUBMITTAL

W&K PROJECT NO. [illegible]	GOVERNMENT OF GUAM DEPARTMENT OF PUBLIC WORKS
CONTRACT NO. –	
DESIGNED BY: TG	SOUTHERN GUAM FLOOD CONTROL MASTER PLAN, PHASE I
DRAWN BY: RS	
CHECKED BY: TG	
SUPV. BY: TG	GUAM U.S.A.
DATE: 12-20-[illegible]	DRAWING TITLE: SITE MAP 12
PROJECT ENGINEER DATE	
SECTION MANAGER DATE	WINZLER & KELLY CONSULTING ENGINEERS
	DRAWER NO.
	DRAWING NUMBER

APPENDIX B

LIST OF DRAINAGE FACILITY CAPACITIES & RUNOFF VOLUMES

NODE	DESCRIPTION	STRUCTURE	Capacity (cfs)	20-yr (cfs)	100-yr (cfs)
1	Taleyfac River	3@(15x7) box	1530	549	845
2	Pagachao Subdivision	36"∅	73	122	178
3	Near Marina	36"∅	37	37	54
4	Chaligan Creek	(11x6.25) box	242	539	829
5	Auau Creek	(6x4.25) box	120	108	159
6	Gaan River	2@ (6x5) box	336	196	295
7	Finile Creek	(11x6) box	418	215	325
8	Salinas River	(5x4) box	160	150	220
8a	Salinas (Mt. Carmel School)	(6x3) box	228	139	205
8b	Salinas R. (San Vicente St.)	(4x4) box	212	79	120
9	Near Fire Station	24"∅	26	56	80
10	San Vicente Ave. (Rt. 2)	(6x3) box	204	86	124
10a	Oceanview HS	(5x3) box	95	58	84
11	Near Supermarket	36"∅	35	95	136
12	Near Cemetary	3@ 36"∅	180	58	84
13	Togcha River	2@(8x7.5) box	880	304	452
13a	Togcha R.	(10x7) box	550	318	472
13b	Togcha R.	(10x6) box	520	320	479
13c	Santa Rita	36" ∅	145	221	332
14	Near Subway	3@36"∅	210	80	116
15	Namo River	3@(19x11) box	6840	531	782
15a	Santa Rosa Subdivision	24"∅	47	142	207
15b	Santa Rosa Subdivision	2@36"∅	316	48	69
15c	Namo R. (Pale Ferdinand)	Bridge	2246	471	694
15d	Near Southern High -Santa Rita	2@40"∅	94	155	232
15e	Rt. 5 (Roberto) -Santa Rita	(5x6) box	215	113	170
15f	Rt. 5 (Roberto) - Santa Rita	2@36"∅	130	113	170
15g	J. Sarmiento - Santa Rita	36"∅ & 24"∅	93	113	169

LIST OF DRAINAGE FACILITY CAPACITIES & RUNOFF VOLUMES

NODE	DESCRIPTION	STRUCTURE	Capacity	20-yr	100-yr
			(cfs)	(cfs)	(cfs)
15h	Pale Roman - Santa Rita	2@30"∅	84	31	45
15i	Rt. 12 - Santa Rita	2@(2.5x2.5) box	135	209	312
16	Atantano River - Piti	Bridge	8815	1508	2258
16a	Tenjo R.	River junction	*	451	669
16b	Atantano River - Piti	River junction	*	786	1182
16c	Apalachao R.	Bridge	5163	307	462
16d	J.C. Diaz Drive	2@36"∅	84	167	252
16e	Chalan Kindo near Los Amigos	2@40"∅	270	103	156
16f	Chalan Kindo	2 @ 40"∅	180	114	170
25	Near GSA Wharehouse	2@24"∅	70	35	50
25a	Piti	18"∅	14	25	36
26	Masso River	3@(19x10) Box	3699	343	511
26a	Assumption Dr.	27" ∅	36	56	82
26b	Masso River (Piti Elementary)	Bridge	1600	352	524
26c	Masso River (Route 6)	(Military)	*	343	510
27	Near 7-11/Mobil	2 @ 36"∅	96	73	106
27a	Assumption Dr. Near Tuncap St.	(3-4"x1-7") box	13.6	69	101
28	Taguag River	Box Culvert	240	126	186
28a	N. End Assumption Dr.	2 @ 36"∅	160	133	196
29	Near PUAG Pump Station	3 @ 24"∅	66	168	244
30	Near S. End of Fisheye Park	2 @ 36"∅	70	140	204
31	Near N. End of Fisheye Park	2 @ 36"∅	70	144	210
32	Matague R.	(10 x 10) Box	1520	247	365
32a	E. Anaco Dr.	(5 x 5-3") Box	932	148	217
32b	Nimitz Dr.	24"∅	67	51	74
32c	Nimitz Dr.	27"∅	288	48	70
33	Asan R.	Box Culvert	3418	400	593
33a	Asan River	Bridge	3845	309	458

LIST OF DRAINAGE FACILITY CAPACITIES & RUNOFF VOLUMES

NODE	DESCRIPTION	STRUCTURE	Capacity	20-yr	100-yr
			(cfs)	(cfs)	(cfs)
33b	Asan River	30" Ø	33	31	46
33c	Asan River	(20 x 8-4") Box	1600	127	188
33d	Asan River	Bridge	1477	138	204
34	Nino Perdido St. / Marine Drive	Box Culvert	494	237	347
34a	Asan	(12 x 8) Box	1104	166	244
34b	Asan	2 @ 36"Ø	211	74	108
34c	Asan	4'x 6' Box	371	150	220
34d	Asan	18"Ø RCP	17.8	137	201
34e	Asan	24"Ø	81	33	48
34f	Asan	18"Ø	17.8	144	212
34g	Asan	24" Ø	35	37	54
35	MSGR. Jose Leon Guerrero Dr.	(3 x 4) Box	120	135	197
35a	Asan	(3 x 4) Box	84	73	107
35b	Asan	2 @ 30" Ø	110	84	123
36	Near Pacific Micronesian Marine	(5.2 x 4) Box	224	64	94
37	Near Chorrito Cliffs - South	(8 x 10) Box	795	84	124
38	Near Chorrito Cliffs - Center	2 @ 24" Ø	60	18	27
39	Near Chorrito Cliffs - North	2 @ 30" Ø	72	27	40
40	Fonte R.	Box Culvert	4866	646	960
40a	Fonte R.	(12.5 x 2.3) Box	328	364	532
40b	Fonte R.	3 @ (8x9) Box	1666	544	810
PUMP	Anigua	Pump	*	60	87
41	Near Ace Hardware	3 @ 36" Ø	210	93	134
42	Near King Ent.	24" Ø	23	43	62
43	Near New Court Bldg.	3 @ 30"Ø	147	136	197
44	Near Stay Well	2 @ 36"Ø	159	94	135
44a	Agana	18" Ø	12.56	73	106
45	North of GCIC	2 @ 24"Ø	46	94	135

LIST OF DRAINAGE FACILITY CAPACITIES & RUNOFF VOLUMES

NODE	DESCRIPTION	STRUCTURE	Capacity	20-yr	100-yr
			(cfs)	(cfs)	(cfs)
45a	Agana	18" ∅	10.8	93	134
46	South of Agana Boat Basin	2 @ 24"∅	43	78	112
46a	Agana	12" ∅	3.4	56	81
47	Agana Boat Basin	2 @ 36" ∅	127	147	212
47a	Agana	12" ∅	3.75	13	20
47b	Agana	12" ∅	3.4	129	187

HEC-1 DATA SHEET

NODE	RAINFALL 20-YR, 24-HR	RAINFALL 100-YR, 24-HR	AREA SQ. MILES	COMPOSITE Cn VALUE	LENGTH (FT)	VERT. DIFF.	SLOPE (FT/FT)	CALCULATED LAG (hrs)
1	12	17	1.9828	76.00	18000	1200	0.0667	14.02
2	12	17	0.1013	87.00	2250	100	0.0444	2.27
3	12	17	0.0293	87.00	1500	40	0.0267	2.12
4	12	17	0.9489	75.12	6562	670	0.1021	5.18
5	12	17	0.1164	84.51	4800	440	0.0917	3.17
6	12	17	0.3377	79.85	6935	500	0.0721	5.60
7	12	17	0.3617	78.50	6893	615	0.0892	5.22
8	12	17	0.1621	84.47	5533	630	0.1139	3.20
8a	12	17	0.1333	83.28	4602	615	0.1336	2.65
8b	12	17	0.0594	78.16	2700	515	0.1907	1.70
9	12	17	0.0358	89.68	1600	65	0.0406	1.63
10	12	17	0.0683	87.58	2950	210	0.0712	2.18
10a	12	17	0.0358	86.42	1500	85	0.0567	1.49
11	12	17	0.0455	89.79	1400	110	0.0786	1.05
12	12	17	0.0410	89.35	2150	110	0.0512	1.87
13	12	17	0.5639	83.04	6622	410	0.0619	5.25
13a	12	17	0.4576	82.63	5792	402	0.0694	4.52
13b	12	17	0.4422	82.37	5367	400	0.0745	4.14
13c	12	17	0.1313	78.29	1755	310	0.1766	1.25
14	12	17	0.0666	88.45	1700	40	0.0235	2.36
15	12	17	1.4877	86.66	14886	500	0.0336	12.01
15a	12	17	0.1317	87.57	2900	135	0.0466	2.67
15b	12	17	0.0262	87.00	1400	95	0.0679	1.26
15c	12	17	0.9647	86.30	10504	480	0.0457	7.90
15d	12	17	0.2425	82.47	5962	350	0.0587	5.05
15e,f	12	17	0.0942	80.55	2000	140	0.0700	2.06
15g	12	17	0.0543	78.78	900	100	0.1111	0.91
15h	12	17	0.0127	87.04	1550	310	0.2000	0.79

HEC-1 DATA SHEET

NODE	RAINFALL 20-YR, 24-HR	RAINFALL 100-YR, 24-HR	AREA SQ. MILES	COMPOSITE Cn VALUE	LENGTH (FT)	VERT. DIFF.	SLOPE (FT/FT)	CALCULATED LAG (hrs)
15i	12	17	0.0850	79.18	1100	275	0.2500	0.70
15j	12	17	0.0630	76.44	945	275	0.2910	0.63
16	12	17	4.4706	82.47	14700	570	0.0388	12.80
16a	12	17	0.6844	83.53	6000	330	0.0550	5.07
16b	12	17	2.2830	81.53	13000	540	0.0415	11.56
16c	12	17	0.4520	80.23	5000	310	0.0620	4.59
16d	12	17	0.1338	78.10	2050	200	0.0976	1.91
16e	12	17	0.0788	77.65	1900	190	0.1000	1.80
16f	12	17	0.0744	80.40	1700	180	0.1059	1.47
25	12	17	0.0244	87.00	1110	25	0.0225	1.82
25a	12	17	0.0134	87.00	675	15	0.0222	1.23
26	12	17	0.7821	84.09	11644	590	0.0507	8.80
26a	12	17	0.0248	85.05	1300	185	0.1423	0.88
26b	12	17	0.7239	83.97	10390	580	0.0558	7.69
26c	12	17	0.6549	83.95	9317	540	0.0580	6.92
27	12	17	0.0374	85.46	1475	150	0.1017	1.13
27a	12	17	0.0224	84.43	765	135	0.1765	0.53
28	12	17	0.1273	83.49	3700	285	0.0770	2.91
28a	12	17	0.1072	83.58	2800	270	0.0964	2.08
29	12	17	0.0649	86.71	1400	290	0.2071	0.73
30	12	17	0.0559	84.79	1300	250	0.1923	0.76
31	12	17	0.0591	85.69	1400	260	0.1857	0.80
32	12	17	0.3769	84.54	6700	410	0.0612	5.07
32a	12	17	0.1402	86.21	3450	225	0.0652	2.72
32b	12	17	0.0196	87.00	900	90	0.1000	0.73
32c	12	17	0.0251	87.00	1400	110	0.0786	1.17
33	12	17	0.8050	84.78	10396	570	0.0548	7.55
33a	12	17	0.5861	84.71	9669	562	0.0581	6.93

HEC-1 DATA SHEET

NODE	RAINFALL 20-YR, 24-HR	RAINFALL 100-YR, 24-HR	AREA SQ. MILES	COMPOSITE Cn VALUE	LENGTH (FT)	VERT. DIFF.	SLOPE (FT/FT)	CALCULATED LAG (hrs)
33b	12	17	0.0130	86.23	1100	130	0.1182	0.81
33c	12	17	0.1624	84.31	6000	540	0.0900	3.86
33d	12	17	0.1606	84.28	5500	530	0.0964	3.48
34	12	17	0.1935	85.30	4000	545	0.1363	2.19
34a	12	17	0.1234	85.02	3500	530	0.1514	1.88
34b	12	17	0.0335	85.24	1600	280	0.1750	0.93
34c	12	17	0.1097	84.32	3400	530	0.1559	1.86
34d	12	17	0.0885	84.06	2900	530	0.1828	1.53
34e	12	17	0.0110	83.93	1100	330	0.3000	0.55
34f	12	17	0.0835	83.89	2400	460	0.1917	1.29
34g	12	17	0.0168	85.48	1600	270	0.1688	0.94
35	12	17	0.0727	85.04	2550	570	0.2235	1.20
35a	12	17	0.0366	84.65	2300	555	0.2413	1.08
35b	12	17	0.0268	83.79	650	105	0.1615	0.50
36	12	17	0.0314	84.66	1900	380	0.2000	1.02
37	12	17	0.0378	83.16	1300	200	0.1538	0.90
38	12	17	0.0067	83.00	1000	200	0.2000	0.65
39	12	17	0.0092	83.00	1000	260	0.2600	0.57
40	12	17	2.3432	84.78	19140	620	0.0324	16.00
40a	12	17	0.3804	86.50	5748	605	0.1053	3.19
40b	12	17	1.9188	84.31	18140	605	0.0334	15.35
Pump	12	17	0.0240	88.38	600	25	0.0417	0.77
41	12	17	0.0359	89.25	1300	180	0.1385	0.76
42	12	17	0.0157	90.00	450	20	0.0444	0.56
43	12	17	0.0650	88.31	1600	180	0.1125	1.04
44	12	17	0.0333	89.77	1200	180	0.1500	0.67
44a	12	17	0.0157	87.12	450	160	0.3556	0.22
45	12	17	0.0362	90.68	1400	190	0.1357	0.77

HEC-1 DATA SHEET

NODE	RAINFALL		AREA	COMPOSITE	LENGTH	VERT.	SLOPE	CALCULATED
	20-YR, 24-HR	100-YR, 24-HR	SQ. MILES	Cn VALUE	(FT)	DIFF.	(FT/FT)	LAG (hrs)
45a	12	17	0.0191	87.70	450	180	0.4000	0.20
46	12	17	0.0340	91.84	1700	190	0.1118	0.94
46a	12	17	0.0108	87.23	350	160	0.4571	0.16
47	12	17	0.0946	90.46	2500	190	0.0760	1.65
47a	12	17	0.0054	83.54	1100	177	0.1609	0.76
47b	12	17	0.0308	84.98	500	147	0.2940	0.29

CALCULATED WATER SURFACE ELEVATIONS

NODE	Elevatio	Q-20 cfs	Calc. Dept feet	WSEL depth + el.	MHW WSEL	Higher WSEL	Q-100 cfs	Calc. Depth feet	WSEL (depth + el.)	100-Yr. Base Flood WSEL	Higher WSEL
1	0	549	3.62	3.62	2.2	3.62	845	4.72	4.72	11.41	11.41
3	0.5	37	1.21	1.71	2.2	2.2	54	1.5	2	12.41	12.41
4	0	539	5.79	5.79	2.2	5.79	829	7.21	7.21	12.41	12.41
5	0	108	1.82	1.82	2.2	2.2	159	2.32	2.32	11.41	11.41
6	0	196	2.1	2.1	2.2	2.2	295	2.68	2.68	12.41	12.41
7	1.95	215	3.97	5.92	2.2	5.92	325	5	6.95	12.41	12.41
8	1.3	150	3.16	4.46	2.2	4.46	220	3.82	5.12	9.41	9.41
10	3	86	0.72	3.72	2.2	3.72	124	0.9	3.9	10.41	10.41
12	1.3	58	2.62	3.92	2.2	3.92	84	3.23	4.53	11.41	11.41
13	0	304	5.54	5.54	2.2	5.54	452	6.85	6.85	11.41	11.41
14	1	80	2.75	3.75	2.2	3.75	116	3.43	4.43	11.41	11.41
15	0	531	2.11	2.11	2.2	2.2	782	2.66	2.66	11.41	11.41
16	-6	1508	6.18	0.18	2.2	2.2	2258	7.77	1.77	10.41	10.41
16C	233.5	307	2.13	235.63		235.63	462	2.73	236.23	N/A	236.23
25		35	2.11	2.11	2.2	2.2	50	2.46	2.46	N/A	2.46
26	2.25	343	4.17	6.42	2.2	6.42	511	5.26	7.51	12.41	12.41
28	3.3	126	3.09	6.39	2.2	6.39	186	3.77	7.07	10.41	10.41
29	2.5	168	5.77	8.27	2.2	8.27	244	6.87	9.37	10.41	10.41
30	3	140	4.07	7.07	2.2	7.07	204	4.82	7.82	11.41	11.41
31	3	144	2.84	5.84	2.2	5.84	210	3.5	6.5	11.41	11.41
32	2	247	4.9	6.9	2.2	6.9	365	5.93	7.93	11.41	11.41
33	3	400	5.71	8.71	2.2	8.71	593	7.12	10.12	15.41	15.41
34	0.5	237	1.88	2.38	2.2	2.38	347	2.34	2.84	15.41	15.41
37	10	84	1.65	11.65	2.2	11.65	124	2.03	12.03	15.41	15.41
40	2	646	5.71	7.71	2.2	7.71	960	6.82	8.82	15.41	15.41