AMERICAN SAMOA
WATERSHED PROTECTION PLAN

Volume 2: Watersheds 24-35

Volume 1: Watersheds 1-23

Volume 3: Watersheds 36-41

Volume 4: Stormwater Management Evaluations

Prepared for:

American Samoa Environmental Protection Agency

and

American Samoa Coastal Zone Management Program

Pago Pago, American Samoa 96799

(684) 633-2304

Prepared by:

Pedersen Planning Consultants

P. O. Box 1075

Saratoga, Wyoming 82331

Tel: (307) 327-5434, Fax: (307) 327-5210

E-mail: ppc@union-tel.com

January, 2000

INTRODUCTION

PURPOSE

The primary purpose of the Watershed Protection Plan is to help focus future resource management efforts of the American Samoa Government. Resource management programs are already being carried out by various agencies of the American Samoa Government and other agencies of the United States Government. The primary agencies of the American Samoa Government (ASG) and federal agencies of the U.S. Government that are involved in resource management programs include the following:

American Samoa Government

American Samoa Environmental Protection Agency
American Samoa Department of Commerce, Coastal Zone Management Program
American Samoa Power Authority
American Samoa Department of Marine and Wildlife Resources
American Samoa Department of Public Works
American Samoa Community College, Land Grant Program
American Samoa Department of Agriculture

U.S. Government

U.S. Environmental Protection Agency
U.S. Department of Agriculture, Natural Resources Conservation Service
U.S. Department of Interior, National Park Service
U.S. Department of Interior, Geological Survey

It is important that future resource management programs in the Territory are closely coordinated to avoid potential overlaps and conflicts in program objectives, and encourage a more cooperative, inter-agency approach to resource management. The Watershed Protection Plan is intended to provide a starting point for future cooperative efforts among these agencies.

SCOPE OF THE PLAN

A wealth of environmental data has been compiled by the American Samoa Government for, at least, the past 30 years. The Watershed Protection Plan brings together a significant amount of selected resource information for 41 watershed planning areas on the Islands of Tutuila, Aunuu, Ofu, Olosega and Tau. The inventory of historical and recent watershed characteristics and related environmental indicators provide the basis for conclusions regarding various resource management issues in each watershed, as well as recommended strategies for future resource management. Specific responsibilities are assigned to various ASG agencies for the implementation of specific resource management projects, as well as longer-term monitoring of selected resources and land uses.

Resource management issues that are addressed in the Plan for each watershed include:

- soil characteristics
- soil suitability for agricultural production, as well as soil-based wastewater treatment and disposal
- stream locations, drainage characteristics, and rates of stream flow
- surface water quality of streams and the nearshore waters
- wetlands
- coral communities and giant clam production
- wildlife habitat for birds and bats
- shoreline protection

- groundwater and surface water supplies
- resident population and land uses, as well as use of the nearshore waters for fishing and general water recreation
- anticipated land uses to the year 2015
- the impact of future population growth upon water consumption and wastewater generation
- flood potential
- stormwater runoff, sedimentation, and the relationship to surface water quality
- nearshore water quality and the marine environment

The level of evaluation associated with each of these issues varies considerably. This variation is dependent upon the availability and reliability of relevant information, as well as the perceived importance of each issue to overall resource management priorities in each watershed.

ORGANIZATION OF THE PLAN REPORT

The Watershed Protection Plan is a three-volume report. Each volume contains this introductory section, a glossary of Samoan words and agency acronyms, and a portion of the individual watershed evaluations. The watersheds included in each volume are as follows:

Volume 1 (watersheds 1-23): North and southeast coasts of Tutuila from Poloa through Laulii
Volume 2 (watersheds 24-35): Southcentral and southwest coasts of Tutuila from Pago Pago Harbor through Amanave, as well as the Island of Aunuu
Volume 3 (watersheds 36-41): Islands of Ofu, Olosega, and Tau

The names and location of each watershed are illustrated at the beginning of the Watershed Evaluations in each volume. The references associated with publications and personal communications, which were used in the preparation of the Watershed Protection Plan, are provided at the end of Volume 3.

PLAN METHODOLOGY

Compilation and Review of Available Information

Available information was gathered from a variety of sources concerning natural resources, land uses, resident population, and other relevant data. Relevant information was summarized for subsequent incorporation into the Plan.

The American Samoa Power Authority, for example, provided recent population, land use, as well as water and wastewater system evaluations that were developed for its draft Utility Master Plan. Soils information was gained from the Soil Survey of American Samoa that was published in 1984 by the U.S. Soil Conservation Service (now the Natural Resources Conservation Service). The ASG Department of Marine and Wildlife Resources and the ASG Department of Agriculture provided results from field surveys concerning wildlife resources and village agricultural activities.

Pedersen Planning Consultants was also assisted by AECOS, Inc. in Kaneohe, Hawaii. Aecos, Inc. provided a review of available water quality information. This information generally represented historical information from the U.S Geological Survey, U.S. Environmental Protection Agency, as well as the American Samoa Environmental Protection Agency.

Field Survey of Watershed Planning Areas

Available information was also supplemented by a field survey of each watershed planning area by Pedersen Planning Consultants (PPC) during April-May, 1996. Informal discussions with one or more residents of each watershed were made in conjunction with the field surveys. Residents that were typically contacted by PPC included village *matai,* or other knowledgeable long-term residents of communities in the watershed. In some cases, residents toured PPC representatives in selected watershed areas to identify or clarify specific watershed issues. Photographs and field notes were taken by PPC representatives for each watershed. Significant issues were also documented on available topographic maps of the Territory that are based upon 1989 aerial photography.

Geographical Information System for American Samoa

A geographical information system (GIS) was developed by Pedersen Planning Consultants to facilitate future reference to selected types of information. This planning tool resource should facilitate future resource planning and management activities. The GIS for American Samoa was developed through the use of ArcView software, version 3.0, which is manufactured and distributed by Environmental Systems Research Institute, Inc. in Redlands, California.

In the development of the GIS for American Samoa, some available digital information was provided by the American Samoa Department of Commerce, the American Samoa Power Authority, and the U.S. Geological Survey. A considerable amount of hardcopy information was also scanned via a high-quality scanner that was available at the University of Wyoming in Laramie, Wyoming. Some other information, e.g., point data, was manually digitized by PPC. Digital files were subsequently organized by Pedersen Planning Consultants to develop the actual geographical information system.

It is important for users of the Watershed Protection Plan to recognize that the illustrations provided in this report reveal only a portion of information that is readily available through the GIS. Users of the Plan are strongly encouraged to use the GIS for American Samoa when reviewing data, conclusions and recommendations in the Plan. The level of detail available in the GIS and the opportunity to correlate various combinations of information, e.g., soils and anticipated growth, enables GIS users to gain a greater understanding of watershed issues and/or share the information with other personnel.

RECOMMENDED STRATEGY FOR PLAN IMPLEMENTATION

Establishment of a Territorial Watershed Resource Management Board

Many of the federal programs of the U.S. Government that are related to resource management now encourage local resource management in the context of *watersheds*. This policy is a move away from past programs that focused primarily upon the preservation of endangered species or unique natural resources. It is widely recognized throughout most of the world that the conservation of natural resources is largely dependent upon the balance of ecological relationships within the watershed where natural resources are located. This is particularly true in the tropical environment of American Samoa.

The implementation of the various resource management programs that are associated with watershed conservation requires a cooperative partnership between several agencies in American Samoa, as well as several federal U.S. Government agencies.

Several federal agencies of the U.S. Government already provide technical assistance and/or grant funds that represent an important contribution to the implementation of various resource management programs in American Samoa. At the same time, several resource management agencies in American Samoa establish and carry out local programs to pursue various resource conservation strategies and, in some cases, related regulatory programs.

In order to formalize a more cooperative resource management effort, it is recommended that a Territorial Watershed Resource Management Board be established. This Board would consist of one representative from each of the following agencies of the American Samoa Government:

- American Samoa Environmental Protection Agency
- American Samoa Department of Commerce, Coastal Zone Management Program
- American Samoa Power Authority

- American Samoa Department of Marine and Wildlife Resources
- American Samoa Department of Public Works
- American Samoa Community College, Land Grant Program
- American Samoa Department of Agriculture
- Office of Samoan Affairs

Ex-officio members of the Watershed Resource Management Board would also include representatives of the following federal agencies:

- U.S. Department of Agriculture, Natural Resources Conservation Service
- U.S. Department of Interior, National Park Service

The Watershed Resource Management Board should meet monthly or quarterly, or as frequently as desired. During regular meetings, the Board would discuss work progress and schedules related to the implementation of specific watershed improvement projects and ongoing monitoring tasks that are identified in the Watershed Protection Plan, as well as other cooperative resource management opportunities not reflected in the Plan. It is envisioned that representatives of participating agencies would also share findings from agency surveys, consultant reports, and other evaluations that would help increase the understanding of information gained from ongoing resource management programs of individual agencies.

Establishment of a Lead Agency

The Watershed Protection Board needs a lead agency that will assume responsibility for the overall management and daily implementation of the inter-agency, resource management program. Since many of the resource management issues relate to water quality, it is logical that the program should initially be managed by ASEPA.

The designation of ASEPA as the lead agency for watershed protection would not supercede the authorities already given to various ASG agencies. Rather, it would act as the catalyst for cooperative, watershed improvement programs that are made on an inter-agency basis. In addition, ASEPA would also help ensure that the progress and information gained from both independent and cooperative resource management programs are shared by all participating agencies which are represented on the Watershed Protection Board.

The lead agency will be responsible for assigning a full-time program manager who will be assigned to coordinate the implementation of the Watershed Protection Plan and the activities of the Territorial Watershed Resource Management Board. The program manager will need to be a strong individual who is willing to listen and constructively respond to the concerns of participating ASG and federal agencies and traditional village leaders, as well as take constructive, aggressive steps to support their decisions.

It is also important that the selected program manager is highly motivated and committed to making the program a successful effort. Knowledge of the Samoan language and culture, as well as the environment of American Samoa, is essential.

The use of a designated consultant firm should also be considered to provide occasional technical assistance to the lead agency, program manager, and the overall Watershed Resource Management Board. The selected firm would provide technical assistance related to specific watershed improvement projects, and possibly help make periodic evaluations of program success. Any firm selected for this work should have considerable experience associated with the environment of American Samoa, as well as some knowledge of *faaSamoa*. The firm should also be willing to supplement its resources with the capabilities of other consultants, if necessary.

Participation of Traditional Leaders and Residents in Resource Management Solutions

The implementation of the Watershed Protection Plan can only be accomplished via a cooperative inter-agency effort that is linked to traditional village leaders and residents. Despite significant changes in land tenure, a significant proportion of lands in the Territory remain as "communally-owned" lands. Many village councils also remain active in the management of village affairs, lifestyle, and village improvement projects. Traditional leaders and village residents in American Samoa are keenly aware of many resource management issues, as well as the specific environmental conditions in their respective watersheds.

Desired modifications in the way people live and use natural resources typically require community motivation. More motivation for desirable changes can be expected when people affected can become involved in resource management decisions and gain some greater understanding and appreciation for the purpose and benefits of recommended changes in lifestyle, land use, and the use of other natural resources. It is their commitment that is essential to long-term change.

Despite many ongoing cultural changes, the village remains the heart of *faaSamoa.*. It is this social unit that binds the families who live in Territory. It is interesting to note that some of the more recent immigrants to American Samoa, e.g., Tongans, are already building small communities within villages such as Nuuuli and Tafuna in order to organize themselves into their own "village units" away from their native islands.

Through the establishment of a constructive working relationship, the American Samoa Government is confirming to its traditional leaders that their wisdom and experience has relevance to addressing long-term management issues. Further, ASEPA and participating resource management agencies on the Watershed Resource Management Board will be sending the message that they stand ready to assist the villages rather than only telling them what to do, or not to do.

Through the sharing of information between villages and participating agencies, this process will help participating agencies better determine program and project priorities. Village leaders, in turn, will gradually begin to recognize that increased village participation and commitment to resource management will yield benefits that will help improve village sanitation, the quality of drinking water, flood control, surface water quality and coral communities, fishing opportunities, recreation, and general lifestyle.

Village leaders will be requested by the core management group to identify one representative that can be the primary point-of-contact for a given village. It is important that this person is respected and trusted by the village council. Ideally, the point-of-contact will also be a member of the village council.

American Samoa Watershed Protection Plan
VOLUME 2 - LIST OF WATERSHEDS

Watersheds in this Volume
Listed by Watershed Number

Watersheds Listed Alphabetically
Watershed/Volume-Number

PAGO PAGO
Watershed 24

GEOGRAPHY

The Pago Pago watershed is near the center of the Island of Tutuila. The watershed comprises about 4.0 square miles of land area (Figure 24-1) that surround Pago Pago Harbor.

Steeper mountain ridges define the upland boundary of the Pago Pago watershed. Mount Alava and Maugaloa Ridge prominently identify the northern portion of the watershed. They lie upland of Pago Pago, Anua, Atuu, Leloaloa, and the north side of Aua.

The summit of North Pioa Mountain represents the east boundary of the watershed. South Pioa Mountain lies southwest of North Pioa Mountain at about 1,600 feet above mean sea level.

The south and west sides of the watershed are bounded by Matautu Ridge, Palapalaloa Mountain, the headwaters of the Utumoa-Vaima-Vaipito drainage, and Fatifati Mountain. Downslope of these geographical features are the villages of Utulei, Fagatogo, and Malaloa.

Along the shoreline, the Pago Pago watershed extends between Tulutulu Point and Breakers Point. Within these landmarks lies Pago Pago Harbor.

Steeper mountain ridges on all sides of the watershed are characterized by numerous basaltic ridges that delineate specific drainages. There are approximately 27 stream drainages in the Pago Pago watershed.

RESOURCES OF THE WATERSHED

Soils

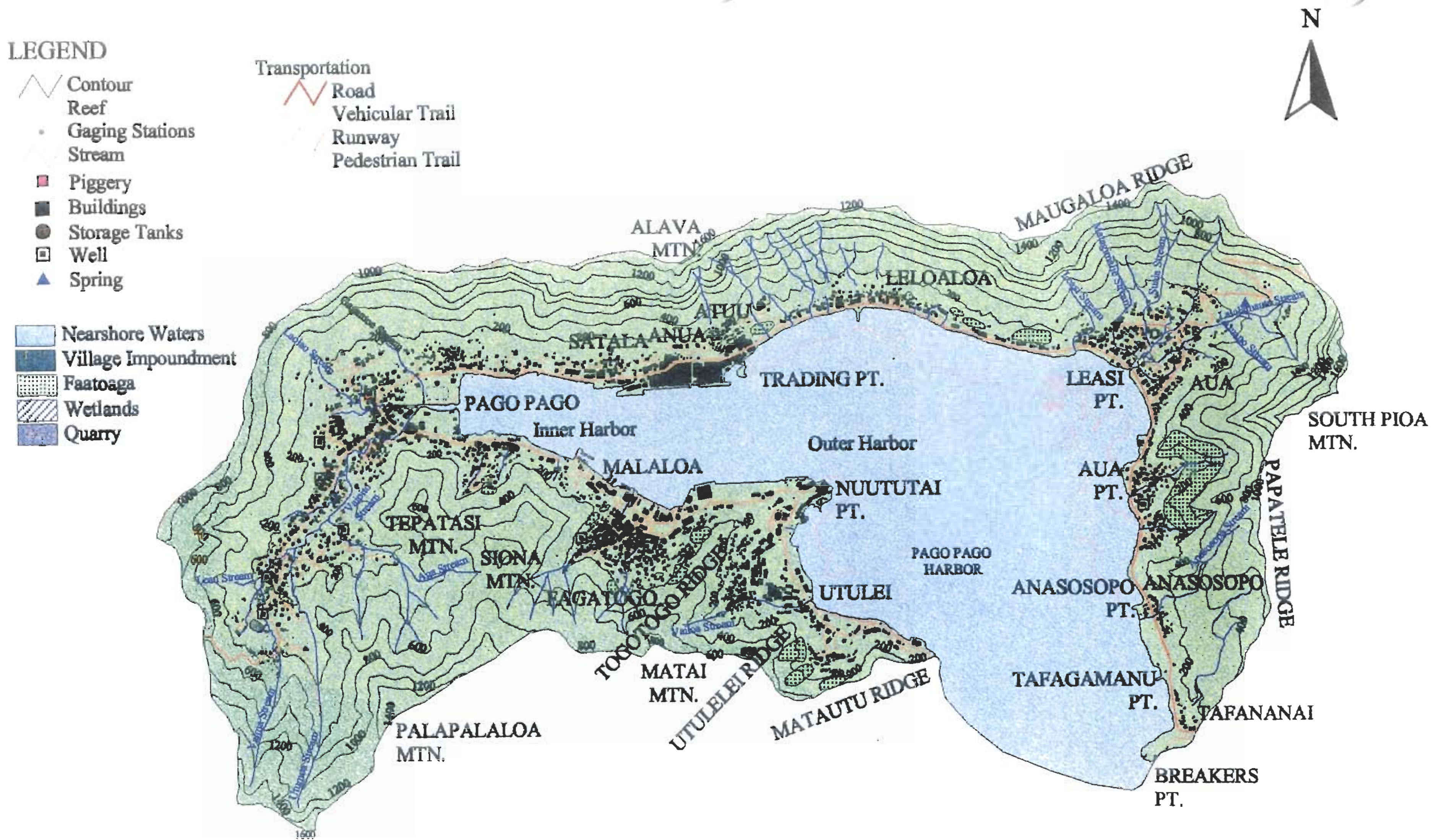
The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 24-2). Four different soil classifications were identified by the U.S. Soil Conservation Service for lands within the Pago Pago watershed (Table 24-1).

TABLE 24-1
SELECTED SOIL CHARACTERISTICS
PAGO PAGO WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Subsistence Ag. Potential
1	Aua Very Stony Silty Clay loam	15-30	None	Med	Mod	>6	<60	Severe Slope	Moderate
2	Aua Very Stony Silty Clay Loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
4	Fagasa Family-Lithic Hapludolls-Rock Outcrop Assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
34	Urban Land-Aua-Leafu Complex	0-30	A.None L. Occ	A.Slow - Med L. Slow	A.Slight to Mod L. Slight	A..>6 L. 3-5	>60	Severe A. Slope L. Flood Wet	Limited

Notes: 1. A.= Aua- found on mountain foot slopes 6-30 percent
2. L.= Leafu- found on coastal plains & valley floors 0-6 percent

Source: U.S. Soil Conservation Service, 1984



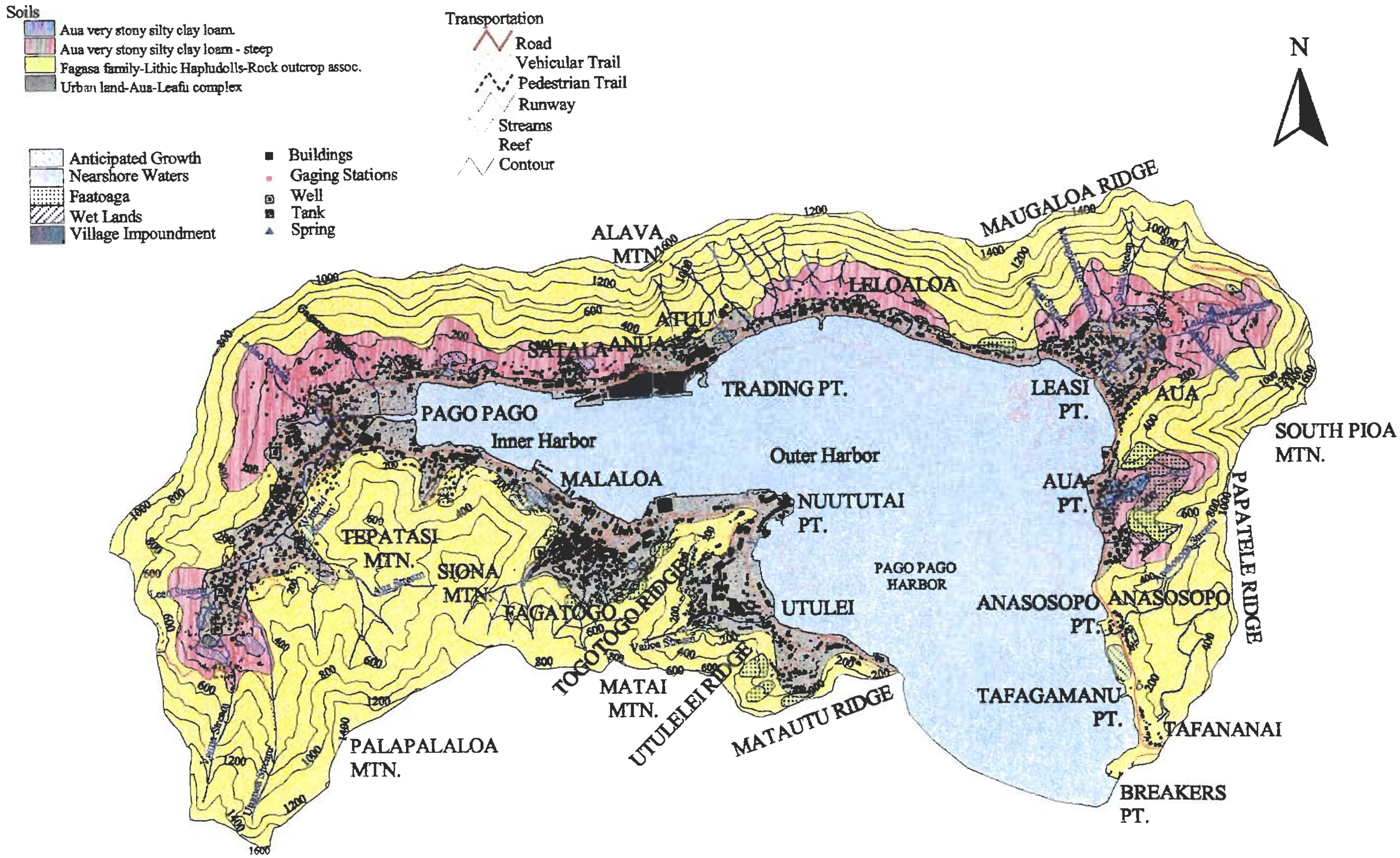
American Samoa Geographical Information System

Miles
Scale: 1:32,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Pago Pago Watershed 24
Existing Conditions

Figure 24-1



American Samoa Geographical Information System

Miles
Scale: 1:32,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Pago Pago Watershed
Management Issues

24

Figure 24-2

Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

The shoreline of Pago Pago Harbor is characterized by the Urban Land-Aua-Leafu complex (SCS mapping unit 34). It is the characteristic soil type where the villages within the Pago Pago watershed are located.

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. The soil has limited to moderate potential for runoff. The erosion potential is slight to moderate.

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, do not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and cesspools in selected areas that contain these soils may be making a contribution of nutrients and bacteria into the nearshore waters of Pago Pago Harbor. Most all of the areas containing Urban Land-Aua-Leafu Complex soils contain sewer mains; however, only 50 percent of all structures in the watershed are actually connected.

Aua Very Stony Silty Clay Loam (15 to 30 percent slopes)

Aua very stony silty clay loam soils (SCS mapping unit 1) occurs in one small area west of Aua Point. Approximately nine acres of Aua very stony silty clay loam extends approximately 2,000 feet inland of a narrow strip of Urban Land-Aua-Leafu Complex soils land on the upland side of the primary shoreline roadway.

These soils typically occur up to about 60 inches in depth. The permeability of these soils ranges between 2 and 6 inches per hour. The potential for runoff or erosion from the Aua soils is believed to be moderate (U.S. Soil Conservation Service, 1984).

While moderately suited for agricultural production, the U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). However, the U.S. Soil Conservation Service also advises that the stony and erosive characteristics of these soils may limit production. While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that typically hamper installation and provide inadequate soil treatment.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

Steeper slopes of the lower watershed contain Aua very stony silty clay loam soils (SCS mapping unit 2). This soil type is present in five areas:

- the upper end of Vaipito Valley;
- the upper slopes of Pago Pago Village;
- upland of Leloaloa Village;
- upslope of the north and east sides of Aua Village; and,

- east of Aua Point and generally upslope of inhabited areas.

The Aua soils range between seven to 60 inches in depth. The permeability of these soils (between 2 and 6 inches per hour) is moderately rapid. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that hamper installation and provide inadequate soil treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

On the east side of the watershed, the area between Breakers Point and Aua Point contains three streams. An unnamed, intermittent stream flows generally north to south below the western edge of Papatele Ridge; this stream course ultimately turns west and discharges into Pago Pago Harbor at Tafananai. Anasosopo Stream, which originates about 720 feet above mean sea level, drains surface flows in a southwesterly direction from the west side of Papatele Ridge through Anaosospo.

A second unnamed intermittent stream originates at about the 400 foot elevation level on the southwest slopes of South Pioa Mountain. This drainage carries surface flows through the south part of Aoa Village before entering the nearshore waters of Pago Pago Harbor.

The primary Aua Village area contains approximately five streams.

- Amano Stream;
- Lalomauta Stream;
- Suaia Stream;
- Matagimalie Stream; and,
- Leasi Stream.

This drainage area of these streams contains approximately 395 acres (Natural Resources Conservation Service, 1995). Lalolamauta Stream is the primary stream that receives surface runoff from Amano Stream before its discharge within a wetland near the center of Aua and, ultimately, the nearshore waters of Pago Pago Harbor. Suaia Stream and Matagimalie Stream drain the south slopes of Maugaloa Ridge and empty into Lalolamauta Stream. A portion of the surface flows from Maugaloa Ridge are carried by Leasi Stream which discharges directly to the nearshore waters of the Harbor.

Between Leloaloa and Satala, there are approximately nine streams. Each of the streams originate between the 800 and 1,280-foot contour. All of these streams discharge surface runoff along steep drainage courses that discharge directly into Pago Pago Harbor.

In Pago Pago Village (generally between Satala and Malaloa), there are approximately 11 streams. Between Satala and the Siufaga area, four unnamed stream discharge directly into the inner portion of Pago Pago Harbor.

Vaipito Stream is a primary drainage that receives surface runoff from Gagamoe Stream, Laolao Stream, Pago Stream, Leau Stream, Vaima Stream, Utumoa Stream, and Aga Stream before its discharge into the nearshore waters adjacent to Pago Pago Park. Its total drainage area is approximately 1.36 square miles (U.S. Army Corps of Engineers, Honolulu District, 1990).

Two unnamed streams flow through the Village of Fagatogo. One of the streams discharges to the nearshore waters of Pago Pago Harbor between the southeast side of the Fagatogo Marketplace and the northwest side of Fagatogo Square.

In Utulei, surface runoff from Matai Mountain, Togotogo Ridge, and Utulelei Ridge are carried by Vailoa Stream. This stream course begins at about the 480-foot elevation and continues downstream through the upper elevations of Utulei Village. The stream proceeds further downstream near the south side of the ASG Executive Office Building and, eventually, discharges to the nearshore waters of the Harbor on the north side of the Pago Pago Yacht Club.

Stream Flows Within the Watershed

A number of stream gages have been operated and stream flow measurements made by USGS in the Pago Pago watershed. More significant data is presented in the following paragraphs. However, it should be noted that other miscellaneous data are available that are not summarized in the report. This information, includes one or two historical measurements at a given stream location for locations along Vaipito, Leau, Fitiuli, and Pago streams.

In the east part of the watershed, a low-flow, partial-record station (No. 16955000) on Anasosopo Stream, approximately 400 feet upstream from a bridge along the primary shoreline roadway, provided 18 measurements of stream flow between 1959 and 1976. These measurements enabled the U.S. Geological Survey to estimate a median flow of 0.15 cubic feet per second (Wong, 1996).

Upland of Aua Village, two gages have provided data for Lalolamauta Stream. A low-flow, partial record station (No. 16952500) on Lalolamauta Stream, about 300 feet upstream from Amano Stream, provided 18 measurements of stream flow between 1959 and 1976. Based upon these measurements, the median flow at this station was estimated by the U.S. Geological Survey to be 0.21 cubic feet per second (cfs). A second gage (No. 16953000) located on Matagimalie Stream, a right-bank tributary of

Lalolamauta Stream, provided 19 measurements from 1959 through 1976. The U.S. Geological Survey estimated the median flow at this station to be approximately 0.14 cubic feet per second (Wong, 1996).

Stream flow along the large and complex Pago Stream system has historically been monitored via not less than six USGS low-flow partial-record gages and a large number of miscellaneous stream flow monitoring sites. Between 1959 and 1976, a low-flow, a partial record station (No. 16949700) on Vaima Stream, approximately 0.4 miles upstream from Vaipito Stream, provided 20 measurements of stream flow. These measurements led the U.S. Geological Survey to estimate a median flow of 0.16 cfs at this location.

Another gage (No. 16949800) was established on Utumoa Stream about 0.6 miles upstream from Vaipito Stream and immediately upstream of the Vaipito intake between 1959 and 1990. Records from this gage provided 29 measurements of stream flow during this period. The U.S. Geological Survey estimated a median flow of 0.42 cfs at this stream location.

From April, 1957 to June 1958, a stream gage (No. 16950000) was located on the Utumoa pipeline at the stilling basin 150 feet below the diversion. During the same period, gage No. 16950500 was located on Utumoa Stream below the diversion. Both stations operated on a daily basis. In July, 1959, stream gage 16950500 was relocated to approximately 0.2 mile downstream of the Utumoa pipeline diversion and re-established as a low-flow, partial-record station. Seventeen measurements between 1959 and 1963 enabled the U.S. Geological Survey to estimate a median flow of 0.25 cfs at this location (Wong, 1996).

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Vaipito Stream in Pago Pago and Laloamauta Stream were two of 37 streams in American Samoa that was inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

<u>Vaipito Stream</u>

Vaipito Stream was surveyed in four locations. Station 29a was located in a broad, shallow riffle just downstream of a bridge along the primary shoreline roadway. Station 29b was situated along Pago Stream near the 80-foot elevation and immediately above a road bridge. Station 29c was located just downstream of the Vaipito/Leafu Stream confluence. Station 29d was established along Utumoa Stream, a tributary of Vaipito Stream, near the 480-foot elevation.

Along the lower reach of Vaipito Stream, five species of gobie fish, one species of mountain bass, eel, mullet, and *ulua,* and two other fish species were observed. Four species of shrimp were also identified at station 29a.

Only one species of gobie fish was recorded at station 29b. An abundant population of one species of mountain bass, as well as an occasional abundance of one species of eel was also present. Four species of shrimp were reported; one of the species was abundant. One species of mollusk was also documented.

Two species of gobie fish and one species of eel were observed at station 29c. Six species of shrimp were also identified; two of the species were abundant. One species of mollusk was also identified.

Only one species of eel was recorded along Utumoa Stream (station 29d). Four species of shrimp were also documented. One specie of mollusk was also observed.

Lalolamauta Stream

Lalolamauta Stream was surveyed in four locations. Station 13a was established underneath the primary shoreline roadway bridge. Station 13b was located immediately upland of the main village below a small marsh. Station 13c was situated at a water quality monitoring station near the 40-foot elevation. Station 13d was established at the confluence of Amano and Lalolamauta Stream near the 100-foot elevation.

Station 13a contained no species of goby fish. However, one abundant species of mountain bass was identified. No invertebrate species were documented.

An occasional species of goby fish, one common species of eel, and two other species of fish were reported at station 13b. Six species of shrimp were identified; three species were abundant. One species of mollusks was also recorded.

Station 13c was characterized by two occasional species of goby fish and one common species of eel. Three species of shrimp were also documented; two species were abundant.

One occasional species of goby fish and one abundant species of eel were recorded at station 13d. Three species of shrimp were also identified; one species was abundant.

Surface Water Quality

General

Significant studies and monitoring of the surface water quality of Pago Pago Harbor have been made since the early 1960's. Past water quality studies and continued monitoring have primarily been prompted by NPDES permit and monitoring requirements associated with two tuna cannery operations in the Harbor, the Utulei Wastewater Treatment Plant (Utulei WWTP), as well as the long-term concerns of the American Samoa Government.

M&E Pacific conducted a comprehensive water quality monitoring program of Pago Pago Harbor and other nearshore locations in 1979. In February, 1984, ASEPA established a long-term water quality monitoring program in the Harbor that has continued through 1998, with only occasional interruption. The ongoing program generally uses the water quality monitoring stations that were originally recommended by M&E Pacific (Figure 24-3). Three additional monitoring stations were established in 1985.

In the early 1980's, the ASG Department of Public Works also established its own long-term water quality monitoring program associated with the Utulei Wastewater Treatment Plant outfall. This responsibility was later assumed by the American Samoa Power Authority when it was given authority to manage the operation and maintenance of the public wastewater system. The water quality monitoring requirements of the U.S. Environmental Protection Agency are required to ensure compliance with National Pollution Discharge Elimination System (NPDES) requirements.

Nutrient Contributions from Tuna Canneries

One of the primary concerns associated with Harbor water quality has been the contribution of nutrients from the tuna cannery outfalls inside the Harbor. Increased nutrient levels can generally increase algal productivity, lower oxygen levels, generate undesirable changes in coral communities, and reduce the population of fish and invertebrates.

Recognizing the importance of improving the quality of its wastewater discharges, the canneries installed dissolved air flotation (DAF) treatment systems in 1975. Historical water quality data suggests that these systems generated a significant decrease in total nitrogen (TN) and total phosphorus (TP) levels between 1974 and 1979 (Hydro Resources International, 1989).

The potential contribution of nutrients from the tuna canneries and other point sources was also examined as part of a Joint Study of Fish Cannery Wastewater Effluent Loading Reduction in Pago Pago Harbor in 1984. CH2M Hill conducted a five-day monitoring program in July, 1984 that includes the sampling of point source flows from eight selected streams that discharge into the Harbor, the Utulei Wastewater Treatment Plant, and the effluent from the Star-Kist and Van Camp canneries. CH2M Hill concluded from the July 10-14, 1984 field studies that canneries contributed 97 percent of the total nitrogen and 96 percent of the total phosphorus that entered Pago Pago Harbor during that time period.

Total phosphorus levels in the inner Harbor (see Figure 24-3) generally increased between 1979 and 1987. Increased total nitrogen levels in the inner Harbor also occurred during this period; however, the pattern was more irregular. Hydro Resources International concluded in its 1989 study that algal productivity was strongly associated with elevated TP levels in Pago Pago Harbor.

Ultimately, these conditions led Star-Kist and Ralston Purina Company to consider three options:

- construction of an outfall discharge into outer Pago Pago Harbor;
- pursue regulatory approvals for the barging of all cannery effluent to an ocean disposal site southeast of Breakers Point; and,
- construction of a longer, larger outfall discharge into inner Pago Pago Harbor.

Around 1992, Samoa Packing and Star-Kist Tuna eventually relocated their cannery outfalls to a location near Tafagamanu Point. The outfall pipeline terminated in a diffuser at a depth of approximately 135 feet below mean sea level. This investment was a significant move aimed at improving the water quality of Pago Pago Harbor. A point-of-discharge in the outer Harbor increased the opportunity for mixing cannery discharges in an area where greater circulation and water exchange was possible.

Since the early 1990's, available nutrient data from Pago Pago Harbor indicates that the surface water quality of Pago Pago Harbor has steadily improved.

Nutrient Contributions from Local Streams

The 1984 study by CH2M Hill examined the discharges eight selected streams that discharge into Pago Pago Harbor. These streams included Vailoa Stream (Utulei), three unnamed streams (probably in Fagatogo and Malaloa), Vaipito Stream, Laolao Stream and Aga Stream. During the 5-day monitoring period in July, 1984, the following water quality indicators were analyzed:

- nonfilterable residue (NFR);
- five-day biochemical oxygen demand (BOD_5);
- chemical oxygen demand (COD);
- nitrate nitrogen (NO_3-N);
- nitrite nitrogen (NO_2-N);
- total (persulfate) nitrogen (total N);
- total phosphorus (total P, or P);
- turbidity; and, salinity.

Data generated from the July, 1984 monitoring program indicated that the selected eight streams contributed about approximately 5,024 pounds per day of total nitrogen and about 500 pounds per day of total phosphorus. These quantities represented approximately 0.47 percent of all total nitrogen contribution and about 1.13 percent of total phosphorus loading into Pago Pago Harbor. The greatest contributions were generated from Vaipito Stream.

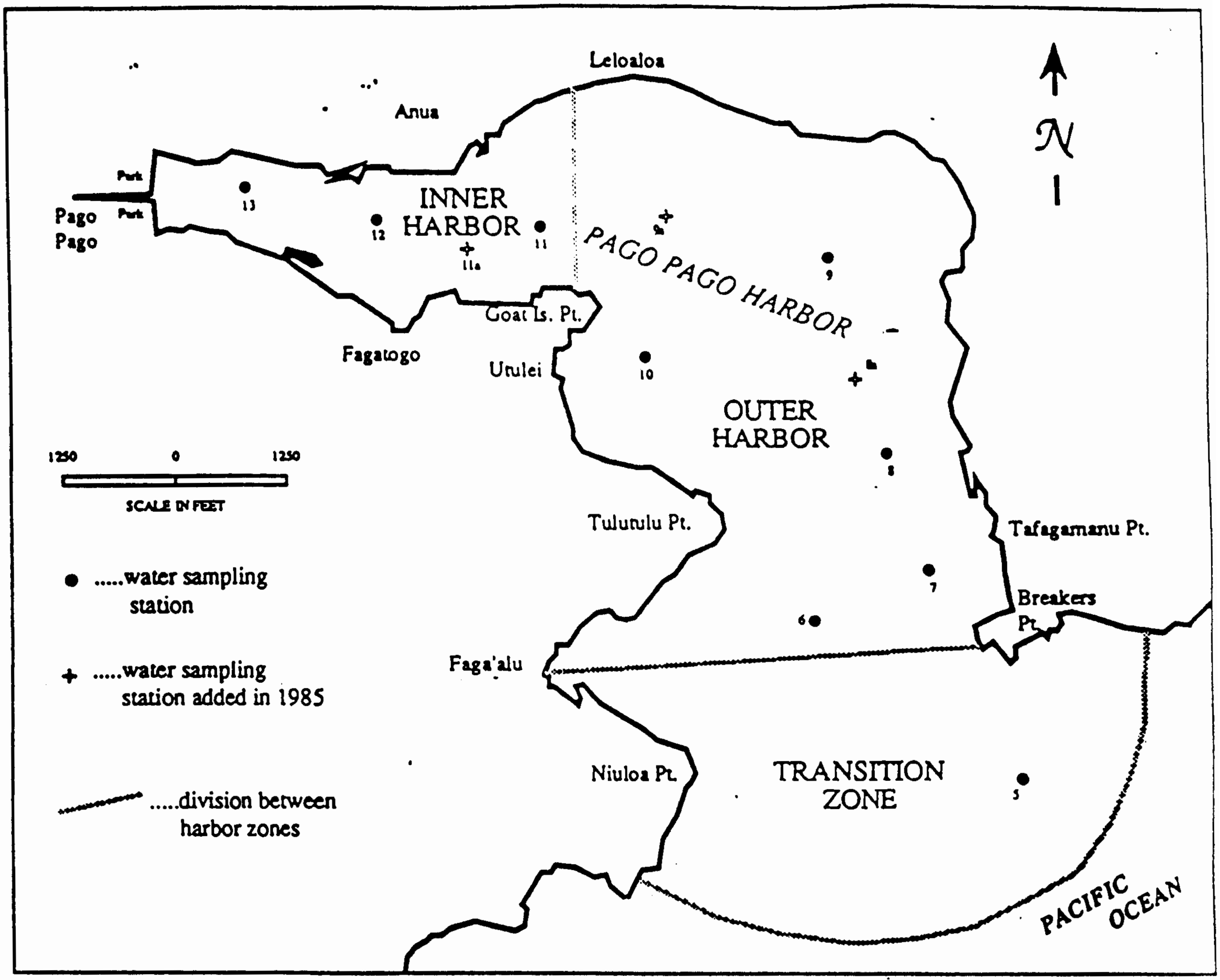


FIGURE 24-3
WATER QUALITY MONITORING STATIONS
PAGO PAGO HARBOR

Source: Hydro Resources International, 1989

Between September, 1984 and February, 1991, water quality samples were collected on 31 occasions at five freshwater stream stations in the Pago Pago Harbor basin (AECOS, 1991). The median values for data collected at these stations are presented in Table 24-2. The ASEPA water quality criterion for total nitrogen (TN) levels in streams (median = 300 µg/l) was exceeded at all five stations, especially at the Fagatogo stations. Total phosphorus (TP) concentrations at Fagatogo I and Fagatogo II were also in excess of the ASEPA criteria of 150 µg/l. Since this data was obtained over a period of more than five years, it is apparent that all five water bodies have chronically poor water quality in terms of total nitrogen, especially at the monitoring stations in Fagatogo. Elevated total phosphorus levels are also present at the Fagatogo monitoring stations.

TABLE 24-2
MEDIAN WATER QUALITY VALUES
FIVE FRESH-WATER MONITORING STATIONS
PAGO PAGO WATERSHED
(MICROGRAM PER LITER)

Station	**Parameter**		
	NO_3+NO_2 (µg/l)	*TN (µg/l)*	*TP (µg/l)*
Pago I	223	456	107
Pago II	230	439	141
Fagatogo I	434	955	262
Fagatogo II	630	1188	293
Aua	168	368	98

Source: AECOS, 1991

The nutrients contained in the fresh water from local streams are derived from, at least, the following cumulative inputs:

- nutrients contained in eroding soils of undeveloped, vacant lands in the upland watershed;
- cesspool discharges from homes and commercial buildings not connected to the ASPA wastewater system;
- limited upland agricultural activities and the runoff of nutrients from related fertilizer applications; and,
- urban runoff.

The continued urbanization of lands along the upper elevations of the Pago Pago watershed represents an important resource management concern. The development of new residential and commercial structures increases the amount of impermeable surfaces, e.g., building roofs and concrete surfaces, that generated increased urban runoff. When increased surface runoff combines with more erosive soils in the upper watershed, i.e., Fagasa family Lithic Hapludolls-Rock outcrop association and Aua very stony silty clay loam, a gradual increase in the sedimentation of Pago Pago Harbor waters can be expected. For this reason, village council representatives should be encouraged to restrict residential and commercial development in these areas.

Nutrient Contributions for the Utulei WWTP

Results from the 1984 CH2M Hill Study indicated that the Utulei WWTP contributed roughly 2.76 percent of the total nitrogen contribution and approximately 3.20 percent of the total phosphorus loading during the July 10-14, 1984 period.

Non-Point Source Pollution

Kennedy Jenks Chilton examined the impact of land use upon the loading of pollutants into Pago Pago Harbor in 1986. Field studies were made at six streams that discharge into Pago Pago Harbor in August and October, 1995. Subsequently, Kennedy Jenks Chilton modeled various land use scenarios to estimate existing and future sediment, phosphate, nitrogen, and BOD_5 loads into the Harbor.

Excluding estimates for Fagaalu, it was estimated that approximately 16,872 tons of sediment were being discharged into Pago Pago Harbor in 1985. The total nitrogen contribution was estimated to be roughly 142 tons while total phosphate loading was approximately 18 tons. The volume of biological oxygen demand was calculated to be 342 tons.

These results vary significantly from the daily contributions from eight streams in the Pago Pago watershed that were calculated by CH2M Hill. This is surprising since Kennedy Jenks Chilton used point source flow data from the 1984 CH2M Hill study. When correlated with CH2M Hill data on an annualized basis, the Kennedy Jenks Chilton estimates are roughly 20 percent of the 1984 estimates for total phosphorus and about 15 percent of total nitrogen loading estimates. While the CH2M Hill study included the analysis of eight rather than six streams, the difference between these estimates remain significant.

Kennedy Jenks Chilton concluded that its the combined point source contribution of pollutants from the two canneries and Utulei WWTP was two to six times greater than the combined non-point source pollution. In contrast, sediment contribution from non-point sources was calculated to be roughly 25 times greater than the total suspended solids input from the two canneries and the Utulei WWTP (Kennedy, Jenks, Chilton, 1986).

Other Historical Water Quality Data

Other miscellaneous, intermittent water quality data are available from various sources. For example, U.S. EPA's STORET system indicates that water samples collected from Vaipito Stream and its tributary, Utumoa Stream, in the fall of 1970 (STORET, 1996) demonstrated the presence of significant concentrations of total coliform bacteria during this time period. A single sample collected from one of two streams in Fagatogo Village in May, 1984 (STORET, 1996) also revealed high kjeldahl nitrogen, total phosphorus and TSS levels; these conditions are characteristic of low water quality (Table 24-3).

TABLE 24-3
MISCELLANEOUS WATER QUALITY MEASUREMENTS
VAIPITO, UTUMOA, AND ONE STREAM IN FAGATOGO

Water Quality Parameter								
Stream	*TN* (*µg/l*)	*TKN* (*µg/l*)	*NO_3+NO_2* (*µg/l*)	*TP* (*µg/l*)	*Turbidity* (*jtu*)**	*TSS* (*mg/l*)	*pH*	*Total Coliform* (*#/100 ml*)
08/04/70	--	--	nd*	--	1.0	--	7.70	7,100
Vaipito								
09/17/70	--	--	nd*	--	15.0	--	7.00	4,700
Utumoa								
09/13/70	--	--	nd*	--	2.0	--	7.00	4,700
Unnamed Stream in Fagatogo								
05/18/84	--	560	--	377	--	40	--	--

Notes:
1. *nd = not detectable
2. ** note use of jtu (Jackson units) rather than ntu now used to measure turbidity.

Source: U. S. EPA, STORET, 1996

Wetlands

One small wetland containing approximately 9 acres of land is located near the center of Aua Village. The wetland represents a small mangrove swamp that extends inland from the primary shoreline roadway to an area immediately southwest of the Church of Jesus Christ of Latter-Day Saints complex and the public elementary School.

The mangrove swamp is fed from downstream fresh-water flows from Lalolamauta Stream, as well as runoff from Suaia Stream and Matagimalie Stream. The swamp is also open to tidal flows from the nearshore waters of Pago Pago Harbor.

Existing soil maps from the Natural Resources Conservation Service identify local soils in this area as urban land-Aua-Leafu complex. This soil represents a combination of imported soil material, Aua, and Leafu soils. The wetland has been encroached upon by adjoining residential uses, as well as a small banana plantation in the mangrove swamp. Otherwise, the primary vegetation in the wetland is red mangrove and beach hibiscus.

The Aua wetland represents a potential opportunity to retard and detain some stormwater flows and Lalolamauta Stream and its tributaries. It is recommended that a conceptual plan be developed to increase the function of this wetland. Any plans should be closely coordinated with the village council and the *sa'o* who has authority over lands considered for any onsite improvements.

Marine Resources

Coral Communities

The perimeter of Pago Pago Harbor, between Niuloa and Breakers Point, once contained some 6 miles of fringing reef. A narrow reef once characterized the inner Harbor except seaward of the Vaipito Stream mouth.

The reefs at Pago Pago Harbor have undergone extensive man-made alteration since 1900. About 23 percent of the original reef flat had been filled by 1973 to provide land for former U.S. military and urban use, as well as dredged to provide a source of fill material for construction and landfill material. The most significant loss of fringing reef occurred in the inner harbor where the original shoreline configuration was changed.

At the head of Pago Pago Harbor, tidal mudflats associated with the Vaipito Stream mouth were filled to create Pago Pago Park

Today, most of Pago Pago Harbor contains a fringing reef. The reef is generally about 1,000 feet wide, although there is considerable variability. The perimeter of the outer Harbor extends includes fringing reef that extend up to 1,500 feet wide.

"Exploratory drilling on the reef flats offshore of Utulei and Aua in 1931 revealed that they are composed almost entirely of bedded calcareous sand and silt, except at the surface, where there is a veneer of cemented coral, coralline algae, and calcareous sand. Basalt rock was encountered at depths of 156 and 121 feet respectively below the reef surface approximately 500 feet offshore of Aua and Utulei" (AECOS, 1980).

Various breaks in the fringing reef occur where *avas* have been formed to accommodate small boat access to deeper nearshore and offshore waters.

Various private consultants have made field investigations of the fringing reef in these areas since the late 1960's. In a cumulative sense, available survey information provides the following overview:

- Coral growth studies were conducted at three locations in Pago Pago Harbor in the 1970's. Those studies indicate that the growth and survival of transplanted corals in the inner harbor at Fagatogo were substantially lower than the outer Harbor sites near Utulei and Fagaalu.
- Through 1974, the seriously degraded reefs of the inner Harbor were subjected to considerable environmental stress for several years and showed relatively little change. Degraded water quality was evident in the vicinity of the two tuna canneries which discharged turbid, nutrient-enriched wastewater from the north side of the inner Harbor. The inner harbor surface waters were often

dark and turbid; a plume of discolored water was frequently evident in the vicinity of the cannery outfalls.

- Within inner Pago Pago Harbor, there were no corals and other reef organisms observed during the 1992 survey. Marine biologists indicated that the Aua site in 1992 was unrecognizable compared to 1969 observations and photos.
- In 1992, an area between Nuututai and Leloaloa Village was essentially devoid of structural coral reefs and living coral reef ecosystems. Marine biologists noted that freshwater and urban runoff, soil erosion, vessel discharges, and sewage pollution. were significantly impacting the Harbor's ecosystem.
- The 1992 survey indicated that tuna canneries continued to have a significant impact on coral reef communities. Water quality increased in the outer harbor, although coral coverage remained low. Many small corals were observed seaward of Punaoa valley; this condition suggested coral recovery after earlier degradation.
- Coral surveys in 1995 continued to observe the poor condition of the coral reefs in Pago Pago Harbor. Recent hurricanes and a mass coral bleaching event apparently compounded the poor condition of the reefs. Marine biologists raised concern about the eutrophication of the harbor due to effluent from the tuna canneries.
- Long term monitoring indicates that the quality of reef communities continues to decline despite improved water quality in the Harbor.

<u>1969-1971</u>

Marine ecologist, Jim Maragos, established coral transplant stations at Aua, Utulei, Nuututai Point, and Faga'alu between 1969-1971 as part of a study to assess the effects of sewage and sediment pollution on reef corals. Data gained from his fieldwork and subsequent evaluations indicated that monitoring stations in the inner Harbor, i.e., Utulei-Nuututai Point area, showed lower coral growth and higher coral mortality.

<u>1978-1979</u>

Inner Harbor

"The 1.2 mile length of reef fronting the innermost harbor between the canneries (at Anua) and the main docks (at Fagatogo) has been devoid of living coral for many years. Early investigations of inner harbor reefs concluded that live corals were destroyed as a result of extensive alteration of natural conditions since 1900. Reef areas located farther into the harbor than Trading Point or Nuututai Point are seriously degraded, with very few live coral heads. The black anoxic silty bottom near the canneries is nearly devoid of invertebrate life. Few fishes are present. Only six species of fish are recorded. Once source states that fishes are abundant in the inner harbor but diversity is low" (AECOS, 1980).

Marine biologists concluded that the lack of live corals in the inner Harbor signaled a continued environmental stress that was evident by a decrease in coral coverage and diversity, a decrease in fish diversity, periods of low dissolved oxygen (DO) concentrations, an accumulation of sediment and floating refuse, elevated nutrient levels, and plankton blooms. Degraded water quality was a primary component of the environmental stress in the inner Harbor. Poor water quality was, in part, a result of limited water exchange that constrained and greatly retarded the flushing, mixing, and circulation of higher nutrient inputs from point source discharges, sedimentation, sewage, petrochemicals, and other pollutants with offshore marine waters.

In 1979, M&E Pacific estimated that waters in the inner Harbor "resided" approximately 34 days before returning to the mouth of Pago Pago Harbor. However, the current meter data obtained from the inner Harbor in 1984 indicated that inner Harbor currents were too weak to generate reliable data (CH2M Hill, 1984).

The reef fringing along the south shore of inner Harbor between the commercial wharf and Rainmaker Hotel was partially dredged in 1969. The reef in this area extended around Nu'ututai Point (seaward of the Rainmaker Hotel). Marine biologists noted that *"...a few coral colonies have established themselves on outcroppings of limestone in the dredged area between the main docks and the Rainmaker Hotel."*(AECOS, 1980).

Outer Harbor

The coral coverage along the reef front seaward of the Hotel ranged between 20 to 40 percent between 10 and 25 feet below mean sea level.

The fringing reef was approximately 300 feet wide seaward of the Rainmaker Hotel beach. The inner reef adjacent to the Rainmaker beach was formerly dredged to provide a sandy area for swimming. Southeast of the Rainmaker Hotel, marine biologists noted that the fringing reef margin appeared to be eroding. Corals were sparse on the inner reef; coral coverage was five percent or less on the outer reef flat and reef margin.

Coral cover along the fringing reef seaward of Lepua was considered "generally impoverished" within a mile and east and west of Lepua.

A lower abundance of coral was observed seaward of Leloaloa. Live coral head coverage was observed on less than one percent of the inner reef flat fronting Leloaloa.

A revisit of a survey site on Utulei reef in 1978 revealed a decline in coral abundance since 1972 when the middle to outer reef areas were dominated by branching *Porites* sp. and *Acrpora* sp.

At Aua, the reef margin is broken by several *ava*, or channels. Along the reef flat northwest of the Lalolamauta Stream mouth, corals were sparse. Coral coverage on the outer reef flat was highly variable, ranging up to 20 percent. Biologists noted that the conditions in 1978 were less than the coverage observed by an earlier 1974 study when 35 percent coral coverage was documented along Aua's reef margin. The reef front near the center of Aua Village contained little coral cover. The reef slopes were free of starfish when surveyed in January-February, 1978.

Seaward of the fringing reef at Aua is a patch reef known as Amuula Rock. Corals were noted to be well developed along the northwest face of Amuula Rock. Otherwise, the growth of coral was generally limited to the upper slopes around Amuula Rock.

Corals were discovered approximately 35 feet seaward of the shoreline in a boulder field that was located north of Aua Point. In this area, coral cover was about 40 percent on limestone boulders that projected above sand (AECOS, 1980).

Coral coverage seaward of the north side of Aua Point averaged about four percent on the reef flat; coral coverage increased to approximately 13 percent on the leeward (south) side of Aua Point. Coral coverage increased to about 50 percent further inshore along the leeward reef flat.

A dredged "lagoon", approximately 130-feet wide, was noted south of Ava Point. Coral heads were attached to outcroppings of reef rock in this area.

"Major alterations to the coral assemblage near Ava Point were evident after a 1973 resurvey of 1917 reef transects. The total number of living coral colonies is 28% less than in 1917, and relative abundance of major species was altered. Although Acropora continues to be a common coral, the number of Psammocora colonies has been reduced by two-thirds. In the reef flat mid-zone, colonies of Pocillopora, especially P.damicornis and P. brevicornis, have increased five-fold, occupying a zone once dominated by Porities. The number of small coral colonies was high in 1973, although 1917 photographs suggest considerable numbers of large colonies" (AECOS, 1980).

Corals covered approximately 15 percent of the consolidated limestone bottom on the outer reef south of Ava Point. West of Ava Point, coral coverage was about 5 percent on the semi-consolidated to consolidated limestone bottom. Along the reef front, coral coverage averaged about 28 percent.

A broad fringing reef extended along the shoreline between Aua Village to Breakers Point. Seaward of Tafananai, the reef flat was roughly 600 feet wide; coral coverage was less than five percent.

Marine biologists noted the clarity of marine water that swept over the reef flat north of Breakers Point. Underwater visibility was documented to be about 50 feet.

1982, 1985, and 1988

During the month of April in 1982, 1985, and 1988, Birkeland and Randall investigated the coral communities in the vicinity of the Rainmaker Hotel. Survey transects were made at a depths of 6-10 feet, as well as 20 feet.

Coral abundance and coverage generally declined in the vicinity of the Rainmaker Hotel during the 1982-1988 period. Coral coverage at 6-10 feet increased from almost seven percent in 1982 to 11 percent in 1985, but diminished to three percent in 1988. At 20 feet, coral coverage declined from almost 28 percent in 1982 to approximately 19 percent in 1985 and 1988 (Birkeland, Randall, and Amesbury, 1990).

1992

Field investigations were also made at Pago Pago Harbor by Maragos, Hunter, and Meier in 1992. One survey site was situated within the inner Harbor area; four sites were located in the outer Harbor.

Inner Harbor

Corals and other reef organisms were not observed within the one survey site within inner Pago Pago Harbor. The scientists reiterated a past conclusion from other marine biologists that the inner Harbor, which is situated between Nuututai Point and Leloaloa Village, was essentially devoid of structural coral reefs and living coral reef ecosystems.

Fringing reefs line were observed along the shoreline of the outer Pago Pago Harbor area. Coral reefs in the outer harbor area generally displayed low to moderate diversity, as well as a low coverage by living corals.

Outer Harbor

Reef slopes at Aua were generally polluted and unhealthy. In contrast, underwater visibility was much higher on the south side of the outer harbor, e.g., Fagatogo. Coral coverage, however, was less than 5 percent. In 1992, Maragos observed that the Aua site in 1992 was unrecognizable compared to earlier observations and photos he had made in 1969 (Maragos, 1972).

At a site seaward of Anasosopo, scientists estimated that coral coverage to be approximately five percent at depths less than six meters. Coral coverage was estimated to be less than one percent at 18 meters.

Coral coverage, at depths less than 6 meters, was estimated to range between one and five percent at the Utulei (Punaoa) site. At 18 meters, coral coverage was documented to less than one percent. Despite declining coral abundance, numerous small corals that were observed seaward of Punaoa Valley (Utulei site), as well as Fagaalu, provided some indication of some potential coral recovery. Scientists noticed that the Utulei site was previously degraded from sewage discharges from the Utulei WWTP. With a higher diversity of corals at the Utulei site, the marine biologists expressed optimism that future *"reductions in sewage, tuna cannery, and sediment discharges could lead to significant coral reef recovery"* (Maragos, Hunter, and Meier, 1992).

<u>1991-1993</u>

In January, 1991 and February, 1993, CH2M Hill conducted field surveys of the fringing coral reef in Pago Pago Harbor. These surveys were made to assess changes to the *"....reef-face habitat in areas of the inner, middle, and outer Pago Pago Harbor"* (CH2M Hill, 1993). These surveys documented, in part, the percent coverage of live reef corals.

In a general comparison of 1991 and 1993 data, CH2M Hill noted that remnant reef fronts in the west half of the inner Harbor did not sustain live hard or soft corals. Between Trading Point and Leloaloa, the north-shore reef face was characterized by less than five percent live, hard coral cover. Coral coverage in the middle harbor area ranged between one and 60 percent, but averaged about 20 percent for all transect depths. In the outer harbor, coral coverage was generally comparable to the middle harbor.

Reef transect stations, which were situated near stream mouths in the middle and outer harbor areas, indicated impacts associated with siltation. These effects included reduced live coral coverage and diversity.

<u>1995</u>

A 1996 study of various coral reefs throughout the Samoan Archipelago by Alison Green included an assessment of coral reef communities seaward of Aua, Leloaloa, Anasosopo, and Utulei. Each of these areas are located in the "outer Harbor" area. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Green also pointed out that Pago Pago Harbor once supported lush coral reefs. She also reiterated concern for the past degradation of water quality in Pago Pago Harbor and its continuing impact upon coral reef communities. One of these impacts has been the eutrophication of the harbor caused by the effluent from the tuna canneries. However, Green points out that Harbor water quality improved after cannery outfalls were relocated to the outer harbor in 1992 (CH2M Hill 1993).

Because of poor water quality in the Harbor, Green does not expect that the coral reefs in the Harbor will recover from past hurricane damage. However, despite the condition of the reef communities, Green points out that the fish communities in the Harbor are similar to those observed elsewhere around the island in terms of their fish species richness, fish density and fish biomass. On this basis, she stresses the importance of the reef communities to support fish habitats, as well as some coral species, that are unique to Samoa (Green, 1996).

Aua

At Aua, coral coverage was considered to be less than 20 percent with coral colony sizes observed to be "most small, few medium."

Field observations indicate that fish species richness at Aua was "high," or greater than 150 species. Fish density was reported to be "high", or greater than 10,000 individuals per hectare (ha). Fish biomass was observed to be "moderate," or between 500 and 999 kilograms per ha.

Leloaloa

At Leloaloa, coral coverage was observed to be less than 20 percent.

Between 100 and 149 species were observed at Leloaloa which Green considered "moderate" fish species richness. Fish density was observed to be "moderate," or between 5,000 and 9,999 individuals per ha. Fish biomass represented less than 500 kilograms per ha.

Anasosopo

Less than 20 percent coral coverage was observed at the Anasosopo site. Coral density was considered "low"; the richness of the coral species was believed to be "moderate".

Fish species richness ranged between 100 and 149 different species. Fish density was "moderate", or between 5,000 and 9,999 individuals per ha. The biomass of the fish observed was assessed to be "low", or less than 500 kilograms per ha.

Utulei

Field observations indicate that fish species richness at Utulei ranged between 100 and 149 species. Fish density was considered to be "moderate" as fish densities ranged between 5,000 and 9,999 individuals per ha. Fish biomass was reported to be "low", or less than 500 kilograms per ha.

Shoreline Protection

Pago Pago Harbor is one of the best deep-draft harbors in the South Pacific. The configuration of the Harbor provides the inner Harbor with excellent natural protection from deep ocean waves and swell.

Concrete wharfs front much of the industrialized shoreline that includes two tuna canneries, commercial port facilities, a fuel dock, and other support facilities. Other portions of the Pago Pago Harbor shoreline are stabilized with rudimentary seawalls or rubble revetments. There is no fringing reef in the inner Harbor that, otherwise, would provide some nominal shoreline protection.

Outside of the more industrialized and commercial areas of the Pago Pago Harbor area, the shoreline is typically characterized by a basaltic and/or coral rubble foreshore and a steeper backshore scarp. Many of these shoreline areas are stabilized with basaltic revetments or seawalls.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Pago Pago Harbor watershed that were determined to be "critical", or "potentially critical" conditions:

Between Breakers Point and Aua Village

- Rocks have been dumped on the shoreline in the Tafananai area. The rocks are generally unstable and slumping in places.

- There is marginal shore protection and some rock revetment in the vicinity of Anasosopo Point. A loose rock revetment was slumping and in poor condition. In several locations, an earthen scarp behind the rocks has reached the primary shoreline roadway and is undermining the asphalt surface.
- Shoreline erosion was occurring along approximately 600 feet of shoreline where the road elevation is about 6-7 feet above mean sea level and potentially overtopped by smaller waves.

Between Aua Village and Leloaloa

- Seven rusted longliner ship hulls remain grounded on the fringing reef margin. Aside from safety hazards, Pedersen Planning Consultants believes that these vessels may also be impacting local nearshore current patterns. During its April-May, 1996 survey, PPC noted significant erosion seaward of Ko store where a small peninsula has formed and show signs of significant shoreline erosion. The presence of a shoreline revetment seaward of the store may also have adversely impacted littoral drift and related sand movements along the coast.

Between Leloaloa and Anua

- A dumped rock revetment, sprayed with grout, extends from the end of the revetment to a man-made groin. The grouted revetment is undermined at the toe, and failing in places.

Between Satala and Malaloa

- Basaltic boulders and rocks are piled about 3-feet high along the shoreline in Lalopua. The rocks are slumping in some places and a scare is eroding behind the rocks. A drain pipe that extended 5 feet seaward of the scarp indicated the extent of this erosion.

Between Malaloa and the Rainmaker Hotel

- In the vicinity of the ASG Port Administration complex, there was 100 feet of failing sheet pile bulkhead, 2,100 feet of concrete deck on pilings of the main dock facility, 150 feet of rock revetment protecting the Casamar fishnet repair yard, and 400 feet of concrete deck on pilings for the fuel dock at the east end of the reach. The backshore of the main dock consists of docking facilities, the Port of Administration, and a container storage area. Critical erosion was observed by Sea Engineering, Inc. along the western 100 feet of the reach where an old sheetpile bulkhead is failing and the concrete deck behind it is collapsing.

Between Rainmaker Hotel and Tulutulu Point

- The reach extending from Nuututai Point to the south of Goat Island Point is approximately 1,600 feet. The shoreline of the Rainmaker Hotel consists of a well constructed, keyed and fitted rock revetment except for 250 feet of a failing grouted rock wall just north of Nuututai Point, 100 feet of lava rock outcroppings at the tip of the point, and a 200-foot long man made swimming beach. The grouted rock wall was observed to be undermined and collapsing, critically threatening nearshore structures. The backshore is occupied entirely by the Rainmaker Hotel and its facilities, including the main lobby, hotel rooms, a swimming pool, small cottages, and the man-made beach. Critical erosion was also documented by Sea Engineering, Inc. along the grouted wall that fronts the shoreline.
- Fronting the ASG tank farm in Utulei, a failing grouted rock revetment was observed by Sea Engineering, Inc. The toe of the revetment was undermined along the entire length which has caused the revetment to fail in some places. In turn, this failing apparently undermined the concrete sidewalk on the *sami* side of the primary shoreline roadway.

Groundwater and Surface Water Supplies

Groundwater Supply

There are five groundwater wells in the Pago Pago watershed that are used by ASPA in the operation of American Samoa's public water system on the Island of Tutuila (Table 24-4).

TABLE 24-4
GROUNDWATER WELLS IN THE PAGO PAGO WATERSHED OPERATED BY ASPA

Pump Location	Well Number	Ground Elevation	Well Depth (feet)	Normal Discharge Rate (gpm)	Normal Head (psi)	Elevation Above Mean Sea Level
Pago Pago	105	80	275	150	70	-195
Pago Pago	107	85	285	320	65	-200
Aua	97	82	243	320	10	-161
Aua	98	93.3	Unknown	Unknown	Unknown	Unknown
Aua	99	192	345	120	0	-153

Source: ASPA, 1995

Groundwater Quality

ASEPA regularly monitors groundwater quality via the regular collection and analysis of groundwater well samples. Once completed, this information is transmitted to the ASPA Water Division for their review.

In recent years, groundwater quality data has generally not indicated the presence of any long-term contamination of groundwater wells in the Pago Pago watershed. One exception is the chloride content of American Samoa's ground water which exceeds the National Secondary Drinking Water Regulations standard in portions of ASPA's overall service area.

On August 8, 1994, ASPA's 32 main system wells were tested for chloride concentrations. Four of these wells, i.e., Iliili #84, Tafuna #53, Aua #97, and Craddick, exceeded the Secondary Regulations maximum contaminant level of 250 milligrams per liter. Each of these wells has, historically, been characterized by elevated chloride levels (ASPA, 1995).

"Higher chloride levels in wells has been a problem since wells were first drilled in American Samoa. During prolonged droughts, chloride levels rise and water rationing is required. Wells must be temporarily removed from service; on two occasions, the tuna canneries were shut down to conserve water. Some wells in the Tafuna-Leone area and in Aua have been permanently abandoned due to saltwater intrusion.

Elevated chloride levels are cause for concern since they indicate saltwater upconing in the wells. This condition can cause long-term damage to the aquifer. The potential impact from saltwater upconing may have already occurred in the Tafuna and Aua areas.

Two primary factors contribute to saltwater intrusion into basal lens wells, which are the more common type of well in American Samoa:

- *the elevation of the bottom of the well in relation to mean sea level; and,*
- *the rate of extraction from the aquifer.*

The Ghyben-Herzberg ratio developed for basal lens aquifers states that the freshwater lens is 40 times as deep as the head of water above the sea level. To minimize upconing of saltwater, wells should not be deeper than one-third of the thickness of the freshwater lens. In the Tafuna Plains area, the lens is believed to be approximately 120 feet thick and wells drilled in a lens of this thickness should be no deeper than 40 feet. Accurate vertical control must be used to determine the static elevation of the lens surface because this will dictate the maximum depth of the well.

The rate of extraction from the aquifer is significant because higher rates are much more likely to cause upconing. At the same time, dikes and layers of the older volcanics can trap freshwater at significant depths below sea level. In Pago Pago and Aua, wells have been drilled more than 100 feet below sea level before freshwater has been encountered. However, wells of this type must be monitored often for chloride content. If levels begin to rise, the pumping rate must be reduced."

The chloride level, well bottom depth and discharge rates for the wells that are most affected by saltwater intrusion are summarized in Table 24-5 (ASPA, 1995).

TABLE 24-5
HIGH CHLORIDE WELL STATISTICS

Well Number and Location	Chlorides (ppm)	Elevation of well bottom below sea level (feet)	Average daily Withdrawal (mgd)
Well 84, Iliili	340	23	0.30
Well 119, Malaeloa	240	34	0.44
Well 53, Tafuna	560	66	0.00
Well 97, Aua	720	161	0.32
Well 99, Aua	560	153	0.34

Notes:
Chloride levels and average daily withdrawal statistics were derived from an August, 1994 ASPA Water Operations Report

Source: ASPA, Water Division, 1994.

Surface Water Supply and Quality

The Vaipito Intake is the only surface water source used in the ASPA water system. This source is located on Utumoa Stream's in Pago Pago's Vaipito Valley. Surface water from the Vaipito Spring is used only by Samoa Packing and Star-Kist Tuna for the processing and packing of tuna.

The two canneries consume approximately 30,000 gallons per day. A 10,000-foot water main connects the surface supply to the two canneries in Anua and Atuu.

Proposed Water System Improvements

The draft ASPA Utilities Master Plan calls for a feasibility study to evaluate the reactivation of the Vaipito spring and reservoir. This surface supply has a very low chloride content, and be delivered without pumps because of the elevation of this supply.

Other proposals in the draft Utilities Master Plan include:

- Construction of an automated booster station to fill the Aua water storage tank.
- Design and construct new water transmission lines that will help increase system pressures and increase the use of the Pago Pago water storage tank.
- Explore new potential sources of ground water in portions of the Pago Pago watershed and later convert selected exploratory wells into producing wells.
- Design and construct upper level water systems in Utulei, Fagatogo, Pago Pago, Satala, and Atuu.

USE OF THE WATERSHED

Resident Population

Utulei

Between 1980 and 1990, the resident population of Utulei Village declined from 980 to 930 residents. Such growth represented an average annual decline in population of about 0.51 percent. Development activity between 1990 and 1995 increased resident population to about 1,123 persons.

Population trends reflected in the 1990 Census statistics for Utulei suggest that significant in-migration has occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 22 percent. Between 1985 and 1990, the proportion increased to 47 percent. In 1990, the proportion decreased slightly to 45 percent.

Fagatogo

Between 1980 and 1990, the resident population of Fagatogo Village increased from 1,944 to 2,323 residents. Such growth represented an average annual growth rate of about 1.95 percent. The resident population declined to an estimated 2,318 persons in 1995.

Population trends reflected in the 1990 Census statistics suggest that significant in-migration has occurred in Fagatogo between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 23 percent. Between 1985 and 1990, the proportion increased to 41 percent. In 1990, the proportion increased to 52 percent.

Pago Pago

Between 1980 and 1990, the resident population of Pago Pago Village increased from 3,075 to 3,519 residents. Such growth represented an average annual growth rate of about 1.44 percent. Development activity between 1990 and 1995 increased resident population to about 4,319 persons.

Population trends reflected in the 1990 Census statistics suggest that some in-migration occurred in Pago Pago between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 26 percent. Between 1985 and 1990, the proportion increased to 39 percent. However, in 1990, the proportion increased slightly to 44 percent. The rise in number of residents who were born outside of American Samoa probably reflects a modest in-migration from American Samoans who were originally born in the continental United States, as well as an increasing number of new residents from the Far East, e.g. Korea.

Anua

Between 1980 and 1990, the resident population of Anua Village increased from 50 to 65 residents. Such growth represented an average annual growth rate of about 3.0 percent. Development activity between 1990 and 1995 increased resident population to about 68 persons.

Atuu

Between 1980 and 1990, the resident population of Atuu Village increased from 377 to 408 residents. Such growth represented an average annual growth rate of about 0.82 percent. Development activity between 1990 and 1995 increased resident population to about 462 persons.

Leloaloa

Between 1980 and 1990, the resident population of Leloaloa Village declined slightly from 414 to 412 residents. Such growth represented an average annual decline in population of about 0.05 percent. Development activity between 1990 and 1995 increased resident population to about 467 persons.

Population trends for Leloaloa reflected in the 1990 Census statistics suggest rather interesting migration characteristics. Between 1980 and 1990, the proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 37 percent. This proportion dropped to 25 percent between 1985 and 1990 and increased slightly to 31 percent in 1990. In contrast to most villages in American Samoa, the in-migration of persons who were not born in American Samoa actually declined from 1980 conditions. Such trends suggest that Leloaloa has a rather stable community where little in and out-migration is occurring. Further, it is believed that population growth in this community is primarily a result of new satellite families being established by persons born and raised in the community.

Aua

Between 1980 and 1990, the resident population of Aua Village increased from 1,379 to 1,896 residents. Such growth represented an average annual growth rate of about 3.75 percent. Development activity between 1990 and 1995 increased resident population to about 2,449 persons.

Statistics from the Census of 1990 for Aua suggest that there has been a significant in-migration of persons who were not originally born in American Samoa. In addition, Aua is the second largest village in the Pago Pago Harbor area.

Land Uses

Residential

Utulei

The 1990 U.S. Census documented 156 homes in Utulei. Sixty-nine percent of the homes were owner-occupied; 24 percent were rental units. The remaining seven percent were vacant or used as vacation homes by absentee owners.

The housing stock in Utulei expanded somewhat during the 1990-1995 period. ASG Building Division records indicate that 23 new residential building permits were issued during this period. Consequently, the 1995 housing stock in Utulei included about 179 houses.

Residential facilities in Utulei are presently scattered in three concentrations of single family housing. Most residential development is situated upland of the Samoana High School complex and the ASG Executive Office Building. Housing densities adjacent to Samoana High School range between five and nine dwelling units per acre. Upland of the PRI fuel storage facilities, housing densities decrease to about three dwelling units per acre.

Roughly 15 single family homes in Utulei are also situated on steeper slopes upland of the primary shoreline between Matafao School and Utulei Wastewater Treatment Plant. Three small concentrations of homes are located in this area. Residential densities are about two dwelling units per acre in each area. About 24 percent of the housing stock was used for rental housing in 1990.

Pago Pago

The residential area in Pago Pago Village is predominantly located in Vaipito Valley. Single family homes are found along the east and west sides of Vaipito Stream, as well as along the steeper slopes of the Valley. The steeper slopes of Mt. Alava also provide housesites for Pago Pago residents that live between Pago Pago Elementary School and the Satala Power Plant.

The 1990 Census documented 534 housing units in Pago Pago. Sixty-four percent of the homes were owner-occupied; 33 percent were rental units. Approximately three percent were vacant or used as a vacation home by their owners.

ASG Building Division records indicate that 122 building permits were issued for new residential structures from 1990 through 1994 within Pago Pago. Consequently, the 1995 housing stock included an estimated 656 homes.

Anua

Roughly 13 housing units were located in this village in 1990. ASG building branch records indicate that no additional housing units were constructed during the 1990-1994 period.

The existing residential area is along the north side and upland of Tutuila's primary shoreline roadway. Housing characteristics from the 1990 Census suggest that about 70 percent of the village housing stock is occupied by renters .

Atuu

Atuu contains about 70 dwelling units in 1995. This estimate is based upon 63 homes counted during the 1990 Census and an additional seven new residential construction permits that were issued between 1990 and 1995.

Most of the existing homes in Atuu are single family residential homes are located on the steeper slopes of Mt. Alava. However, several multi-unit apartment buildings are also available. Roughly 36 percent of the available housing stock is rented. Some rental housing units are built over the second floor of a small commercial building.

A representative of the family trust that owns most, if not all, of the lands in Atuu Village indicates that the Trust intends to continue residential leasing in the Village (Lia, 1994). Future residential expansion is expected to include the replacement of about 16 existing single family homes with two story, four-unit apartments, as well as the construction of four new four-unit apartments on the northeast side of the existing residential area. Such housing will continue to serve cannery workers and others involved in the related fisheries industry.

Leloaloa

The 1990 Census documented 72 housing units in Leloaloa Village. Sixty-percent of the homes were owner-occupied; 40 percent were rental housing units.

ASG Building Division records for Leloaloa indicate that 12 building permits were issued for new residential buildings from 1990 through 1994. Consequently, the 1995 housing stock represented approximately 84 homes.

Aua

In 1990, Aua village Census area included 275 housing units. More recent residential construction since 1990 suggests that the housing stock represented about 364 in 1995. Roughly 83 percent of all homes in the Village are owner occupied. Almost all of the homes in the Village are one-story single family units.

The size of the Aua Village housing stock has steadily increased in recent years, particularly since 1990. Statistics from the Census of 1990 suggest that there has been a significant in-migration of persons who were not originally born in American Samoa. In addition, Aua is the second largest village in the Pago Pago Harbor area.

Agriculture

Faatoaga are primarily located in the following areas within the Pago Pago watershed.

- Two areas northwest of Leloaloa Village
- North of the west central part of Leloaloa
- North of Lepua Village
- East side of Atuu Village
- South of Aua Village
- West side of Pago Pago Village
- Two areas in the southern half of Vaipito Valley
- Two areas in the southern half of Happy Valley
- Southern edge of Fagatogo Village
- Three areas on the southeastern side of Fagatogo
- Three areas in the Punaoa Valley

Piggeries are scattered throughout the villages of this watershed. Most of the piggeries are small and generally support family consumption and occasional traditional village gatherings.

Commercial

Utulei

There are about 60 commercial enterprises that are based in Utulei Village. These enterprises represent a wide variety of commercial retail stores, professional and technical services, as well as import and wholesale trade companies. Many of these operations are located within one and two-story commercial buildings along the southwest side of Tutuila's shoreline roadway. However, a sizable number of smaller retail stores are situated in the residential areas upland of Samoana High School and the ASG Executive Office Building.

American Samoa's primary visitor accommodations are located at the Rainmaker Hotel. Governor Lutali's Tourism Task Force recommended in late 1994 that the American Samoa Government should get out of the hotel business. The Development Bank of American Samoa presently owns 80 percent of the shares (ASG Economic Development Planning Office, 1994); the remainder of hotel ownership is held by several local investors. The Tourism Task Force recommended that the Development Bank shares be sold to a private investor who has considerable experience with the operation of visitor accommodations.

The sale of the hotel has been reviewed various times during the past 15 years. An agreement with Aiga Tasi, a Houston, Texas-based investor, was almost reached in 1985. More recently, various other investors have approached the American Samoa Government. For example, expressions of interest have been made by investors from Japan and the continental United States, but no formal agreements have been developed.

Fagatogo

ASG business license records indicate that there are about 281 commercial enterprises based in Fagatogo. Nine of these enterprises were established in Fagatogo between 1990 and 1995. Many are located on or adjacent to the Fagatogo Malae, the Tedi O Samoa commercial building, and along the north and south sides of Tutuila's primary shoreline roadway. A wide range of professional and technical services, financial institutions, wholesale representatives, and retail trade stores are found in Fagatogo that support the entire Island population and local economy. In addition, there are also a sizable number of fast-food and upscale restaurants, laundromats, and other operations that primarily support Fagatogo residents and persons employed in the Pago Pago Bay area.

In addition, Herb and Sia's Motel is located just inland of the Fagatogo Malae. This facility contains 10 guest rooms.

Pago Pago

Pago Pago Village has approximately 225 commercial enterprises that are based in the Village. Retail sales and technical services, as well as bus companies, are the primary commercial activities. Professional services, eating establishments, bars, and amusement facilities are also scattered throughout the community. Most of these commercial enterprises are located along both sides of Tutuila's primary shoreline roadway. Secondarily, other village-based facilities are situated within the residential area adjacent to Vaipito Stream.

Anua

Several fast-food operations, general stores, amusement centers, and two gas stations are located along the north side of the primary shoreline roadway. These enterprises primarily serve cannery workers during break periods and while workers await ground transportation home.

Atuu

ASG business license records indicate that there are about 28 commercial enterprises that are operating in Atuu. Most of these establishments include fast food, bars, night clubs, a laundromat, and restaurants. Retail stores, a medical clinic, a fish agent, and a consultant organization are also present in the village.

Leloaloa

ASG business license records indicate that there are almost 40 commercial enterprises that operate in Leloaloa Village. A restaurant, fast-food operation, grocery store, a video store, amusement center, and laundromat are situated adjacent to the north side of the primary shoreline roadway.

Aua

There are about 70 commercial enterprises that are based in Aua Village. Many of the commercial establishments are located on the east side of the primary shoreline roadway. Several are situated adjacent to Aua Elementary School. The majority are full or part-time home-based businesses.

Industrial

Utulei

The ASG Tank Farm complex is situated on the north side of the Utulei Wastewater Treatment Plant in Utulei. Plans were recently announced by the American Samoa Petroleum Cooperative (ASPC), a joint venture between the American Samoa Government, ASPA, and BHP Petroleum, that three new fuel storage tanks will be developed at the ASG Tank Farm in Utulei. The three new tanks, which will have a capacity of five million gallons, will be used for the storage of diesel fuel.

ASPC representatives have stated publicly that the concept of the Cooperative is to increase the fuel storage volume and attempt to sell more fuel within the South Pacific region. Through the sale of fuel, more revenues are collected to subsidize ASG road maintenance, the operation and maintenance of the tank farm, and other public works projects. Long term plans for the development of increased storage tank capacity at the ASG Tank Farm are not available at the time of this report.

Fagatogo

Industrial activity within Fagatogo is limited to the Port of Pago Pago where incoming breakbulk and containerized cargo is delivered via various international cargo vessels. International cargo is unloaded by local stevedores and delivered to local consignees.

Pago Pago

Limited industrial activities occur in Pago Pago. One exception is some fishing vessel servicing and stevedoring activity.

Anua

The Samoa Packing and Star-Kist Tuna cannery facilities are located on the north and south sides of the primary shoreline roadway.

The Southwest Marine operation also provides dry-dock facilities to a variety of incoming vessels to Pago Pago Harbor. This operation provides services primarily to longliner and purse seiner vessels. In April, 1996, company representatives indicated that the facility dry-docked approximately one to two purseiners and 30 longliners in 1995. The level of business traffic is considerably down from an average of 50 to 60 vessels in the early 1990's. Increased fuel prices and increased government regulations have encouraged longliner dry-docking services to be obtained in Fiji (Stoll, 1996).

Dry docking services provided by Southwest Marine use a blasting grit product to remove material from vessel hulls. The cleaning of a typical longliner vessel requires approximately four tons of grit; about 10 tons are need to service a purseiner (Stoll, 1996).

Southwest Marine regularly collects waste oil from vessels being serviced at the dry dock facility. In some cases, the waste oil is processed to a second oil-water separator that is located at the dry-dock facility. Ultimately, the waste oil collected is delivered to Samoa Packing which uses the oil in the operation of its diesel engine generators.

Sewage and bilge waters are collected by Harbor Refuge and Environmental Services. The arrangement for this service for an incoming vessel is sometimes coordinated by Southwest Marine.

Atuu

A small portion of the Starkist Tuna complex is situated in Atuu. The assumptions regarding the future operation of the two existing canneries is presented in the Anua Village description.

Leloaloa

Existing industrial activities within Leloaloa Village include two welding services. One of the welding services also performs related fabrication services. A small reclamation center is also situated in Leloaloa.

Aua

Several light industrial services are based in Aua. These enterprises offer services for welding and fabrication, motor rewinding, and auto repair.

Public Facilities

Utulei

Shoreline properties in Utulei village are used primarily for the Executive Office Building, Samoana High School, KVZK studio, and DOE administrative offices. These facilities are situated upon flatter lands which were once filled and graded to accommodate a former hospital and later ASG Public Works administrative activities, Samoana High School, and the Rainmaker Hotel. Several shoreline residences have more recently been renovated and converted into ASG offices.

The ASG Department of Education offers an early childhood education (ECE) in Utulei. The ECE program, which serves children three and four years of age, provided educational opportunities to 134 children in September, 1994.

Elementary school students attend Matafao Elementary School in Fagaalu. In September, 1994, this facility had a student enrollment of Pago Pago. High school students attend Samoana High School in Utulei.

Fagatogo

Public facilities in the Fagatogo area include the Fono building complex, the High Court of American Samoa building, the Port Administration building, a new Marine Resources building, the ASG Office of Communications, and Department of Public Safety complex. Smaller administrative office buildings are also provided for the ASG Department of Local Government, Department of Public Works, Office of Tourism, Territorial Registrar's Office, the Jean Haydon Museum and Arts Council. These facilities are scattered throughout the village. However, most are located near or adjacent to the primary shoreline roadway.

The ASG Department of Education offers an early childhood education (ECE) program at two different sites in Fagatogo. The ECE program, which serves children three and four years of age, provided educational opportunities to 65 Fagatogo children in September, 1994.

Elementary school students from Fagatogo are bussed to Pago Pago Elementary School in Pago Pago. High school students attend Samoana High School in Utulei.

Pago Pago

Public facilities in Pago Pago include the Territorial Administration on Aging and Pago Pago Elementary School. The ASG Department of Education offers an early childhood education program in Pago Pago. In September, 1994, this program was attended by 98 younger children. Elementary school-aged children attend Pago Pago Elementary in Pago Pago. In September, 1994, this facility had a student enrollment of 893. High school students attend Samoana High School in Utulei.

Anua

No public facilities are situated in the Anua area due to a lack of developable land and the proximity to industrial activities. School-aged children in Anua are currently transported to nearby school facilities.

Atuu

No public facilities are located in the Village. No future public facilities are expected to be developed because of limited developable land area. Odors from both cannery operations are also incompatible with most types of public facility activities. School-aged children in Atuu are bussed to school facilities in nearby villages.

Leloaloa

The ASG Department of Education does not offer an early childhood education (ECE) in Leloaloa. Elementary school students attend Aua Elementary School in Aua. High school students are bussed to Fagaitua High School in Fagaitua.

Aua

Aua Elementary School and the Early Childhood Education (ECE) program are the only public facilities in the Village. In September, 1994, the student enrollments for these facilities were 553 for Aua Elementary, and 72 students for ECE. High school students from the village are transported to Fagaitua High School.

Village Facilities

Marist Brothers pre-school and elementary school facilities are situated along the north side of the primary shoreline roadway in Leloaloa. In September, 1994, 90 preschool and 215 elementary students attended the Marist Brothers facilities which represented a total student enrollment of 305 children.

The Catholic Church also operates a preschool and an elementary school out of their facilities in Leloaloa. MMM Catholic Preschool for ages three to five had a September 1994 enrollment of 90 students, while Marist/St. Francis Elementary School for grades one to eight had an enrollment of 215 students. Students come from various villages throughout American Samoa.

Use of the Nearshore Waters

General Water Recreation

General water recreation such as swimming and snorkeling takes place at the nearshore waters that adjoin Utulei Beach. On April 28, 1996, about 30 persons were observed using the nearshore waters at Utulei Beach (between the Pago Pago Yacht Club and the south end of Rainmaker Hotel). The beach park is occasionally used for larger group functions. During these occasions, greater use is often made of the nearshore waters.

In April, 1996, four young boys were observed using "boogie boards" in the nearshore waters seaward of Leloaloa.

The nearshore waters adjoining Aua Village were being used for swimming in April and May, 1996. One to four persons were observed on two different occasions during this period.

Fishing

Despite the water quality of Pago Pago Harbor, considerable use is made of the nearshore waters of the watershed for recreational and subsistence fishing. Fishing methods typically include use of rod and reel, hand lines, bamboo poles, gleaning, spear diving, throw nets, and gill nets.

Available inshore creel survey data for the 1991-1993 period, which was collected by the ASG Department of Marine and Wildlife Resources, suggests that the primary fishing areas include the nearshore waters of Fagatogo and Anasosopo. However, fishing in the watershed also takes place in the nearshore waters seaward of Utulei and the inner Harbor.

The potential consumption of contaminated fish and shellfish harvested from the inner Harbor and Utulei is of potential concern. A human risk assessment for the consumption of fish and shellfish contaminated with heavy metals and organochlorine compounds was prepared by EnviroSearch International in October, 1994. This study concluded, in part, that:

- Fish and/or shellfish contaminated with lead from the inner Harbor, Utulei, Laulii, Matuu, and Fagaitua Bay pose a potential risk to children;
- Fish with mercury concentrations above 0.12 milligrams per kilogram (mg/kg) wet weight pose a potential risk to children consumers of four fish meals per week. Survey sites containing 0.12 ppm wet weight mercury or greater included the inner Harbor, Anasosopo, Utulei, Fagaalu, Nuuuli, Leone, Poloa, and Fagaitua Bay. Soldierfish, jack, groupers, and crab were characterized by the highest average of concentrations of mercury.
- Lead sampling results published by AECOS, Inc. in 1991 included lead concentrations that are elevated enough to cause potential serious health effects in children. These sites included the inner Harbor, Utulei, Fagaitua Bay, Matuu, and Laulii. Contaminated mullet and crab are of primary concern in the inner Harbor; mackerel is the principal concern for fish harvested from Utulei.
- Fish with mercury concentration greater than 0.20 ppm wet weight pose a potential risk to adults and children who consume four fish meals per week. Survey sites characterized mercury levels greater than 0.20 ppm included the inner Harbor, Anasosopo, Utulei, and Fagatogo.
- Concentrations of Aroclor 1260 in fish from the inner Harbor pose a greater than 10^{-5} cancer risk. EnviroSearch International suggested that ASEPA may want to consider continuing a ban on fishing from the inner Harbor until the extent of Aroclor 1260 contamination is determined.

On the basis of these conclusions, it appears that an adequate health risk is present in Pago Pago Harbor to establish a ban upon future fishing. Such a ban could be lifted when future data suggests a decline in health risk.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Utulei

Greater residential expansion is expected to occur in Utulei during the next 20 years. It is anticipated that future residential growth will almost reach an average of four percent per year. This growth will occur with a shift toward multi-unit housing since Utulei has a limited availability of accessible, developable land.

Limited residential expansion can occur in Utulei's three residential areas. Future residential development will be limited to housesites on somewhat steeper slopes at higher elevations. The limited availability of developable lands will probably limit residential construction to not more than 15 new single family units on the slopes above Samoana High School and the ASG Executive Office Building. Six potential housesites upslope of Matafao Elementary School are also expected to be constructed on these somewhat steeper slopes. It is believed that recent construction of the Utulei Sewer Project improvements and the proximity of these areas to government and commercial employment opportunities will encourage increased single family housing development and exhaust available developable land in these areas by the year 2000.

The depletion of available developable lands for single family residential development will lead to the gradual conversion of about 40 various single family homes to multi-story residential buildings. As stated earlier, about 24 percent of the existing housing stock in Utulei is rental housing. Between 1995 and the year 2000, the demand for rental housing in Utulei is not expected. However, once the Tafuna Plains area becomes more developed, Utulei and other residential areas closer to the Pago Pago Bay Area will become likely targets for increased multi-unit residential development.

About 24 percent of the housing stock was used for rental housing in 1990. By the year 2010, it is expected that an additional 40 single family homes in Utulei will be converted to multi-unit apartments that will contain an average four apartment units. Homeowners will make these conversions to derive income from a growing rental market. The potential rental housing market will include some returning American Samoans, as well as new immigrant laborers and their dependents from other Pacific Islands and the Far East.

During the next 20 years, ASPA believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Utulei.

1996-2000 Five new single family homes on moderate slopes above Samoana High School (between 100-200-foot elevation).

Two new single family homes on the steeper slopes upslope of Matafao Elementary School between 75 and 175-foot elevation.

2001-2005 Five new single family homes on moderate slopes above Samoana High School (between 100-200-foot elevation).

Two new single family homes on the steeper slopes upslope of Matafao Elementary School between 75 and 175-foot elevation.

The conversion of 14 single family homes to four-unit apartments (or 42 new housing units) upslope of Samoana High School (between 50 and 200-foot elevation).

2006-2010 Five new single family homes on moderate slopes above Samoana High School (between 100-200-foot elevation).

Two new single family homes on the steeper slopes upslope of Matafao Elementary School between 75 and 175-foot elevation.

The conversion of 13 single family homes to four-unit apartments (or 39 new housing units) upslope of Samoana High School (between 50 and 200-foot elevation).

2011-2015 The conversion of 13 single family homes to four-unit apartments (or 39 new housing units) upslope of Samoana High School (between 50 and 200-foot elevation).

The cumulative effect of this prospective residential growth is that Utulei's housing stock will increase to roughly 320 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.36 persons per household, the future village population will include about 1,714 persons.

Fagatogo

Little residential expansion is expected to occur in Fagatogo during the next 20 years. It is anticipated that future residential growth will not exceed an average of one percent per year. Limited future growth, which was about 1.5 percent per year from 1990 through 1994, is due the lack of developable land.

Remaining undeveloped lands upslope of the Fagatogo Malae and adjoining commercial area are expected to gradually provide housesites for about 23 single family housing units. The lands upslope of Sadie's Restaurant have somewhat greater development potential. While slopes of almost 40 percent are in this area, steeper ridges are characterized by wider plateaus that could provide ample space for about 21 single family units.

The scenic views of Mt. Alava, the marina, and Pago Pago Bay give Fagatogo considerable potential marketability for multi-family apartment units, as well as single family housing units. Apartment units were located on the site until the early 1980's and regularly occupied by ASG expatriate workers. ASPA believes the combined single family and apartment development scenario is the more likely to occur because a greater amount of immigrants are coming to the Island of Tutuila without housing opportunities that can be afforded via *faaSamoa*. Under this scenario, ASPA believes that approximately 24 apartment units and 15 single family units will be developed in this part of Fagatogo.

During the next 20 years, ASPA believes that these potential development opportunities and constraints are expected to generate the following sequence and volume of residential construction in Fagatogo.

1996-2000 15 single family units on moderate slopes upland of the Fagatogo Malae.

2001-2005 12 apartment units on lands upland of Sadie's Restaurant

2006-2010 Eight single family units on moderate slopes upland of the Fagatogo Malae.

2011-2015 12 additional apartment units on lands upland of Sadie's Restaurant.

The cumulative effect of this prospective residential growth is that Fagatogo Village housing stock will increase to roughly 421 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.51 persons per household, the future village population will include about 2,321 persons.

Residential growth in this community averaged about 3.3 percent per year between 1990 and 1995. Future residential expansion will be occur at a much slower pace; during the 1996-2015 period, ASPA believes that residential expansion will be at an annual rate of approximately 1.4 percent. Residential development is hampered by the lack of developable land.

Pago Pago

Future residential expansion is possible in Pago Pago. However, such expansion is expected to be limited to single family construction along steeper slopes. ASPA estimates that roughly 27 single family housesites are available along the slopes that drain into Vaipito Stream. An additional 24 potential housesites are situated northwest and north of Pago Pago Park on the steeper slopes of Mt. Alava. ASPA believes that these remaining potential housesites will gradually become fully developed and occupied by the year 2005.

During the next 20 years, ASPA believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Pago Pago.

1996-2000	14 new single family homes in Vaipito Valley between 75 and 375-foot elevation.
	12 new single family homes north and northwest of Pago Pago Park between 50 and 200-foot elevation.
2001-2005	13 new single family homes in Vaipito Valley between 75 and 375-foot elevation.
	12 new single family homes north and northwest of Pago Pago Park between 50 and 200-foot elevation.
2006-2010	No new residential construction except for home replacements, additions, and renovations.
2011-2015	No new residential construction except for home replacements, additions, and renovations.

The cumulative effect of this prospective residential growth is that Pago Pago Village's housing stock will increase to roughly 707 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.62 persons per household, the future village population will include about 3,974 persons.

Anua

Most of the developable land that is suitable for residential development is already occupied. There is a potential to build about 13 additional single family homes on 30 to 40 percent slopes upslope of the existing residential area. A second potential scenario is that six four-unit apartment buildings are also possible in the same portion of Anua Village. The pole construction used for the adjacent Starkist Samoa management housing may set a pattern for future housing in this area.

The odors from the adjacent cannery operations hamper the marketability of rental units in this area to most families on Tutuila. However, the proximity of rental housing in Anua will probably remain attractive for those persons who work in tuna fisheries or at the canneries. For this reason, ASPA believes that six new four-unit apartment buildings will be constructed in the village by the year 2000.

The lack of available developable land will curtail any future residential development between 2001 and 2015. The only anticipated construction will be housing replacements, repairs, and renovations.

Given the prospective residential growth in the next 20 years, it is likely that the housing stock will increase to roughly 37 units by the year 2015. During the same period, it is believed that the average household size in Anua will have gradually decreased to approximately 4.49 persons per household. The 2015 village population will, therefore, include about 166 persons.

Atuu

Housing in the village is marketable to those workers who wish to live close to work, but proximity to work is somewhat offset by the odors from the adjacent cannery operations. The eventual conversion or replacement of existing single family residential housing with four-unit apartment buildings, as well as four additional apartment buildings, is expected to occur by the year 2015.

More specifically, new housing development in Atuu is expected to include the following residential construction during the next 20 years.

1996-2000	Replacement of four existing single family homes with two-story, four unit apartment buildings which, less demolition, will add 12 new housing units
2001-2005	replacement of six existing single family homes with two-story, four unit apartment buildings which, less demolition, will add 18 new housing units
2006-2010	no new residential construction except for home repairs and expansions
2011-2015	replacement of six existing single family homes with two-story, four unit apartment buildings which, less demolition, will add 18 new housing units

The cumulative effect of this anticipated residential development will be the construction of 48 new housing units by the year 2015, providing an estimated total of 118 housing units in Atuu. During the 1996-2015 period, it is believed that the average household size will have gradually decreased to approximately 5.64 persons per household. Consequently, the 2015 village population will include about 665 persons.

Leloaloa

Potential residential expansion in Leloaloa cannot accommodate more than about two additional single family units on steeper slopes upslope of the shoreline residential area. Residential demands that exceed the potential single family housesites can only be accommodated by the expansion of some existing single family housing to incorporate a second or third floor.

During the next 20 years, ASPA believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction in Leloaloa.

1996-2000	Two new single family homes on moderate slopes upslope of the existing shoreline residential area (between 100-200-foot elevation).
2001-2005	Conversion of four existing single family homes to 4-unit apartment buildings (12 new housing units).
2006-2010	No new residential construction except for home replacements, additions, or renovations.
2011-2015	The conversion of three existing single family homes to three four-unit apartments (or 9 new housing units).

The cumulative effect of this prospective residential growth is that the housing stock will increase to 107 housing units in the year 2015 within Leloaloa. During the same period, it is believed that the average household size will have gradually decreased to approximately 4.74 persons per household. Consequently, the 2015 village population will include about 507 persons.

Future residential growth will likely slow considerably from the 1990-1995 period when residential expansion occurred at a rate of about 4.5 percent per year. The lack of developable will decline future residential expansion to less than one percent per year during the next 20 years.

Aua

Despite a considerably larger land area, most of the flatter lands near the shoreline have already been developed. Consequently, the main village area below the 25-foot contour probably does not contain more than about seven single family housesites within the main village of Aua and seven potential housesites in Anasosopo. Similar to other villages in the Pago Pago Harbor area, residential expansion is now moving upslope of the main village and will continue until developable lands are depleted.

Pedersen Planning Consultants forecasts that there will be continued home construction within Aua, but the rate of growth will be slow. The village is already blessed with good vehicular access within the village, a variety of commercial services, an elementary school, various churches, and an attractive shoreline area. These characteristics and strong family ties have evidently fostered a continued in-migration that will lead to the construction of about seven more homes within the main village of Aua, approximately 25 single family housing units on the upland slopes of Aua between 50 and 500 feet above mean sea level, and seven homes behind the existing shoreline residential area in Anasosopo. Such development is expected to occur between 1996 and 2000.

No vacant developable lands will be available after 1999. Consequently, about 40 older single family homes will be converted to two-story two-unit homes between 2001 and 2005. No new residential construction is expected to occur beyond 2005 except for home replacements and renovations in Aua.

The cumulative effect of this prospective residential growth is that the housing stock will increase to roughly 436 housing units in the year 2015 in Aua. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.74 persons per household, the 2015 village population will include about 2,505 persons.

Commercial

Utulei

Future commercial development will remain in the residential areas upland of Samoana High School and the ASG Executive Office Building in Utulei. Commercial facilities along Tutuila's shoreline roadway will gradually include a greater number of three and four-story structures. Such development will be made to accommodate future floor space demands for professional services and retail floor space. The age of existing structures and considerable competition in the Nuuuli-Pavaiai area will prompt much of this re-development.

This redevelopment in Utulei is expected to provide four new retail services between 1996 and the year 2000. Six new retail stores and four new commercial office spaces are anticipated between 2001 and 2005. Each retail store and office space will employ an average of four persons.

Fagatogo

Future commercial expansion in Fagatogo is expected to support increased demands for professional and technical services. Limited developable lands that are available and suitable for this purpose are located primarily between Fagatogo Marketplace and the marina. However, continued redevelopment of older buildings on the upland side of the Malae and the north side of the primary shoreline roadway (between the Marketplace and the marina) represent areas where three to four story buildings can be expected. Consequently, the development of greater commercial floor space will occur where commercial activity already is present.

Between 1996 and the year 2000, 15 new retail stores and 10 commercial offices will be established via redevelopment in Fagatogo. During the 2001-2005 period, five new retail stores and 15 new offices will be established. Each new retail store will employ an average of four persons; each office will be administered by an average of four employees.

In addition, some professional and technical services in the private sector will also locate into some smaller commercial office space that will become available following the closure or relocation of some smaller ASG agencies in Fagatogo. This change will bring about 15 new offices into Fagatogo during the 2001-2005 period.

Pago Pago

Commercial expansion is limited in Pago Pago somewhat by the lack of developable land that is accessible to potential customers. More specifically, there is probably no more than five new commercial sites along the primary shoreline roadway. For this reason, it is expected that future commercial development will be the replacement of existing one-story commercial buildings with two to four-story buildings.

With this perspective, the following type and sequence of commercial expansion is anticipated within Pago Pago.

1996-2000	Five new commercial buildings along primary shoreline roadway.
2001-2005	Conversion of four single-story commercial buildings along primary roadway with two to four story buildings. These structures will typically have ground floor retail combined with upstairs offices and commercial services. Such development will generate the establishment of 20 new retail spaces and 20 new offices. Each enterprise will employ an average of four persons.
	Establishment of two additional laundromats within Vaipito Valley area. Each laundromat will operate eight washing machines.
2006-2010	Establishment of two additional laundromats northeast and northwest of Pago Pago Park upland of primary shoreline roadway.
2011-2015	Establishment of five retail stores within Vaipito Valley. Three persons will be employed at each store.

Anua

Commercial facility expansion is not expected. Limited market potential is derived from the residential population of the Village. Further, this Village is close to nearby commercial services and retail stores in the Pago Pago Bay Area.

Atuu

Commercial expansion will continue at Atuu. Commercial expansion will be limited to the conversion of existing one-story commercial store buildings to two and three story buildings because of limitations in developable lands. Such redevelopment is dependent upon a continued fish industry on the north side of Pago Pago Bay. The number of commercial enterprises will probably increase to about 40 enterprises by the year 2010.

Leloaloa

Similar to residential development, commercial expansion can only occur in Leloaloa if existing commercial facilities are renovated to incorporate additional floors. No lands appear to be available for any new commercial development in the next 20 years.

Such expansion is most desirable along the north side of the shoreline roadway where retail stores and services can attract both local residential and "road" traffic. Between the years 2005 and 2009, ASPA believes that three existing stores along the primary roadway will be renovated to two-or three story buildings within Leloaloa. Such renovations will generate the establishment of ten new retail stores and 12 small offices. Various professional services presently based in the community will likely occupy upper floor offices above ground floor retail spaces.

Aua

The Aua Foodland grocery store is a three-story commercial building. This building signals what can be anticipated in future years. Similar to Leloaloa, a number of professional and technical services in Aua will eventually become successful enough to warrant relocation of these business to a somewhat larger location outside of the home. The potential development of several two and three-story commercial buildings can be expected to eventually meet these demands and the related market demand of the community. By the year 2005, about 20 businesses will be located with three or four expanded commercial buildings. Another 10 village enterprises will be relocated in expanded or renovated commercial buildings by the year 2010.

Hotel and Visitor Accommodations

The decline in overall guest arrivals in Fagatogo since 1990 and the lack of developable land suggests that an expansion in hotel and visitor accommodations is not likely. The primary visitor accommodation need in the Pago Pago Bay Area is the availability of a well-operated business hotel. The Rainmaker Hotel in Utulei remains as the more likely option; its sale and eventual renovation is anticipated.

A minority of incoming visitors, however, will prefer more quaint and less expensive accommodations in a centralized location such as Fagatogo. Herb and Sia's Motel meets this demand and is expected to satisfy a portion of these demands in the future via its existing facility. No expansion of this facility is envisioned during the next 20 years.

Despite the past reluctance of ASG and local investors to sell its financial interest to any off-island investors, ASPA believes that the Rainmaker Hotel will be sold to an experienced off-island investor by the year 2000. The American Samoa Government cannot afford to subsidize an unprofitable enterprise in the face of declining governmental revenues from the U.S. Government. These conditions and a recognition of the opportunity to shift this government operation to private enterprise and reduce overall ASG operating expenditures will prompt the sale of the Hotel.

Any prospective investor will probably make an extensive renovation of the hotel to incorporate a greater number of rooms and other onsite amenities that will be provided to generate increased hotel revenues. It is expected that some 20 additional rooms will be constructed between the year 2001 and 2005.

Industrial

Utulei

The ASG Tank Farm is expected to be the only significant industrial facility in Utulei Village through the year 2015.

Fagatogo

No current master plan is available for the Port in Fagatogo. However, existing container storage demands and the apparent lack of space for cargo handling, transit and storage activities suggest that a future expansion of the Port area will be necessary to safely sustain existing general cargo volumes.

In the absence of any detailed port evaluation in Fagatogo, the only adjacent lands for potential port expansion would include the area presently used by the Jean Haydon Museum and the Territorial Registrar. The incorporation of these lands, which include about 1.9 acres, into the Port area is expected to occur by the year 2005. This expansion is expected to provide additional space for cargo handling, transit and storage

Pago Pago

No significant expansion of industrial activity is expected within Pago Pago during the next 20 years. Limited land area is available for such development.

At the present time, tuna cannery facilities in Anua and Atuu are the primary industrial activity on the north side of Pago Pago Bay. The limited availability of land almost dictates that any future industrial activity in Pago Pago will be a small industrial service enterprise that supports the tuna fishery and related cannery operations. Should cannery operations be curtailed or closed, this condition would not open provide any new opportunities for industrial facility expansion

Anua

Future use of the shoreline area occupied by Samoa Packing and Starkist Samoa is uncertain. Neither of the two canneries have indicated any plans for closure. ASPA senses that one of two canneries will close its operation during the 2006-2010 period. The potential closure of the Starkist cannery is suggested by:

- the recent closure and subsequent relocation of the former can plant in Tafuna to Puerto Rico after management determined apparent work inefficiencies.
- Starkist's reluctance to proceed with a $35 million improvement of its existing cannery to improve production efficiency.

The anticipated closure of the existing Starkist Tuna cannery during the 2006-2010 period will likely prompt serious attention by the ASG Governor's Office and Economic Development Planning Office to locate another industrial operation that would help rebuild the private sector. Any potential new user of the present Starkist Tuna facility would likely be involved in limited fish processing and the related air transshipment of whole tuna fish to international fish markets in Japan or the United States. For that matter, it is not unthinkable that Starkist Tuna might close its cannery operation and renovate the existing facility to support the air transshipment of tuna.

Atuu

A small portion of the Starkist Tuna complex is situated in Atuu. The assumptions regarding the future operation of the two existing canneries is presented in the Anua Village description.

Leloaloa

Future expansion of industrial activities is not anticipated due to limited land area. A continuation of three home-based industrial operations is expected through the year 2015 within Leloaloa. It is assumed that each enterprise employs an average of two persons.

Aua

Two additional auto repair services are expected to be established in Aua between 2001 and 2005. However, they will be home-based services and not generate a demand for industrial property in the Village. Even if a demand did materialize, it is very unlikely that there will be any additional lands available for industrial facility development.

Public Facilities

Utulei

All of the administrative complexes in Utulei are expected to remain within their existing sites. One exception is the several offices that are located on the shoreline between Utulei Beach and the Pago Pago Yacht Club. Between 2001 and the year 2005, Pedersen Planning Consultants anticipates that these buildings will be removed to provide greater recreational area adjacent to Utulei Beach. An anticipated decline in the size of ASG operations is expected to negate the need for these buildings which will also be near the end of their useful "facility life".

Population characteristics for Utulei in 1990 suggest that approximately five percent of the village population is three and four years of age, 21 percent is elementary school age (5-13), and 10 percent is high school age (14-18).

Application of these assumptions to anticipated future population suggests that Utulei will contribute the following student enrollments in the year 2015:

- early childhood education 86 students
- elementary school 360 students
- high school 172 students

Fagatogo

During the next 20 years, ASG offices in Fagatogo that are primarily supported by U.S. domestic grant program monies will reduce in size, be absorbed by larger ASG agencies, or be closed. It is believed that such reductions will impact all agencies within the American Samoa Government. However, smaller buildings that are leased by the Government for administrative offices will likely represent some of the early budget cuts. Consequently, some existing offices will gradually become available to the private sector.

Pedersen Planning Consultants believes that a noticeable reduction in leased office space to smaller ASG agencies will likely occur by the year 2000. The increased demand for professional and technical services in Fagatogo will likely absorb most of the closed office space for smaller ASG agencies.

The Territorial Office of Aging is expected to be closed or significantly reduced in response to anticipated cuts in U.S. domestic grants. Closure of the agency's administrative facility in Pago Pago is expected by the year 2005.

Population characteristics for Fagatogo in 1990 suggest that approximately six percent of the village population is three and four years of age, 18 percent is elementary school age (5-13), and 8 percent is high school age (14-18).

Application of population assumptions to anticipated future population suggests that Fagatogo will contribute the following student enrollments in the year 2015:

- early childhood education 139 students
- elementary school 418 students
- high school 186 students

Pago Pago

Population characteristics for Pago Pago in 1990 suggest that approximately six percent of the village population is three and four years of age. Elementary school-aged children (5 and 13 years old) include about 20 percent of the village population; high school students represented about ten percent of the population.

The application of 1990 population characteristics to the anticipated 2015 village population suggest increased student enrollments in Pago Pago in future early childhood, elementary education, and high school programs within and outside of Fagaitua. Anticipated student enrollments from the village population are expected to be as follows in the year 2015:

- early childhood education 238 students
- elementary school 795 students
- high school 397 students

Anua

Population characteristics for Anua in 1990 suggest that approximately five percent are three and four-year-olds who would potentially attend an early childhood education program, 14 percent are elementary school age (5 through 13), and five percent are high school age.

Application of these assumptions to anticipated future population suggests that Anua will have the following estimated student enrollments in the year 2015:

- early childhood education 8 students
- elementary school 23 students
- high school 8 students

Atuu

Population characteristics for Atuu in 1990 suggest that approximately eight percent of the Village population are three and four-year-olds who would potentially attend an early childhood education program, 18 percent are elementary school age (between the ages of five and 13), and 12 percent are high school age.

A growing residential population in Atuu will impact student enrollments. The three and four year old (ECE) age group represented about six percent of the total village population in 1990; while the elementary school age group (ages five to 13) represented 20 percent, and high school age group (14 to 18) represented 11 percent.

Applications of these assumptions to anticipated future population suggests that Atuu will have the following estimated student enrollments in the year 2015:

- early childhood education 53 students
- elementary school 120 students
- high school 80 students

Leloaloa

Population characteristics for Leloaloa in 1990 suggest that approximately six percent of the village population is three and four years of age, 20 percent is elementary school age (5-13), and 13 percent is high school age (14-18).

Application of population assumptions to anticipated future population suggests that Leloaloa will contribute the following student enrollments in the year 2015:

- early childhood education 30 students
- elementary school 101 students
- high school 66 students

Aua

A growing residential population will impact student enrollments in Aua. The three and four year old (ECE) age group represented about six percent of the total village population in 1990; while the elementary school age group (ages five to 13) represented 20 percent, and high school age group (14 to 18) represented 11 percent.

Application of these assumptions to anticipated future population suggests that Aua will have the following estimated student enrollments in the year 2015:

- early childhood education 152 students
- elementary school 507 students
- high school 279 students

Future increases in student enrollment may require an expansion of the existing elementary school in Aua. Such an expansion will be dependent upon DOE standards for classroom sizes and related student-teacher ratios. Discussions with ASG Department of Education representatives indicated no plans for school expansion or consolidation were available at the time of this report. Nevertheless, the existing school site probably does not contain a significant amount of developable land area to accommodate any significant expansion. Consequently, no additional public facilities are anticipated during the next 20 years.

Village Facilities

No expansion of village facilities, such as church complexes, are expected to occur in Leloaloa through the year 2015.

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Pago Pago watershed will increase the volume of future drinking water consumption and the volume of wastewater that is generated by local residents (Tables 24-6 and 24-7). These forecasts were developed by Pedersen Planning Consultants in 1996 and are based upon population and land use assumptions that were developed for the draft ASPA Utilities Master Plan.

TABLE 24-6
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
PAGO PAGO WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Utulei	229,240	318,953
Fagatogo	283,452	368,801
Pago Pago	421,124	555,426
Anua	1,464,705	1,473,490
Atuu	34,162	69,029
Leloaloa	59,672	77,660
Aua	39,121	222,309

Source: Pedersen Planning Consultants, 1995

TABLE 24-7
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
PAGO PAGO WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Utulei	160,468	223,267
Fagatogo	198,416	258,161
Pago Pago	294,787	388,798
Anua	3,294	9,443
Atuu	23,913	48,320
Leloaloa	41,770	54,362
Aua	27,385	155,616

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of several streams in the Pago Pago watershed.

100-Year Peak Discharge Areas

The Federal Emergency Management Agency (FEMA) estimated 100-year peak discharges for the several streams in the Pago Pago watershed. These streams included the following:

- Vailoa Stream in Utulei;
- Vaipito Stream and selected tributaries in Pago Pago; as well as
- Leasi Stream, Matagimalie Stream, Suaia Stream, Lalolamauta Stream in Aua Village.

These estimates are summarized in Table 24-8.

TABLE 24-8
ESTIMATED 100-YEAR PEAK DISCHARGES
SELECTED STREAM LOCATIONS
PAGO PAGO WATERSHED

Flooding Source & Location	Drainage Area (square miles)	100-Year Peak Discharge (cubic feet per second)
Vailoa Stream mouth (Utulei)	0.10	280
Vaipito Stream mouth (Pago Pago)	1.36	3,050
Vaipito Stream above confluence w/ Laolao Stream	0.96	2,360
Vaipito Stream below confluence w/Fitiuli Stream	0.76	1,950
Vaipito Stream above confluence w/Fitiuli Stream	0.48	1,320
Vaipito Stream above confluence with Utumoa Stream	0.26	770
Leasi Stream mouth (Aua)	0.06	190
Suaia Stream mouth (Aua)	0.51	1,400
Suaia Stream downstream of confluence w/Matagimalie Stream (Aua)	0.32	930
Suaia Stream downstream of confluence w/Lalolamauta Stream (Aua)	0.26	770
Suaia Stream above confluence w/Lalolamauta Stream (Aua)	0.10	310
Lalolamauta Stream (left branch) above confluence w/Sauia Stream (Aua)	0.18	550
Lalolamauta Stream (left branch) 200 feet downstream of confluence w/Lalolamauta Stream (Aua)	0.15	460

Source: Federal Emergency Management Agency, 1991

Flood insurance rate maps, prepared by FEMA, indicate potential 100-year flood elevations along the Vailoa Stream drainage in Utulei that range between 10 and 21 feet above mean sea level. Under such conditions, portions of the first floor of the ASG Executive Office building and adjoining one-story structures could be inundated by these potential flood elevations.

Peak 100-year discharges along Vaipito Stream are estimated by FEMA to generate flood elevations between 15 and 102 feet above mean sea level. Most of the potential flood areas are generally located along existing drainage courses. However, some potential flooding could generate private property damage along the east side of the lower Vaipito Stream drainage.

In Aua Village, peak 100-year flood elevations would likely impact significant portions of the main village area. Estimated peak discharges range 7 and 15 feet above mean sea level. The elementary school is situated at approximately 14.9 feet above mean sea level.

Upland areas in the Pago Pago watershed, which are beyond the 25-foot contour, have generally been designated by the Federal Emergency Management Agency as “zone x.” These areas are beyond the 100-year floodplain (FEMA, 1991). In essence, FEMA is suggesting that there is limited flood potential in these areas.

Coastal Flood Hazards

The flood insurance rate maps for Pago Pago Harbor watershed suggest that there is a coastal flood hazard, i.e., "zone ve" along almost all of the Harbor shoreline. This designation indicates a potential coastal flood with velocity (wave action).

Between Utulei Village and the Rainmaker Hotel, anticipated base flood elevations from a 100-year flood are expected to range between four and feet above mean sea level (MSL).

In Fagatogo, the ASG Port Administration complex is situated in an area that would be influenced by a potential coastal flood elevation of approximately six feet above MSL. The coastal hazard area could also generated flood levels of roughly seven feet above MSL in the vicinity of the Fono, Fagatogo Malae, Fagatogo Square, the Fagatogo marketplace and adjoining commercial facilities.

In Pago Pago (Malaloa to Satala), the coastal flood elevations range between eight and 11 feet above MSL. The higher coastal flood elevations are located in the Pago Pago Park area and lower portions of the Vaipito Valley. Consequently, FEMA estimates suggest that a 100-year coastal flood hazard would damage public and private facilities in lower portions of Pago Pago Village, e.g., Happy Valley.

Between Pago Pago Park and Satala, coastal flood elevations would range between 8 and 10 feet above MSL. FEMA predicts that such flooding would occur along or seaward of the primary shoreline roadway.

Between Anua and Anasosopo, coastal flood hazards diminish to between seven feet above MSL in the vicinity of the two tuna canneries to about four feet above MSL seaward of Aua Village. The coastal flood area generally is limited to lands seaward of the primary shoreline roadway except in the Village of Aua.

Potential tsunami elevations have also been estimated for the U.S. Army Corps of Engineers for the shoreline locations in Table 24-9.

A review of topographic elevations along the shoreline of Pago Pago Harbor suggests that potential 100-year tsunami inundation levels would most likely generate the most damage in the lower portions of Pago Pago Village. This area would likely include the land area, between the mouths of Vaipito Stream and Laolao Stream, up to about 12-feet above MSL.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Stormwater runoff in the Pago Pago watershed carries a significant amount of sediment to the surface waters of Pago Pago Harbor. While these discharges are not as significant as cannery discharges upon surface water quality in the Harbor, they are significant to any long-term restoration of coral reef communities in the outer Harbor area. From this perspective, every feasible opportunity should be made to detain or retard stormwater flows to the Harbor.

Potential Stormwater Detention Opportunities

Steeper slopes in the watershed, as well as the extent of urbanization, limit feasible opportunities for the detention future stormwater flows. Two potential opportunities may be available to detain future stormwater runoff and the settling out of sediments prior to their discharge into Pago Pago Harbor.

TABLE 24-9
100-YEAR TSUNAMI ELEVATIONS

Location	Potential Tsunami Inundation (Feet Above Mean Sea Level)
Shoreline at Niuloa Point (Point Distress)	2.9
Shoreline at Fagaalu (East)	3.2
Approximately 2,000 feet East along Fagaalu Shore	3.3
North Shore of Tulututu Point	3.6
South Side of Utulei (East)	4.0
South Side of Utulei (West)	4.1
North Side of Utulei	4.1
South Side of Nuututai Point	4.1
Eastern-most Edge of Nuututai Point	4.6
Just West of Nuututai Point	5.0
Between Nuututai Point and East Edge of Main Dock at Fagatogo	5.2
East Edge of Main Dock at Fagatogo	5.6
West Edge of Main Dock at Fagatogo	6.7
Shoreline approximately 500 ft West of main dock at Fagatogo	7.0
Shoreline at center of Fagatogo	7.3
Shoreline east of Malaloa	7.6
Shoreline west of Malaloa	8.7
Shoreline at east side of Autapini	9.4
Shoreline at Autapini	10.3
Shoreline at Fusi	11.2
Shoreline at center of Pago Pago	11.1
Shoreline at Siufaga	11.2
Shoreline between Siufaga and Lalopua	10.5
Shoreline at Lalopua	9.2
Shoreline at Satala	8.1
Shoreline just west of Anua	7.2
Shoreline just east of Anua	6.5
Shoreline west of Atuu	6.3
Shoreline just east of Atuu	6.0
Shoreline approximately 1,000 feet east of Atuu	5.4
Shoreline at Leloaloa	4.9
Shoreline at Lepua	4.4
Shoreline west of Leasi Point	4.1
Shoreline east of Leasi Point	4.1
Shoreline just west of Aua	4.1
Shoreline just south of Aua	4.1
Shoreline approximately 1,300 feet south of Aua	4.1
Shoreline approximately 400 feet north of Aua Point	4.0
Shoreline at Aua Point	3.9
Shoreline approximately 400 feet south of Aua Point	3.7
Shoreline approximately 950 feet north of Anasosopo Point	3.6
Shoreline at Anasosopo Point	3.6
Shoreline at Tafagamanu Point	3.4
Shoreline at Tafagananai	3.3
Shoreline at Breakers Point	3.0

Source: U. S. Army corps of Engineers.

Vaipito Stream Mouth

Historical stream flow and water quality data indicates that Vaipito Stream is the greatest source of sedimentation in the Pago Pago watershed. One potential opportunity to detain stormwater runoff is located near the mouth of Vaipito Stream between Pago Plaza and Pago Pago Park. A recent stormwater management plan for this area, prepared by Pedersen Planning Consultants, suggests that a 100-year flood along Vaipito Stream would generate approximately 3,300 cfs of stormwater. In the absence of any detention facilities, this discharge would also generate the discharge of approximately 201 tons of sediment into Pago Pago Harbor.

In its investigations, Pedersen Planning Consultants modeled 10, 20, 50 and 100-year events and evaluated adjoining land uses. On this basis, Pedersen Planning Consultants concluded that a detention facility at Vaipito Stream could feasibly be developed to detain a 2-year storm. For a 2-year storm event, a detention facility near the mouth of Vaipito Stream could keep approximately 1.3 tons of sediment from entering Pago Pago Harbor.

These improvements can be made without reducing existing recreational opportunities at Pago Park. The proposed improvements along the north side of Pago Plaza will also enable a greater use of the existing vehicular parking area during higher runoff periods.

Aua Wetland

Another significant contributor of sediment into Pago Pago Harbor is Lalolamauta Stream and its tributaries.

The wetland in the central part of Aua Village represents a continuing opportunity to detain future stormwater flows. This wetland already supports this function to some extent. However, an evaluation should be made to determine if greater stormwater detention and sediment deposition can be achieved within the wetland. For example, an existing banana plantation could be possibly be relocated to reclaim lands that were probably part of the original wetland area. Other wetland improvement opportunities may also be situated in other parts of the nine-acre wetland.

Nearshore Water Quality and the Marine Environment

Long-Term Monitoring of Water Quality and Coral Communities

The past and continuing discharges to the waters of Pago Pago Harbor necessitate the continued monitoring of:

- water quality at long-term monitoring stations within the inner and outer Harbor to determine the periodic status of nutrient loading into Pago Pago Harbor;
- sediment loading into the Harbor from selected stream discharges; and,
- coral communities in the outer Harbor at least once every three years.

These long-term programs are required to help direct and prioritize future resource management efforts of ASEPA, the ASG Coastal Zone Management Program, and the ASG Department of Marine and Wildlife Resources.

Long-Term Maintenance of Harbor Waters

It is also critical for ASEPA to initiate efforts that will continue to improve Harbor water quality and foster a restoration of coral communities in the outer Harbor.

Reduction of Solid Waste Materials in Harbor Waters

The water quality of Pago Pago Harbor is also degraded by the long-term disposal of solid waste materials into local streams and along the Harbor shoreline. These solid wastes are discharged into the waters of Pago Pago Harbor via stormwater runoff and disposal into the nearshore waters along the shoreline of the Harbor. Solid waste material is also dumped into the Harbor via transient commercial and recreational vessels, as well as a few yachts that are moored inside the inner Harbor on a seasonal basis.

For the past 15 years, periodic collection of solid waste material in the Harbor waters has been made by Harbor Refuge and Environmental Services. It is recommended that these contract operations should continue. Solid waste materials typically carry a considerable amount of bacteria and other contaminants that do not promote desirable water quality. However, these collection efforts should be supplemented by more aggressive anti-litter campaigns that are administered by ASEPA.

Reduction of Petrochemical Discharges in Harbor Waters

The continued collection of oil wastes and other petrochemicals from incoming commercial vessels is equally important. Otherwise, vessel crew members will be encouraged to dispose a significant volume of petrochemicals into the waters of Pago Pago Harbor.

Harbor Refuge and Environmental Services typically pump out about 100 vessels per year (McCoy, 1996). Once collected, waste oil is delivered by Harbor Refuge and Environmental Services to the Tafuna Power Plant where the oil is reused for the operation and maintenance of diesel engine generators.

During the May, 1996 survey, a very small discharge of waste oil was observed to be leaking from the Langkilde Service Station in Malaloa. This facility is apparently one of the few waste oil collection stations that is operated by the American Samoa Power Authority. The station had installed an oil-water separator on the *sami* side of the service station. An owner representative indicated collections of the waste oil by ASPA were irregular and were, in part, responsible for the leakage of waste oil. Field observations by Pedersen Planning Consultants noted that a metal waste oil storage cabinet at the service station was deteriorating. Waste oil was leaking from the exterior storage cabinet and draining into an adjoining ASG storm collection system along the road on the south side of the small boat marina. This leakage missed the oil-water separator.

It is important that waste oil collection stations continue to be available to the general public for its disposal of waste oil. Otherwise, the general public will be encouraged to dispose of waste oil into Pago Pago Harbor and other shoreline areas on Tutuila. It is equally essential that adequate labor and equipment resources are allocated for the regular collection of waste oil from these collection stations.

Groundwater and Surface Water Supplies

As stated earlier, some groundwater wells in Pago Pago and Aua have been drilled more than 100 feet below sea level before fresh water has been encountered. The chloride content of these type of wells must be regularly be monitored. When chloride levels become elevated, the pumping rate from these wells must be reduced (ASPA, 1995).

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Pago Pago watershed will be to:

- Investigate and develop feasible opportunities to detain stormwater discharges from Vaipito Stream in Pago Pago and Lalolamauta Stream in Aua.
- Encourage village council representatives and family *sa'o* to restrict residential and commercial development in upland watershed areas that contain highly erosive soils known as Fagasa family-Lithic Hapludolls-Rock outcrop association or Aua very stony silty clay loam.
- Encourage a 100 percent connection of all facilities in the watershed to the ASPA wastewater system.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with a designated residents of Utulei, Fagatogo, Pago Pago, Anua, Atuu, Leloaloa, and Aua, and encourage the villages implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 24-10. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 24-10
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
PAGO PAGO WATERSHED

Participating Public agency	Resource Management Objective	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASEPA	Monitor changes in water quality of Pago Pago Harbor	Continue water quality monitoring program at long-term monitoring stations in the inner and outer Harbor.
ASEPA	Monitor the long-term discharge of sediments and nutrient loading into Harbor waters via local streams.	Use 1984 streams monitored by CH2M Hill that were measured for flow and nutrient contribution to the Harbor waters.
ASEPA	Reduce solid waste materials in Harbor waters	Continue the use of private contractor to periodically collect solid waste materials from the surface waters of Pago Pago Harbor.
ASEPA	Reduce petrochemical discharges into Pago Pago Harbor	Continue the use of a private contractor to regularly collect waste oil from incoming commercial vessels.

continued – next page

TABLE 24-10 (Continued)
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
PAGO PAGO WATERSHED

ASEPA	Investigate and develop feasible stormwater detention facilities at Vaipito Stream mouth and increase the detention capabilities of the Aua wetland	1. Make required field investigations and coordinate potential plans with village councils in Pago Pago and Aua. 2. Prepare conceptual site plans and order-of-magnitude cost estimates. 3. Where feasible, prepare detailed design and construction drawings. 4. Secure funding and build improvements.
DOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
DOC	Assist traditional leaders with the identification of desirable housesites and other land uses.	Prepare a community land use plan for each village in the watershed in close cooperation with traditional leaders.
ASPA	Decrease nutrient contribution from faulty cesspool installations.	Develop a program to encourage the connection of all residential and commercial facilities to the ASPA wastewater system.
ASPA	Decrease discharge of petrochemicals into Harbor waters.	Maintain waste oil collection centers and a regular collection schedule.
ASPA	Maintain desirable groundwater quality	Closely monitor chloride levels of groundwater wells in the watershed. Reduce well pump rates when chloride levels become elevated.
ASPA	Reduce potential saltwater intrusion into groundwater wells of the watershed.	ASPA Board of Directors and Water Division should adopt policy that no groundwater wells will be drilled no deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered.
ASG Dept. of Public Works	Maintain stormwater culverts at shoreline discharge points.	Establish a periodic maintenance program. Consider use of village labor to supplement DPW heavy equipment. Maintain all culverts along the primary shoreline roadway.
ASG Dept. of Marine and Wildlife Resources	Restore healthy marine communities in the waters of the outer Harbor	1. Monitor changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) in a selected location in the nearshore waters approximately every three years. 2. Identify stresses upon coral communities and marine life.

Source: Pedersen Planning Consultants, 1997

FAGAALU
Watershed 25

GEOGRAPHY

The Fagaalu watershed is located southwest of the Pago Pago watershed near the center of Tutuila. The watershed comprises about 0.96 square miles of land area (Figure 25-1).

The inland boundaries of the watershed are delineated by steeper mountain peaks and ridges. The north boundary of the watershed is formed by Matautu Ridge, Matai Mountain, and Palapaloloa Mountain, Matafao Mountain, and Sina Ridge.

The shoreline of the watershed is situated between Tulutulu Point and Niuloa Point. Fagaalu Bay lies between the two points. In the context of water quality, Fagaalu Bay is also considered a portion of "outer Pago Pago Harbor".

Fagaalu Stream and approximately eight tributaries are the primary drainage in the Fagaalu watershed. In the upper reaches of the Fagaalu Stream drainage, this stream course is called Matafao Stream. Smaller drainages are located on the northeast and southeast side of Fagaalu Village.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (Natural Resources Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 25-2). Two soil classifications were identified by the U.S. Soil Conservation Service for lands within the Fagaalu watershed (Table 25-1).

TABLE 25-1
SELECTED SOIL CHARACTERISTICS
FAGAALU WATERSHED

SCS Soil Unit	Name	Typical Slope (per cent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
34	Urban land-Aua-Leafu complex	0-30	A. None L. Occ	A.Slow to Med L. Slow	A.Slight to Mod L. Slight	A. >6 L. 3-5	>60	Severe A. Slope L. Flood Wet	Limited

Notes:
1. A.= Aua soils found on mountain foot slopes on 6-30 percent slopes.
2. L.= Leafu soils found on coastal plains and valley floors where slopes range between 0-6 percent.

Source: U.S. Soil Conservation Service, 1984

American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1 1.25

Miles

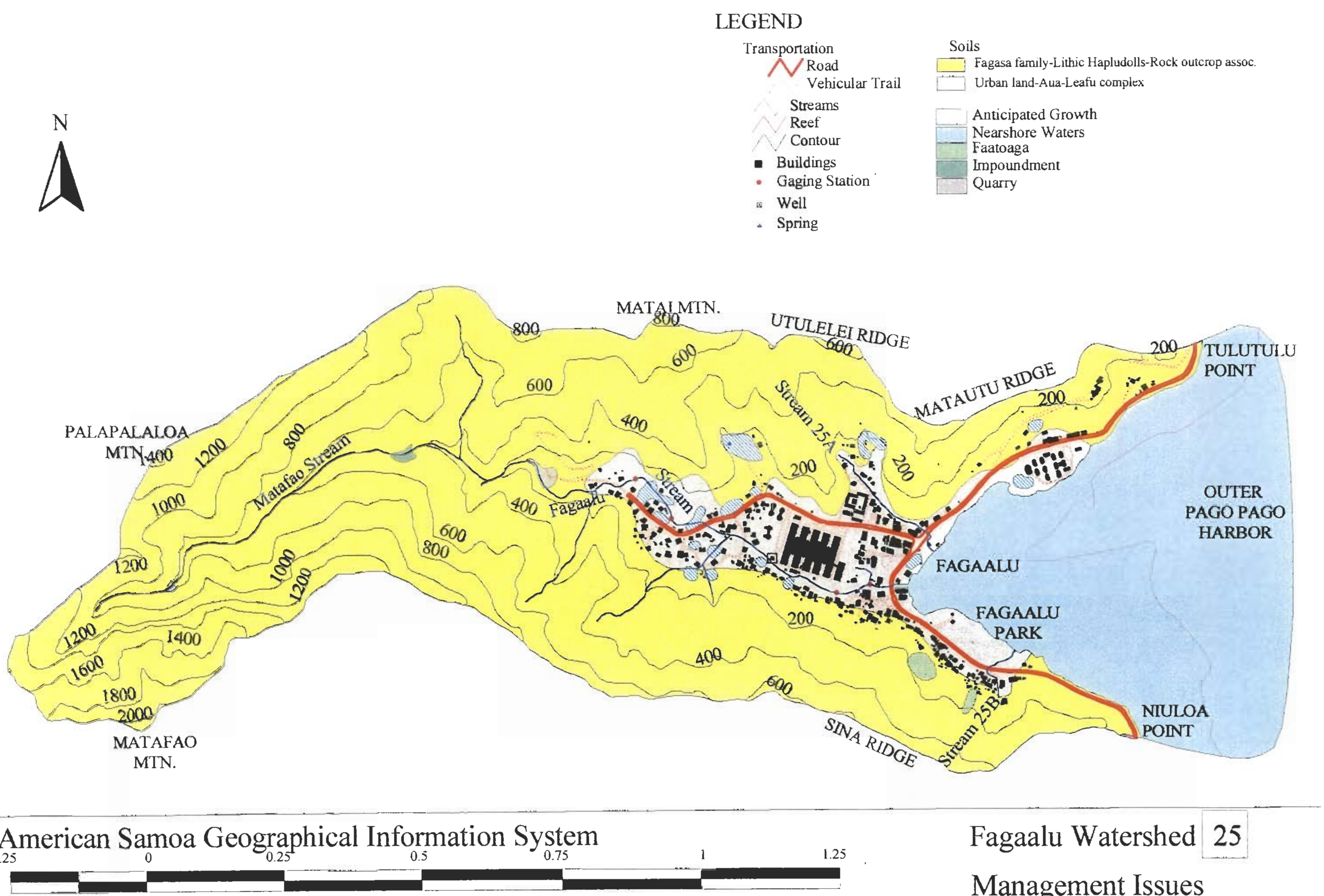
Scale: 1:15,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Fagaalu Watershed 25

Existing Conditions

Figure 25-1



American Samoa Geographical Information System

Prepared by: Pedersen Planning Consultants   Tel: 307-327-5434

Fagaalu Watershed 25

Management Issues

Figure 25-2

Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

The inhabited Fagaalu Village area is characterized by the Urban Land-Aua-Leafu complex (SCS mapping unit 34). Along Fagaalu Stream, this soil type extends approximately 3,100 feet inland of the Fagaalu Stream mouth.

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. The soil has limited to moderate potential for runoff. The erosion potential is slight to moderate.

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, do not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and cesspools in areas that contain these soils may be making a contribution of nutrients and bacteria into the nearshore waters of Vatia Bay.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to the Fagaalu Stream drainage. Such erosion can significantly influence downstream water quality.

Streams

Stream Locations

Matafao Stream begins at about the 1,400-foot contour and continues downslope to a stream fall. A stream diversion, at about the 812-foot elevation, was formerly used as a surface water source that supplied three reservoirs for a public potable water supply.

Below a stream fall at approximately 500 feet above mean sea level, the Matafao Stream course becomes Fagaalu Stream. Downstream of the falls, the stream course continues, at least, 5,000 feet before its discharge into the nearshore waters of Fagaalu Bay.

An unnamed stream (Stream 25A) on the northeast side of Fagaalu Village begins near the 175-foot elevation. This stream discharges along the shoreline in the area that is seaward of village commercial facilities.

A second unnamed stream (Stream 25B) drains the lower slopes of Sina Ridge. This drainage begins on the upper slopes of the inhabited village area on the southeast side of Fagaalu. Stream flows are carried through a culvert underneath the primary shoreline roadway. A man-made swale transports flows from the roadway, through the southeast end of Fagaalu Park, to the nearshore waters.

Stream Flows Within the Watershed

Records from two low-flow partial-record gages and a number of miscellaneous measurement sites provide stream flow data for Fagaalu Stream. Fagaalu Stream flows throughout the year.

A low-flow, partial-record station (No. 16949000) on a Matafao Stream tributary, approximately 100 feet upstream of Vaitanoa Pool, provided 9 measurements of stream flow between 1959 and 1964. These measurements enabled the U.S. Geological Survey to estimate a median flow of 0.33 cubic feet per second (cfs).

Between 1958 and 1963, a second low-flow, partial-record station (No. 16949500) on Fagaalu Stream was located 75 feet upstream from a pipeline diversion. Only two historical measurements of stream flow were made at this location. A median flow calculated for this stream location was estimated to be 0.32 cfs.

Instantaneous measurements of stream discharge at the mouth of Fagaalu Stream were made during the July 10-July 14, 1984 period. These measurements indicated a five-day mean of 1.7 cfs (CH2M Hill, 1984).

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Fagaalu Stream was one of 37 streams in American Samoa that was inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

Fagaalu Stream was surveyed in four locations. Station 15a was located in a gravel and cobble streambed below a primary shoreline roadway bridge. Station 15b was adjacent to a water quality monitoring station at an elevation of approximately 15 feet. Station 15c was located at an elevation of approximately 90 feet above mean sea level. Station 15d was established below Vaitauoa Pool near the 140-foot elevation.

Along the lower reach of Fagaalu Stream, one species of gobie fish, two species of mountain bass, and one species of eel were observed. Two species of shrimp and one species of mollusks were also identified at station 15a.

Two species of gobie fish was recorded at station 15b and one specie of mountain bass were documented. An abundant specie of eel was also present. Two species of shrimp and one specie of mollusk was also were reported.

Two species of gobie fish were observed at station 15c. However, no mountain bass or eels were identified. Four species of shrimp were also identified; one of these species was abundant. Two species of mollusk were also identified.

Below Vaitauoa Pool, only one species of gobie fish and one species of eel were recorded (station 15d). Four species of shrimp and two species of mollusk were also observed.

Surface Water Quality

General

Significant studies and monitoring of the surface water quality of Pago Pago Harbor have been made since the early 1960's. Past water quality studies and continued monitoring have primarily been prompted by NPDES permit and monitoring requirements associated with two tuna cannery operations in the Harbor, the Utulei Wastewater Treatment Plant (Utulei WWTP), as well as the long-term concerns of the American Samoa Government.

M&E Pacific conducted a comprehensive water quality monitoring program of Pago Pago Harbor and other nearshore locations in 1979. In February, 1984, ASEPA established a long-term water quality monitoring program in the Harbor that has continued through 1998, with only occasional interruption. The ongoing program generally uses the water quality monitoring stations that were originally recommended by M&E Pacific (Figure 25-3). Three additional monitoring stations were established in 1985.

The potential contribution of nutrients from the tuna canneries and other point sources was also examined as part of a Joint Study of Fish Cannery Wastewater Effluent Loading Reduction in Pago Pago Harbor in 1984. CH2M Hill conducted a five-day monitoring program in July, 1984 that include the sampling of point source flows from eight selected streams that discharge into the Harbor, the Utulei Wastewater Treatment Plant, and the effluent from the Star-Kist and Van Camp canneries. CH2M Hill concluded from the July 10-14, 1984 field studies that canneries contributed 97 percent of the total nitrogen and 96 percent of the total phosphorus that entered Pago Pago Harbor during that time period.

Nutrient and Sediment Contributions from Fagaalu Stream Discharges

The 1984 study by CH2M Hill examined eight selected streams that discharge into Pago Pago Harbor. These streams included Fagaalu Stream, Vailoa Stream (Utulei), three unnamed streams (probably in Fagatogo and Malaloa), Vaipito Stream, Laolao Stream and Aga Stream. During the 5-day monitoring period in July, 1984, the following water quality indicators were analyzed:

- nonfilterable residue (NFR);
- five-day biochemical oxygen demand (BOD_5);
- chemical oxygen demand (COD);
- nitrate nitrogen (NO_3-N);
- nitrite nitrogen (NO_2-N);
- total (persulfate) nitrogen (total N);
- total phosphorus (total P, or P);
- turbidity; and,
- salinity.

Data generated from the July 10-14, 1984 monitoring program indicated that the selected eight streams contributed about approximately 5,024 pounds per day of total nitrogen and about 500 pounds per day of total phosphorus. These quantities represented approximately 0.47 percent of all total nitrogen contribution and about 1.13 percent of total phosphorus loading into Pago Pago Harbor. The greatest contributions were generated from Vaipito Stream in Pago Pago Village.

Available data that was collected by CH2M Hill for Fagaalu Stream during the July 10-14, 1984 period is summarized in Table 25-2.

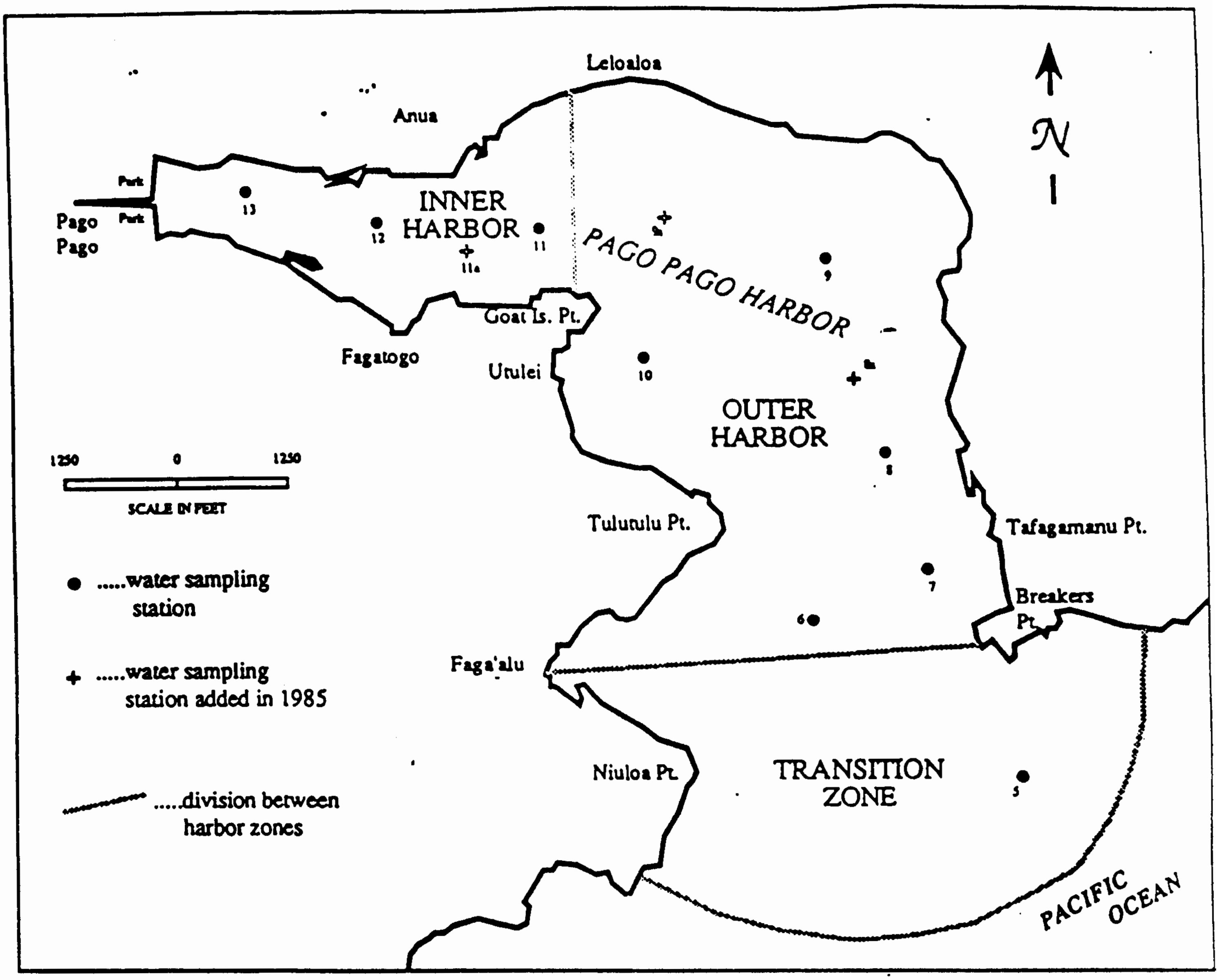


FIGURE 25-3
WATER QUALITY MONITORING STATIONS
PAGO PAGO HARBOR

Source: Hydro Resources International, 1989

TABLE 25-2
SURFACE WATER QUALITY DATA
FAGAALU STREAM, JULY 10-14, 1984

Water Quality Indicator	Mean	Range	Median	Proportion of Total Contribution to Pago Pago Harbor (%)
Stream Flow (mgd)	1.07	0.32-1.42	1.163	22.3
Turbidity (mg/l)	1.70	1.0-3.7	1.1	0.95
Non-Filterable Residue (mg/l)	32	4-100	28	4.52
BOD_5 (mg/l)	2	1-2	2	0.09
COD (mg/l)	--	<20-48	<20	0.55
NO_3-N	0.361	0.248-0.555	0.293	30.79
NO_2-N	0.003	<0.001-0.008	0.001	3.04
TKN	0.550	0.13-1.63	0.336	0.06
Total Nitrogen	0.369	0.423-1.866	0.593	0.11
Total Phosphorus	0.792	0.141-2.850	0.234	0.45

Source: CH2M Hill, 1984

Two water quality samples collected in May 1984 and August 1987 (STORET, 1996) reveal that total nitrogen (measured only in the 1987 sample), total phosphorus, and TSS (measured on in the 1984 sample) exceeded ASEPA water quality criteria (Table 25-3). The TSS level was 17 times higher than the median value of 5 mg/l specified by the ASEPA indicating stream conditions of very poor water quality. Higher total suspended solid levels often occur during periods of heavy rainfall and subsequent runoff to streams.

TABLE 25-3
MISCELLANEOUS WATER QUALITY MEASUREMENTS
FAGAALU STREAM

Water Quality Parameter								
Stream *Fagaalu*	TN (μg/l)	TKN (μg/l)	NO_3+NO_2 (μg/l)	TP (μg/l)	Turbidity (ftu)*	TSS (mg/l)	pH	Total Coliform (#/100 ml)
05/18/84	--	100	--	162	4.5	86	--	--
08/27/87	610	313	300	216	--	--	--	--

* Note: Use of ftu (Formazin units) rather than ntu now used to measure turbidity.

Source: ASEPA, 1996

Thirty-one water quality samples were collected between September 1984 and February 1991 at Fagaalu (AECOS, 1991). Median nutrient values derived from laboratory analyses of these samples (Table 25-4) indicate total nitrogen and total phosphorus levels that were in excess of ASEPA water quality criteria.

TABLE 25-4
NUTRIENT DATA
FAGAALU STREAM, SEPTEMBER, 1984-FEBRUARY, 1991

Station	Parameter		
	NO_3+NO_2 (μg/l)	*TN (μg/l)*	*TP (μg/l)*
Fagaalu	171	354	196

Source: AECOS, 1997

Soil Erosion Modeling of Pago Pago Harbor

Kennedy Jenks Chilton examined the impact of land use upon the loading of pollutants into Pago Pago Harbor in 1986. Field studies were made at six streams that discharge into Pago Pago Harbor in August and October, 1985. Subsequently, Kennedy Jenks Chilton modeled various land use scenarios to estimate existing and future sediment, phosphate, nitrogen, and BOD_5 loads into the Harbor.

It was estimated that 4,804 tons of sediment were being discharged into Fagaalu Bay and Pago Pago Harbor in 1985. The total nitrogen contribution was estimated to be roughly 47 tons while total phosphate loading was approximately 4.4 tons. The volume of biological oxygen demand was calculated to be 99.2 tons.

Wetlands

There are no wetlands in the Fagaalu watershed.

Marine Resources

Coral Communities

A fringing coral reef characterizes the nearshore waters of Fagaalu Bay. The reef extends from roughly 150 to 1,400 feet seaward of the shoreline. A large channel indents the reef seaward of the Fagaalu Stream mouth.

Various private consultants have made field investigations of the fringing reef since the late 1970's. In a cumulative sense, the available survey information provided suggests that:

- In early 1978, the crown-of-thorns starfish infestation of the coral reef front in Fagaalu Bay was considerably less than other locations around Tutuila.
- In 1995, coral coverage along the reef front was estimated to be between 20 percent and 39 percent coverage. Increased coral coverage along the reef front between 1994 and 1995 indicated a rapid recovery of the fringing reef that previously was impacted by Hurricane Val in 1991.

<u>1978-1979</u>

Rock outcrops along the channel margin, which is seaward of the Fagaalu Stream mouth, were largely devoid of corals.

Smaller colonies of corals represent about one percent of the bottom cover on the inner reef flat that is seaward of the southeastern end of Fagaalu Village. Between 80 and 250 feet offshore, coral coverage increased to 30 percent.

Seaward of this area, staghorn coral was observed along with clumps of soft coral. Between roughly 410 to 500 feet offshore, coral coverage on the bottom declined from 10 percent to less than 5 percent. Considerable live coral coverage, i.e., about 30 percent, was documented in the offshore area approximately 560 to 660 feet offshore.

In early 1978, infestation by the crown-of-thorns starfish was reported along the reef front seaward of Fagaalu. Marine biologists noted that the infestation in the outer Pago Pago Harbor area was considerably less than other locations around Tutuila. One local resident also mentioned to biologists that the only previous infestation occurred in the late 1920's (AECOS and Aquatic Farms, 1980).

During their observations of corals, marine biologists also noted that surface waters over the reef flat fringing the southwestern margin of Fagaalu Bay were especially clear. Underwater visibility was reported to be about 100 feet. In contrast, visibility reduced significantly on the mud flat near the Fagaalu Stream mouth. Visibility was only about 20 feet where underwater topography descended to the mid-bay channel.

1992

Field investigations were also made in Fagaalu Bay by Maragos, Hunter, and Meier in 1992. This team of marine biologists documented a coral coverage between one and five percent at a depth of six meters. At 18 meters in depth, coral coverage was observed to be less than one percent.

1995

A recent 1996 study of various coral reefs throughout the Samoan Archipelago included a survey of the reef front of Fagaalu Bay. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Coral coverage was estimated to be between 20 percent and 39 percent coverage. Coral colony sizes were observed to be small and medium in size.

Field results indicated that fish species richness ranged between 100 and 149 species. Fish density was estimated to be between 5,000 and 9,999 individuals per ha. Fish biomass was reported to be "low", or less than 500 kilograms per ha.

Shoreline Protection

The shoreline of Fagaalu Bay is afforded some protection by various natural and man-made features.

Between Tulutulu Point and Matafao Elementary School, the shoreline is primarily characterized by basaltic boulders. The boulders, which may have been installed with past road construction, does not represent an engineered revetment.

The shoreline that fronts Matafao School contains an engineered revetment structure that was constructed in 1984. This structure was designed by the U.S. Army Corps of Engineers.

A sandy beach extends between Matafao School and the southeast end of Fagaalu Park. An engineered revetment is generally located on the north side of the Fagaalu Stream mouth. Adjoining residences on the shoreline are also protected by grouted rock and concrete walls. Roughly 300 feet of the shoreline seaward of Fagaalu Park is stabilized with some basaltic rock to reduce potential shoreline erosion.

Basaltic rock and boulders are also located seaward of the primary shoreline roadway southeast of the urbanized village area. The boulders provide some protection to utility poles along the seaward side of the primary shoreline roadway.

In March 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following condition in the Pago Pago Harbor watershed that were determined to be "critical", or "potentially critical" :

Between Fagaalu Park and Niuloa Point

- Even though basaltic rocks and boulders have been place seaward of the primary shoreline roadway, some segments of the shoreline are characterized by scarp within five feet of the roadway.

During the May 1996 survey, Pedersen Planning Consultants observed one roadside culvert that transports storm runoff to the shoreline via a 3-foot culvert buried underneath the Park. Along the shoreline where the culvert reappears, there was evidence of significant shoreline erosion and loss of land.

Groundwater and Surface Water Supplies

Groundwater Supply

There is one groundwater well in the Fagaalu watershed that is used by ASPA in the operation of American Samoa's public water system on the Island of Tutuila (Table 25-5). This well is located on the west side of the hospital and is immediately adjacent to Fagaalu Stream.

TABLE 25-5
GROUNDWATER WELLS IN THE FAGAALU WATERSHED OPERATED BY ASPA

Pump Location	Well Number	Ground Elevation	Well Depth (feet)	Normal Discharge Rate (gpm)	Normal Head (psi)	Elevation Above Mean Sea Level
Fagaalu	127	20	120	200	34	-100

Source: ASPA, 1995

Groundwater Quality

ASEPA regularly monitors groundwater quality via the regular collection and analysis of groundwater well samples. Once completed, this information is transmitted to the ASPA Water Division for their review. Available groundwater quality data indicates no significant contamination of this groundwater source.

Surface Water Supply and Quality

Prior to 1972, the Territory of American Samoa relied exclusively upon surface water resources for its potable water supply. The Fagaalu intake along Matafao Stream was one of five surface water sources that served the Territory's centralized public water distribution system. Most villages had individual village water systems that relied upon local stream flows.

The Fagaalu intake, which is located about the 812-foot elevation, produced an average flow of 0.32 million gallons per day. It has a potential storage capacity of roughly 1.7 million gallons.

Proposed Water System Improvements

The draft ASPA Utilities Master Plan points out that a desirable operational objective is for ASPA to produce water in the same area that it is consumed. The operation and maintenance of extensive water transmission systems are costly. In the long term, the Master Plan recommends the drilling of exploratory wells in various areas of Tutuila. Where adequate yields are found, permanent groundwater wells are recommended for subsequent use. Fagaalu is noted as one location where significant amounts of potable water may be discovered. No specific location in the watershed is identified for this improvement. However, it is recommended that the well head of the exploratory well should not exceed 150 feet above mean sea level to accommodate drill rig limitations.

The draft Utilities Master Plan also includes recommendations to investigate the potential renovation and reactivation of the Fagaalu intake to ensure the availability of long-term, water storage requirements in the Pago Pago Harbor and east Tutuila areas.

USE OF THE WATERSHED

Resident Population

Between 1980 and 1990, the resident population of Fagaalu Village increased from 757 to 1,006 residents. Such growth represented an average annual growth rate of about 3.29 percent. Development activity between 1990 and 1995 increased resident population to about 1,253 persons.

Population trends reflected in the 1990 Census statistics suggest that considerable in-migration has occurred in Fagaalu between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 21 percent. Between 1985 and 1990, the proportion increased to 42 percent. In 1990, the proportion remained the same. These statistics suggest that Fagaalu has been significantly influenced by the in-migration of persons born outside of American Samoa and/or the out-migration of existing residents.

Land Uses

Residential

The 1990 U.S. Census documented 153 homes in the Fagaalu Village. Seventy-five percent of the homes were owner-occupied; 24 percent were rental units. Roughly one percent of the houses were vacant or were used by owners as vacation homes. ASG Building Division records indicate that 42 building permits were issued for new residential structures from 1990 through 1994. Consequently, the 1995 housing stock includes approximately 195 houses.

Residential development in Fagaalu has historically occurred along the north and south sides of Fagaalu Stream. Residential densities range between four and 13 housing units per acre along the Stream. Steeper slopes that rise above the north side of Fagaalu Stream also provide some existing housesites. This area is characterized by residential densities of about two units per acre.

Residential housing is also located upland of Fagaalu Park along Tutuila's primary shoreline road and adjoining steeper slopes. Steeper slopes in this area range from roughly 35 to 50 percent. However, the lower portions of these slopes contain smaller plateaus with considerably less slope where some 30 to 35 homes have been built. Residential densities in this area are approximately six homes per acre.

Agriculture

At least three piggeries were observed during a May 3, 1996 survey of the Fagaalu watershed. Two piggeries were located along Fagaalu Stream; a third was observed about 500 feet northwest of the hospital.

Two areas of *faatoaga* are located southeast of the inhabited village area. One of these areas is devoted to banana production.

Commercial

There are about 53 commercial enterprises that are based in Fagaalu Village. Several commercial retail facilities are located in one and two-story commercial buildings along the west side of Tutuila's primary shoreline road and Dr. Jim Turner Road. These facilities and other commercial enterprises within the village generally include two small bakeries, a laundromat, grocery and various retail stores. Most of these commercial facilities are based in commercial buildings Most commercial enterprises in the village are professional and retail services, e.g., attorneys and import/export companies, that are home-based occupations.

Industrial

A quarry operation is located Fagaalu between the 100 and 125-foot contour at the west end of the inhabited village area. This operation is owned and operated by Samoa Maritime. A company representative indicated in May, 1996 that this operation generates approximately 500 cubic yards of reject material per week. Heavier rainfall typically generates a discharge of turbid waters and some sediments into Fagaalu Stream.

Public Facilities

The LBJ Hospital complex represents the most significant land use within Fagaalu. This facility consumes approximately seven acres. The Hospital site is a former marsh area that was filled in the early 1960's to accommodate construction of the hospital.

Elementary school-age children attend Matafao Elementary School in Fagaalu. High school students travel to Samoana High School in Utulei.

Use of the Nearshore Waters

Recreational and Subsistence Fishing

A considerable use is made of the nearshore waters of the watershed for recreational and subsistence fishing. Fishing methods typically include use of rod and reel, hand lines, bamboo poles, gleaning, spear diving, throw nets, and gill nets. Available inshore creel survey data for the 1991-1993 period, which was collected by the ASG Department of Marine and Wildlife Resources, suggests that the primary fishing areas are the reef flats between Fagaalu and Fatamafuti.

In this area, the ASG Department of Marine and Wildlife Resources estimated between 9,100 and 12,000 hours of annual fishing activity in this area during the 1991-1993 period. Fishing methods typically included use of rod and reel, hand lines, bamboo poles, gleaning, spear diving, throw nets, and gill nets. DMWR creel survey data for the 1991-1993 period reveals that gleaning and spear diving are the two more popular methods of fishing on the reef flats between Fagaalu and Fatamafuti.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Future residential expansion in Fagaalu will probably include some limited infilling of about 22 potential housesites along the north and south sides of Fagaalu Stream. The continued construction of new homes on the steeper slopes on the north side of the valley will also occur on not more than five feasible sites. It is estimated that future single family residential expansion will include not more than 27 housing units.

It is believed that no further residential construction will occur upslope of Fagaalu Park. Expanded housing development on these steeper slopes will increase storm drainage that could cause significant damage to adjacent homes. These and other considerations will likely prompt reviewing ASG agencies to curtail any building permits in this area.

Other potential residential expansion in Fagaalu is feasible via the conversion of some single family housing to multi-unit apartments. As stated earlier, about 24 percent of the existing housing stock in Fagaalu is rental housing. Between 1995 and the year 2000, no significant demand for rental housing in Fagaalu is expected. However, once the Tafuna Plains area becomes more developed, Fagaalu and other residential areas closer to the Pago Pago Bay Area will become likely targets for increased multi-unit residential development. By the year 2015, it is believed that roughly 25 percent of the 1995 housing stock in Fagaalu will include multi-unit structures that contain an average of four units.

During the next 20 years, ASPA believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Fagaalu Village.

1996-2000 Seven new single family homes along the north and south sides of Fagaalu Stream between the 75-foot elevation.

Two new single family homes on the steeper slopes on the north side of the valley.

2001-2005 Five new single family homes along the north and south sides of Fagaalu Stream between the 75-foot elevation.

Three new single family homes on the steeper slopes on the north side of the valley.

The conversion of nine single family units to four-unit apartment buildings (27 new housing units).

2006-2010 Five new single family homes along the north and south sides of Fagaalu Stream between the 75-foot elevation.

The conversion of nine single family units to four-unit apartment buildings (27 new housing units).

2011-2015 Five new single family homes along the north and south sides of Fagaalu Stream between the 75-foot elevation.

The conversion of eleven single family units to four-unit apartment buildings (33 new housing units).

The cumulative effect of this prospective residential growth is that the Fagaalu Village housing stock will increase to roughly 309 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.49 persons per household, the future village population will include about 1,696 persons.

Commercial

A significant expansion of the existing commercial facilities in Fagaalu is not expected. The most promising commercial sites are along the shoreline road. The only vacant land includes an important village cemetery that would certainly not be appropriate for such development. Another potential expansion area is the existing quarry site should this operation be discontinued during the next 20 years.

Future commercial expansion within Fagaalu is expected to include the eventual renovation of existing commercial facilities and/or the replacement of existing commercial buildings with three and four-story buildings. It is believed that such renovations will provide additional commercial space that will include four new offices by the year 2000, two new commercial services during the 2001-2005 period, and three new commercial services between 2011 and 2015. Future offices are expected to include an average of three employees; future commercial services will employ an average of two persons.

Industrial

The potential life of Fagaalu's existing industrial operation is unknown. However, it is believed that this site will likely be redeveloped for commercial purposes if the quarry operation is discontinued.

Public Facilities

Expansion of the present hospital facility in Fagaalu is not expected. Structural defects associated with the Hospital were identified in the late 1980's. The potential repair of these defects and other desired facility improvements prompted the former Lutali Administration to explore the feasibility of developing a new medical complex in the Tafuna Plains area. However, a more recent U.S. Army Corps of Engineer study indicated that prior conclusions regarding the structural stability of the Hospital were misleading and that relocation was not required.

It is believed that the Hospital will remain in its present location during the 20-year planning period. In 1995, Mercy International estimated that the proposed hospital relocation would cost approximately $60 million.

Population characteristics for Fagaalu in 1990 suggest that approximately six percent of the population represented younger children three to four years of age. Approximately 20 percent of the population was of elementary school age (5 to 13 years of age) while 11 percent were high school age (14-18 years of age).

Application of these assumptions to anticipated future population suggests that Fagaalu will contribute the following estimated student enrollments to facilities outside of Fagaalu in the year 2015:

- early childhood education 102 students
- elementary school 339 students
- high school 187 students

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Fagaalu watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. Wastewater generation, for example, is expected to rise from about 107,394 gallons per day (gpd) to 191,139 gpd in the year 2015.

The consumption of potable water will also increase with a growing population. The American Samoa Power Authority (ASPA) estimates that the average day demand for water in Fagaalu was about 153,420 gallons in 1995. By the year 2015, ASPA anticipates that the average demand will increase to roughly 273,056 gpd

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of Fagaalu Stream.

Anticipated 100-Year Peak Discharges

The Federal Emergency Management Agency (FEMA) determined the drainage area and 100-year peak discharges for two streams in the Fagaalu watershed.

Calculations for Fagaalu Stream were made at the stream mouth and at its upstream study limit on the northwest side of the hospital. A 100-year peak discharge of 1,720 cubic feet per second (cfs) was estimated for the Fagaalu Stream mouth. Downstream of the Samoa Maritime quarry, the 100-year peak discharge was calculated to be 920 cfs.

Above the confluence of an unnamed tributary with Fagaalu Stream, the 100-year peak discharge was estimated to be 190 cfs.

The upland areas to the north, west, and south of Fagaalu Stream and Fagaalu Village have been designated by FEMA as “zone x.” This designation indicates that the area is outside the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in this area is limited.

Inland Flood Hazards

In general, flood profiles developed for the lower reaches of Fagaalu Stream suggest 100-year flood elevations that would range between 5 and 70 feet above MSL. Potential flooding can be expected between the Fagaalu Stream mouth and the hospital. Upstream of the hospital, FEMA estimates that some flooding could occur on both the east and west side of Fagaalu Stream.

Coastal Flood Hazards

The flood insurance rate map for Fagaalu Bay indicates that there is a coastal flood hazard along the nearshore waters and adjoining shoreline. A potential 100-year flood is estimated to generate a coastal flood elevation of approximately three feet above mean sea level (MSL).

Potential 100-year tsunami inundation elevations have also been estimated by the U.S. Army Corps of Engineers for the following shoreline locations:

- Shoreline at Niuloa Point (Point Distress) – 2.9 feet above mean sea level (MSL);
- Shoreline at Fagaalu (East) – 3.3 feet above MSL;
- Shoreline at Fagaalu (West) – 3.2 feet above MSL;
- Approximately 2,000 feet east along the shore from Fagaalu – 3.3 feet above MSL;
- South Shore of Tulutulu Point – 3.3 feet above MSL.

Most all of Fagaalu Village is set back a considerable distance from the shoreline at elevations well above the potential tsunami elevations. Four homes near the mouth of Fagaalu Stream and seaward of the primary shoreline roadway are situated between three and five feet above sea level. Consequently, a 100-year tsunami may generate damage to residential structures in this area.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Available water quality data and other water quality evaluations of Fagaalu Stream indicate a long-term degradation of surface water quality in the watershed. This degredation represents elevated levels of nutrients, total suspended solids, and turbidity.

Potential Sources of Nutrients and Sediments

There are a number of potential sources of nutrients and sediments that impact the water quality of Fagaalu Stream and the nearshore waters in Fagaalu Bay.

- Steeper, upland slopes that drain into Fagaalu Stream carry silt-laden runoff during and following periods of heavier rainfall.
- The Samoa Maritime quarry operation, which is situated inland and upslope of the urbanized Fagaalu Village area, regularly discharges turbid drainage into Fagaalu Stream. The Samoa Maritime Quarry generates about 500 cubic yards of reject material per week. Heavy rains transport turbid waters and sediments into Fagaalu Bay.
- At least two piggeries are located immediately adjacent to Fagaalu Stream that discharge nutrient-enriched wastewater into Fagaalu Stream.
- Impermeable surfaces in the developed portions of the lower watershed generates a considerable amount of urban runoff in the watershed. A significant proportion of this runoff drains to Fagaalu Stream.
- The residential and commercial area southwest of Fagaalu Park contains steeper slopes upslope of the primary roadway that generate considerable storm runoff. A 36-inch underground culvert also carries a portion of the urban runoff from this area to the nearshore waters adjacent to Fagaalu Park. The natural swale located in Fagaalu Park provides an excellent infiltration area. However, surface runoff cannot effectively reach this area because of curbing around the large vehicular parking area.
- Two *faatoaga* on the steep slopes in the southwest part of the watershed likely generate some turbid runoff during and following heavier rainfall periods.

Potential Opportunities for Stormwater Detention

Existing development patterns and the configuration of the watershed limit potential options for the detention of stormwater flows into Fagaalu Stream and Fagaalu Bay. A greater use of Fagaalu Park for the detention of stormwater flows might be accomplished through a combination of improvements:

- the elimination of curbs around the vehicular parking areas in Fagaalu Park; and,
- the expansion of an existing swale along the southwest side of the Park.

The use of onsite drywells in new commercial facilities throughout the watershed would enable some filtering of stormwater into the local substrata. The proximity of these areas to the shoreline would, in most cases, not generate any recharge to the basal aquifer.

Constructive discussions need to occur between Samoa Maritime and ASEPA to determine a prudent and feasible course of action that will lead to the reduction or elimination of sediment discharges into Fagaalu. Constructive discussions should consider various options ranging from potential relocation to other practical onsite measures that could be incorporated into quarry operations.

Nearshore Water Quality and the Marine Environment

The long-term input of nutrient-enriched and turbid waters into Fagaalu Bay represents an important concern. These inputs are potential detrimental to the quality and composition of the nearshore marine environment. However, the degree of impact upon water quality is also highly dependent upon currents and water exchange within Fagaalu Bay.

Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of Fagaalu Bay. They provide shelter to fish, invertebrates, and other marine organisms, as well as a supplemental food source for some residents of the watershed and other nearby villages.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Fagaalu watershed will be to:

- Reduce turbid, nutrient-enriched discharges into Fagaalu Stream.
- Where feasible, detain a portion of the stormwater runoff from the steeper residential and commercial areas in the southwest part of the watershed.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with a designated resident of Fagaalu, and encourage the village's implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 25-6. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 25-6
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
FAGAALU WATERSHED

Participating Public agency	Resource Management Objective	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASEPA	Monitor changes in water quality of Fagaalu Bay	Continue water quality monitoring program at the existing long-term monitoring station in the Fagaalu Bay.
ASEPA	Monitor long-term discharge of sediments and nutrient loading into Fagaalu Bay via Fagaalu Stream.	Monitor nutrient and sediment levels at the mouth of Fagaalu Stream.
ASEPA	Reduce nutrient and sediment contribution to Fagaalu Bay	1. Investigate feasible methods of detaining turbid discharges from reject quarry material generated from Samoa Maritime quarry operation. 2. Discuss potential options with Samoa Maritime that lead to onsite detention or possible relocation.
ASEPA	Investigate the feasibility of drainage and stormwater improvements in Fagaalu Park. Develop potential opportunities to increase stormwater detention within Fagaalu Park.	1. Make required field investigations and coordinate potential plans with the village council in Fagaalu. 2. Prepare conceptual site plans and order-of-magnitude cost estimates. 3. Where feasible, prepare detailed design and construction drawings. 4. Secure funding and build improvements.
ASEPA	Detain stormwater runoff in future residential and commercial areas.	1. Require the use of onsite drywells for all new commercial facilities. 2. Require the use of onsite drywells for all new residential construction on steeper slopes of the watershed.
ASDOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
ASG Dept. of Public Works	Maintain stormwater culverts along the primary shoreline roadway, Jim Turner Drive, and shoreline discharge points.	1. Establish a periodic maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Maintain all culverts along the primary shoreline roadway.
ASG Dept. of Marine and Wildlife Resources	Restore healthy marine communities in the waters of Fagaalu Bay.	1. Monitor and quantify changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) along the fringing reef front approximately every three years. 2. Identify stresses upon coral communities and marine life.

Source: Pedersen Planning Consultants, 1998

MATUU
Watershed 26

GEOGRAPHY

The Matuu watershed is located west of Tutuila's Pago Pago Harbor area. The watershed comprises about 1.0 square mile of land area (Figure 26-1).

The inland boundaries of the Matuu watershed include the peak of Matafao Mountain, Matafaofafine Peak, Sina Ridge, and Amaile Ridge. Fafiga Peak, which is located at about the 1,549-foot contour, is situated downslope of Matafao Peak in the northern part of the watershed.

Along the shoreline, the watershed extends between Niuloa Point (north of Fatamafuti) and Amaile Ridge which is situated northeast side of Nuuuli Village. A small unnamed embayment fronts Matuu Village. Three small coves lie between Mataae Point and the seaward face of Amaile Ridge. One of these coastal indentations is Nuuosegi Cove which is located seaward of Amaile Ridge.

There are six streams in the watershed. These streams include Sina Stream, one unnamed stream (Stream 26A), Afuelo Stream, Afu Stream, Utulaina Stream, and Auau Stream.

The Matuu watershed includes the villages of Fatamafuti, Matuu, and Faganeanea. Other residential areas include Tagapofu, Vasaaiga, Avau, and Oneoneloa. Historically, one or more of these residential areas may have once represented a separate traditional village

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 26-2). Three soil classifications were identified by the U.S. Soil Conservation Service for lands within the Matuu watershed (Table 26-1).

TABLE 26-1
SELECTED SOIL CHARACTERISTICS
MATUU WATERSHED

						Soil Depth To:		Land Use Suitability	
SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	HighWater (feet)	Bed Rock (inches)	Soil Based WW Treatment	Subsistence Ag. Potential
2	Aua very stony silty clay loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
34	Urban land-Aua-Leafu complex	0-30	A.None L.Occ	A.Slow to Med	A.Slight to Mod L.Slight	A.>6 L.3-5	>60	Severe A.Slope L.Flood Wet	Limited

Notes:
1. A.= Aua- found on mountain foot slopes 6-30 percent
2. L.= Leafu- found on coastal plains & valley floors 0-6 percent

Source: U.S. Soil Conservation Service, 1984

American Samoa Geographical Information System

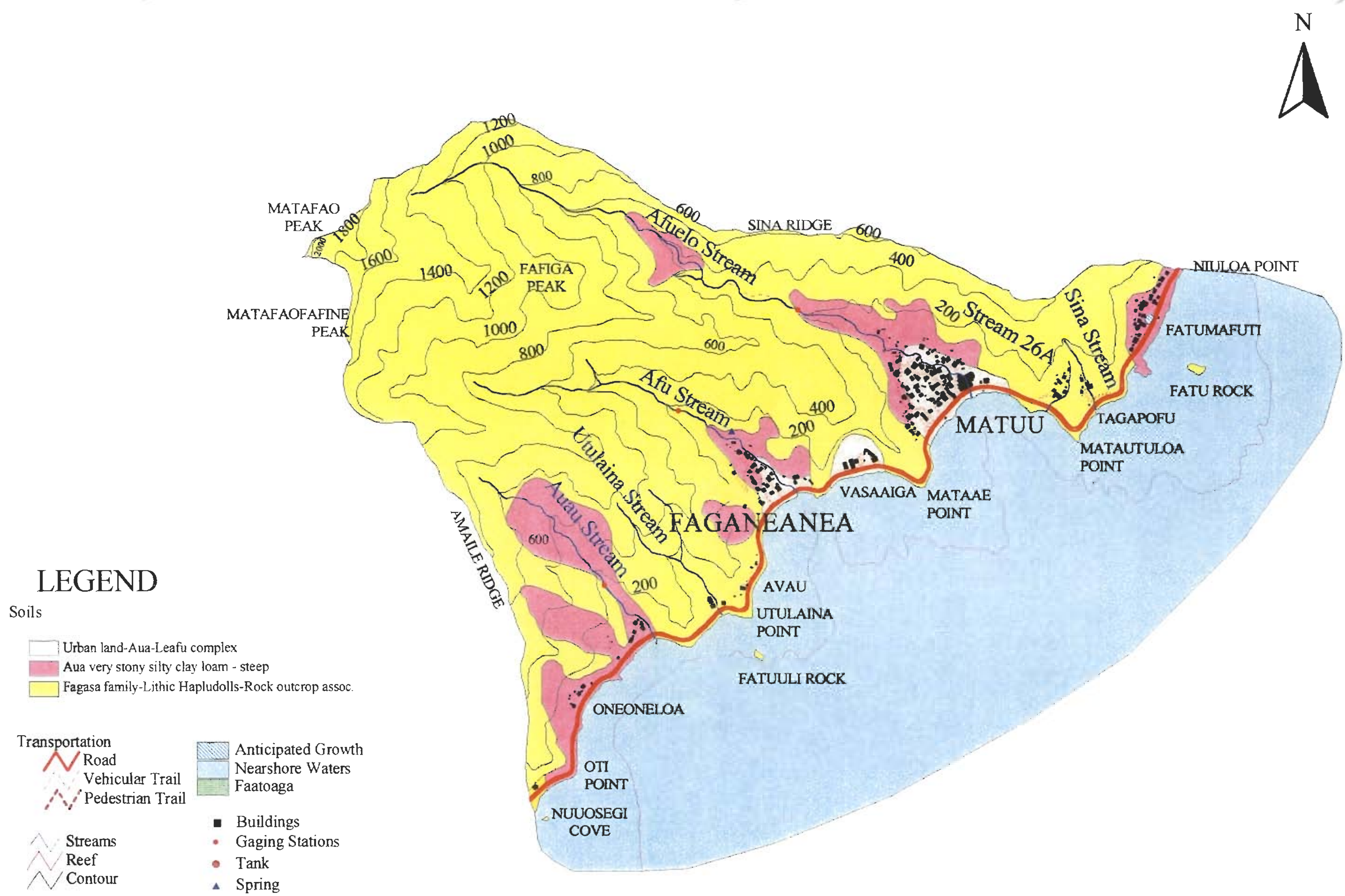
Scale: 1:18,000

Prepared by: Pedersen Planning Consultants   Tel: 307-327-5434

Matuu Watershed Existing Conditions

26

Figure 26-1



American Samoa Geographical Information System

0.5 | 0 | 0.5 | 1 | 1.5

Miles

Scale: 1:18,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Matuu Watershed 26

Management Issues

Figure 26-2

Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

Urban Land-Aua-Leafu complex soils (SCS mapping unit 34) are found in most of the inhabited portions of Matuu, Vasaaiga, and the seaward half of Faganeanea.

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. The soil has limited to moderate potential for runoff. The erosion potential is considered to be slight to moderate (U.S. Soil Conservation Service, 1984).

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, do not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and other soil-based treatment systems in Matuu, Vasaaiga, and Faganeanea may be making a contribution of nutrients and bacteria into the nearshore waters of the watershed.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

Many of the steeper slopes of the lower watershed, between the shoreline and the 600-foot elevation, contain Aua very stony silty clay loam soils (SCS mapping unit 2). These soils are also situated in the steeper slopes of the inhabited village areas of Fatamafuti, Matuu and Faganeanea.

The Aua soils range between seven to 60 inches in depth. The permeability of these soils (between 2 and 6 inches per hour) is moderately rapid. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that hamper installation and provide inadequate soil treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes. The potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

There are six streams in the Matuu watershed.

Sina Stream and an unnamed stream (Stream 26A) are short streams that flow on the east and west sides of Matautuloa Point.

Four streams drain the east and southeast slopes of Matafao Peak, Matafaofafine Peak and Fafiga Peak:

- Afuelo Stream;
- Afu Stream;
- Utulaina Stream; and,
- Auau Stream.

Afuelo Stream is long for an unbranched stream that originates at about 1,350 feet elevation. Afuelo Stream flows through Matuu Village before its discharge into the nearshore waters.
Afu Stream begins at approximately 750 feet above mean sea level. This stream course flows through Faganeanea and is the only stream discharge along the village shoreline.

Utulaina Stream and one tributary originate at about the 525-foot contour. Auau Stream generally parallels Utulaina Stream but begins slightly higher at about the 580-foot elevation. Both streams drain surface runoff from the southeast slopes of Matafaofafine.

Stream Flows Within the Watershed

A continuous-record stream gage (No. 16948000) was maintained 0.3 mile upstream from the mouth on Afuelo Stream between 1958 and 1990. Measurements from the 1973-1990 period enabled the U.S. Geological Survey to estimate a median of 0.30 cubic feet per second (cfs) for this 17 year period (Wong, 1996).

Between 1958 and 1976, a low-flow, partial-record station (No. 16947000) was operated on Afu Stream, approximately 0.3 mile upstream from the stream mouth. Available records provided 20 measurements of stream flow. A median flow of 0.17 cfs was estimated by the U. S. Geological Survey for this location (Wong, 1996).

A low-flow, partial-record station (No. 16946000) was established on Avau Stream, about 0.2 mile upstream from the stream mouth, between 1959 and 1976. Eighteen measurements of stream flow enabled U.S. Geological Survey to estimate a median of 0.23 cubic feet per second (cfs) for the 17 year period (Wong, 1996).

Surface Water Quality

Streams

Three water quality samples were collected at Afuelo Stream in 1970 and 1971 (STORET, 1996). Total coliform levels were elevated on sampling days in August and September, 1970 (Table 26-2). Elevated coliform levels could have been derived from a variety of sources. Elevated coliform levels probably represented the cumulative effect of cesspool discharges, wastewater from village piggeries, or other contaminated sources in Matuu Village and/or other adjoining residential areas.

TABLE 26-2
MISCELLANEOUS WATER QUALITY DATA
AFUELO STREAM
1970-1971

	Water Quality Parameter							
Stream *Afuelo*	**TN** (μg/l)	**TKN** (μg/l)	**NO_3+NO_2** (μg/l)	**TP** (μg/l)	**Turbidity** (jtu)**	**TSS** (mg/l)	**pH**	**Total Coliform** (#/100 ml)
08/04/70	--	--	nd*	--	2.0	--	7.20	3,100
09/13/70	--	--	nd*	--	4.0	--	6.80	11,000
10/12/71	--	--	nd*	130	nd*	--	6.60	--

*nd = not detectable ** note use of jtu (Jackson units) rather than ntu now used to measure turbidity.

Source: ASEPA, 1996

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila on July 25 and August 2, 1992 (Table 26-3). The samples were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the waters seaward of Faganeanea met American Samoa water quality standards in late July and early August of 1992. Laboratory results also suggest that stormwater runoff from undeveloped lands upland of these embayments do not generate any significant discharge of nutrients.

TABLE 26-3
SURFACE WATER QUALITY
OUTER SHORES NEAR FAGANEANEA
JULY-AUGUST, 1992

Sample Depth	Nitrate/ Nitrite mg N/l	Total N mg N/1	Kjeldahl N mg N/l	Total P mg P/l	CHL a mg/m^3
3 feet	0.004	0.162	0.158	0.017	0.13
60 feet	<0.001	0.128	0.128	0.008	0.19

Source: ASEPA, 1992

Wetlands

There are no significant wetlands in the Matuu watershed.

Marine Resources

Coral Communities

A fringing reef is located in the nearshore waters that front the Matuu watershed.

Offshore of Niuloa Point, the reef extends almost 900 feet seaward of the shoreline. Immediately seaward of the villages of Matuu and Faganeanea, the fringing reef extends between 250 and 300 feet inside coves and one embayment. Outside of these areas, the width of the fringing reef ranges 800 to about 1,300 feet offshore between Mataae Point and Nuuosegi Cove.

Various private consultants have made field investigations of the fringing reef since the late 1970's. In a cumulative sense, the available survey information provided suggests that:

- A heavy infestation of the crown-of-thorns starfish was present in the nearshore waters of the Matuu watershed during the late 1970's.
- The abundance of corals in the vicinity of Fatu Rock remained stable between 1982 and 1988; coral cover generally increased.
- Results from the 1995 survey indicated that coral coverage seaward of Fatamafuti was generally comparable to coral coverage observed between 1982 and 1988.

<u>1978-1979</u>

In December 1977, 75 to 90 percent of the live coral on the reef flats between Nuuuli and Pago Pago Harbor were destroyed by the crown-of-thorns starfish. By early 1978, most of the reef flat between Nuuuli and Fatamafuti was heavily infested by the starfish. The starfish was also observed on the reef front seaward of the infested reef flats; however, corals were largely undamaged (Aecos and Aquatic Farms, 1980).

Low coral cover was documented seaward of Fatamafuti Village. In May 1978, the crown-of-thorns starfish was not observed on the reef front seaward of Fatamafuti Village. However, numerous feeding scars were evident at depths of 66 to 75 feet (Aecos, Aquatic Farms, 1980).

On the inner reef flat west of Matautuloa Point, coral coverage was about 50 percent on the bottom of a depression.

An *ava* is located seaward of the Vasaaiga area. Coral cover increased toward the margin of the *ava*; however, total cover coverage did not exceed 10 percent.

Seaward of Faganeanea Village, a few unattached coral heads were scattered on the inner reef flat within 80 feet from shore. Marine biologists concluded that the presence of unattached coral heads provided evidence of a shoreward transport by waves.

The crown-of-thorns starfish was observed along the reef front seaward of Faganeanea Village in May 1978. Numerous feeding scars on the corals were reported at depths of 43 to 66 feet. However, most coral at these depths appeared to have been killed at an earlier time (Aecos and Aquatic Farms, 1980).

South of Utulaina Point, live coral cover was reported to be about five percent in 1979 about 40 feet from shore. Between 80 and 165 feet from shore, total coral coverage increased to approximately 15 percent (Aecos and Aquatic Farms, 1980).

In a nearshore depression northeast of the old causeway in Nuuosegi Cove, coral coverage ranged between 5 and 25 percent. Coral coverage on the middle reef was considered "patchy" and ranged from 10 to 50 percent.

On the irregular limestone that formed the transition between middle and outer reef area, coral cover ranged from 30 to 60 percent. The reef margin was characterized by a coral cover up to 10 percent.

1982, 1985, and 1988

During the month of April in 1982, 1985, and 1988, Birkeland and Randall investigated the coral communities seaward of Fatamafuti in the vicinity of Fatu Rock. Survey transects were made at a depths of 6-10 feet, as well as 20 feet.

Field survey data indicated generally stable coral abundance and increased during the 1982-1988 period. Coral coverage at 6-10 feet was reported to be 17 percent in 1982, increased to 61 percent in 1985, and declined to 30 percent in 1988. Coral coverage at the 20-foot depth was observed only in 1988 when coverage was reported to be 23 percent in 1988 (Birkeland, Randall, and Amesbury, 1990).

1992

Field investigations were also made in the nearshore waters seaward of Faganeanea, Matuu, and Fatamafuti by Maragos, Hunter, and Meier in 1992. The fringing coral communities in these areas were considered by these marine biologists to be healthy.

At Fatamafuti, the coverage of live stony corals was less than one percent at a depth of six meters. At 18 meters, live stony coral coverage increased to five percent.

In the nearshore waters seaward of Togapofu, live stony coral coverage was documented to be 30 percent at 18 meters.

The percentage of live stony corals off of Faganeanea Village was determined to be less than one percent coverage at 6 meters. Coral coverage ranged between 5 and 10 percent at 18m.

1995

A recent 1995 survey of various coral reefs throughout the Samoan Archipelago included a survey of the reef front seaward of Fatamafuti Village. Field surveys in the vicinity of Fatamafuti consisted of five transects between Fatu Rock and Niuloa Point. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

With respect to fish communities and habitat characteristics, fish species richness was documented to include between 100 to 149 species. Fish density was observed to be contain between 5,000 and 9,999 individuals per ha. Fish biomass represented between 500 and 999 kilograms per ha. Coral coverage ranged 20 and 39 percent.

Wildlife Resources

A small colony of the uncommon sheath-tailed bat may roost in a cave near Mataae Point near Matuu Village.

Fatu and Futi Rocks near the Village of Fatamafuti also may represent seabird habitat. A small colony of reef herons and the common white tern may nest on Fatu Rock. The blue-grey noddy may also roost and nest on Fatu and Futi Rocks (Aecos and Aquatic Farms, 1980).

Shoreline Protection

Since 1978, considerable shore protection has been constructed along most of the shoreline that fronts the watershed's three villages. These improvements have included engineered revetments, as well as home-made basalt walls filled with gunite.

In 1997-1998, most of the shoreline of the Matuu watershed between Matululoa Point and Utulaina Point was again protected by a new engineered revetment that is comprised by armor stone and an outer layer of small concrete bags.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

The villages in the Matuu watershed rely upon a potable water supply that is supplied by the American Samoa Power Authority. There are no groundwater wells in the watershed that are used by ASPA for the production of ground water

Surface Water Supply and Quality

Prior to 1972, the Territory of American Samoa relied exclusively upon surface water resources for its potable water supply. Most villages had individual village water systems that relied upon local stream flows or springs.

In 1987, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. Two systems were identified in the Matuu watershed.

Matuu

In April, 1986, a concrete stream catchment was documented in Matuu along Afuelo Stream. The stream catchment was located at about the 160-foot elevation; a storage tank was situated near the 50-foot contour. The distribution system served the Village of Matuu and was characterized by numerous leaks. It is unknown whether or not this system remains in use.

Historical data suggests from the 1981-1986 period indicates that this system contained significant coliform contamination. A median of greater than 80 coliforms per 100 milliliters was documented during this period.

Faganeanea

A second village water system served Faganeanea. This system was supplied by a spring at about 100 feet above mean sea level. Water was stored in a storage tank at about the 50-foot elevation. It is unknown whether or not this system remains in use.

Historical data suggests from the 1981-1986 period indicates that this system contained significant coliform contamination. A median of greater than 80 coliforms per 100 milliliters was documented during this period.

Avau

During the April, 1996 survey, one resident of Avau reported that some residents in this village use a stream catchment for potable supply. It is believed that a third surface supply may be located along Auau Stream that originates upland of the Village.

Proposed Water System Improvements

In its draft Utilities Master Plan, ASPA proposed no facility or system improvements that would be constructed in the Matuu watershed.

USE OF THE WATERSHED

Resident Population

Fatamafuti

Between 1980 and 1990, the resident population of Fatamafuti Village increased from 76 to 81 residents. Such growth represented an average annual growth rate of about 0.66 percent. Development activity between 1990 and 1995 increased resident population to about 107 persons.

Population trends for Fatamafuti reflected in the 1990 Census statistics suggest that some in-migration occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 37 percent. Between 1985 and 1990, the proportion increased to 56 percent. In 1990, the proportion declined to 33 percent.

Matuu

Between 1980 and 1990, the resident population of Matuu Village increased from 239 to 364 residents. Such growth represented an average annual growth rate of about 5.23 percent. Development activity between 1990 and 1995 increased resident population to about 546 persons.

Faganeanea

Between 1980 and 1990, the resident population of Faganeanea Village declined from 191 to 168 residents. This represented an average annual decline in growth of about 1.2 percent. However development activity between 1990 and 1995 increased resident population to about 248 persons.

The general Census boundaries for Faganeanea also include the smaller residential area known as Vaiaaga.

Land Uses

Residential

Fatamafuti

The 1990 Census documented 11 houses in Fatamafuti. Roughly 82 percent of them were owner-occupied; the remaining 18 percent were rental houses. ASG Building Division records indicate that four building permits for new residential structures were issued during the 1990-1994 period. Consequently, the housing stock in 1995 comprised about 15 single family homes.

Matuu

In 1990, Matuu Village contained 59 houses. Seventy-one percent were owner-occupied; 25 percent of the houses were rental units. Roughly four percent were vacant or used as a vacation home by absentee owners. Between 1990 and 1995, 29 new homes have been constructed (ASG Economic Development Planning Office, 1994). Consequently, the housing stock in 1995 represented about 88 housing units.

Faganeanea

The 1990 Census documented 25 houses in Faganeanea Village. About 68 percent were owner-occupied; 24 percent were rental housing units. The remainder of the houses in Faganeanea were vacant and possibly used by absentee owners for vacation purposes.

Ten new residential building permits were issued in Faganeanea Village between 1990 and 1995. Consequently, the 1995 housing stock included about 35 single family homes.

Residential housing continues to be concentrated in the main Faganeanea village area. Secondarily, several homes are scattered near Utulaina Point along the shoreline and adjoining mountain slopes. One two-story apartment building is located in the Vasaaiga area.

Agriculture

In April 1996, one piggery was documented on the southwest side of Matuu Village.

Some agricultural production was observed in the upland areas above Avao in April, 1996. Few *faatoaga* were documented near other inhabited village areas. The lack of agricultural production in these areas is likely due to the presence of steeper slopes and highly erosive soils that are generally not suitable for subsistence crop production.

Commercial

Fatamafuti

There is one commercial operation based in Fatamafuti. This enterprise is the Chicken Out fast-food operation. Two additional fast-food operations in the Village at the same site recently closed.

Matuu

There are seven commercial enterprises that are based in Matuu. Three of these businesses are owned by Aveina Brothers, Inc. which own and operate a bakery and grocery store, as well as a related wholesale import and distribution business. Other commercial operations in the community include a seafood market, a second grocery store, a retail store, an appliance store and repair business, and two commercial taxi operations.

Faganeanea

There are five commercial enterprises that are based in Faganeanea. These enterprises include a construction company, a shipping agent, a marine commission agency, a financial consultant, and one bus company.

In the Vasaaiga area, five automotive repair businesses are based in close proximity. It is evident that general automotive repair entrepreneurs refer clients to adjacent auto painting and engine repair specialists who work in the same area.

Industrial

No light industrial activities are based in the Matuu watershed.

Public Facilities

The ASG Department of Education does not offer an early childhood education (ECE) program in Fatamafuti. Elementary school students attend Matafao Elementary School in Utulei. High school students attend Samoana High School in Utulei.

No public schools, dispensaries, or other public facilities are located in Matuu. One Early Childhood Education program is coordinated in Matuu. Like other ECE programs in American Samoa, this public program utilizes the village guest *fale* or a private home. The September, 1994 ECE enrollment in Matuu was 26 students, and included children from other nearby villages.

Elementary students from Matuu attend nearby Matafao School in Utulei, while high school students are transported to Samoana High School.

No public facilities are located in Faganeanea. Village students in elementary school level attend Matafao Elementary in Utulei. High school students attend Samoana High School in Utulei.

Village Facilities

One privately-owned school is situated in Fatamafuti Village. South Pacific International Christian Center, which serves preschool children through grade one, is located in the existing shoreline residential area. Student enrollment for this facility in September, 1994 was 101 students. This enrollment included 53 preschool children, as well as 48 students in Kindergarten and first grade.

Use of the Nearshore Waters

Recreational and Subsistence Fishing

A considerable use is made of the nearshore waters of the watershed for recreational and subsistence fishing. Fishing methods typically include use of rod and reel, hand lines, bamboo poles, gleaning, spear diving, throw nets, and gill nets. Available inshore creel survey data for the 1991-1993 period, which was collected by the ASG Department of Marine and Wildlife Resources, suggests that the primary fishing areas are the reef flats between Fatamafuti and Fagaalu, as well as Matuu.

In the Fatamafuti-Fagaalu area, the ASG Department of Marine and Wildlife Resources estimated between 9,100 and 12,000 hours of annual fishing activity during the 1991-1993 period. Annual fishing activity in the Matuu area ranged between 2,800 and 6,100 hours.

DMWR creel survey data for the 1991-1993 period reveals that gleaning and spear diving are the two more popular methods of fishing on the reef flats Fatamafuti-Fagaalu area. These same methods, as well as the use of rod and reels, are also popular with those persons fishing at Matuu.

Other Shoreline Recreation

The nearshore waters of the watershed are also regularly used for swimming, wading and general water recreation. In April, 1996, for example, about 20 persons were observed playing in the waters by Fatu Rock in Fatamafuti on a Saturday afternoon. Another eight persons were playing in the waters on the reef flat at Faganeanea on a Sunday afternoon; one of these persons was diving.

The nearshore waters are occasionally used for board surfing. Some surfers ride waves seaward of the Vasaaiga area at Faganeanea, and use the current in the ava to reach the offshore surf break. Others surf near Fatuuli Rock (seaward of Utalaina Point) or offshore of Nuuosegi Cove. More favorable surfing conditions take place between November and March, or when calm or northwest conditions occur during a rising tide (Aecos and Aquatic Farms, 1980).

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

<u>Fatamafuti</u>

Onsite observations of Fatamafuti Village in October, 1994 indicate that no land area is available within the existing shoreline residential area between Niuloa Point and Fatu Rock. The last remaining building sites were developed during the 1990-1994 period.

One additional home in Fatamafuti Village could be built at the rear of the existing small valley west of Matautuloa Point. Additional development in the valley is unfeasible because of steep slopes. Developable lands have already been built upon. It is believed that the remaining potential housesite, which is situated between the 75 and 100-foot elevation, will be developed for a single family home between 1996 and the year 2000.

From 2001 through 2015, no residential expansion is expected in Fatamafuti Village except for potential home replacements, additions, or renovations. The cumulative effect of this prospective residential growth is that the housing stock will increase to 16 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.10 persons per household. Consequently, the 2015 village population will include about 98 persons.

Matuu

The latest surge in residential construction has almost exhausted the supply of developable land for future residential expansion within Matuu. Onsite observations of the Village in October, 1994 suggest that not more than five developable housesites exist on the moderate slopes upland of the Village. It is believed that these potential sites, which are situated between the 75 to 100-foot elevation, will be developed between 1996 and the year 2000. In addition, there is one vacant house on the east end of the village (adjacent to the primary roadway) that will be occupied during the 1996-2000 period.

The cumulative impact of anticipated residential growth in Matuu during the 1996-2015 period will be the expansion of the village housing stock to include 94 homes by the year 2015. Assuming the average household size decreases to approximately 5.3 persons per household, the village population in 2015 will be about 498 persons.

Faganeanea

Onsite observations of Faganeanea Village in November, 1994 and a careful review of 1990 topographic conditions suggest that not more than five housesites remain on the slopes upland of the main village. Such housing is feasible between the 50 and 75-foot elevation. An additional apartment building could also be developed on vacant land on the west side of the existing apartment unit in Vasaaiga.

Between 1996 and the year 2000, five single family homes are expected to be built on the slopes upland of the main Faganeanea village area between 50 and 75 feet above mean sea level. It is also envisioned that a second apartment building, containing 8 units, will be built between 2001 and 2005.

The cumulative effect of this prospective residential growth is that the housing stock will increase to roughly 48 housing units in the year 2015 within Faganeanea. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.05 persons per household. The future village population will include about 290 persons.

Commercial

The construction of additional commercial facilities within Fatamafuti is not foreseen in light of the lack of vacant, developable land. It is also assumed that no residential structures will be demolished to accommodate additional commercial facilities.

The lack of developable land within Matuu will discourage future commercial facility expansion. One vacant commercial building on the east end of the village will permit one additional business to be established during the 1996-2000 period.

Future commercial enterprises in this community will have to be home-based operations in Faganeanea since no additional land is available for commercial construction. Consequently, the construction of no new commercial facilities is anticipated during the 1996-2015 period.

Industrial

No new construction of industrial facilities are anticipated in Fatamafuti or Faganeanea during the 1996-2000 period. The lack of developable land will discourage such development.

A few operations may be established in Matuu in the future as home-based occupations. Otherwise, there is no land area available for the construction of any industrial facility in the Village. Consequently, no industrial facilities are expected to be developed during the 1996-2015 period.

Public Facilities

The lack of available land will discourage the future development of public facilities in Fatamafuti, Faganeanea, and Matuu. Consequently, the development of new public facilities is not anticipated during the 1996-2015 period.

Through the application of 1990 age characteristics to anticipated village populations in the year 2015, the general demand for future early childhood programs, elementary education, and high school education was quantified (Table 26-4). These demands may generate the future development of expanded public school facilities outside the Matuu watershed.

TABLE 26-4
POTENTIAL DEMAND FOR PUBLIC SCHOOL FACILITIES
YEAR 2015
MATUU WATERSHED
(NUMBER OF STUDENTS)

Village	Early Childhood	Elementary	Secondary
Fatamafuti	86	360	172
Matuu	17	100	60
Faganeanea	17	58	35

Source: Pedersen Planning Consultants, 1995

Village Facilities

No expansion of the facility in Fatamafuti is anticipated even though substantive demands are present on Tutuila for educational opportunities at private schools. The lack of developable land represents the primary constraint.

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Matuu watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 26-5 and 26-6).

TABLE 26-5
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
MATUU WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Fatamafuti	5,575	8,684
Matuu	20,883	55,653
Faganeanea	5,654	26,413

Source: Pedersen Planning Consultants, 1997

TABLE 26-6
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
NUUULI PALA WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Fatamafuti	3,903	6,079
Matuu	14,618	38,957
Faganeanea	3,958	18,489

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. No detailed study was made of the nearshore waters and adjoining shoreline in the Matuu watershed.

Inland Flood Potential

The flood insurance rate maps for the Matuu watershed indicate that all lands have been designated by FEMA as "zone x." This designation indicates that these areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in the watershed is limited.

Coastal Flood Hazards

There is a coastal flood hazard along the entire shoreline and nearshore waters of the watershed. A potential 100-year flood is estimated to generate flood levels in this area of three feet above mean sea level (MSL). Since all inhabited village areas are situated above the 10-foot contour, the potential flooding of residential and commercial buildings is not expected from a 100-year flood condition.

The U.S. Army Corps of Engineers has also estimated a potential tsunami elevation of 2.9 feet above mean sea level for Niuloa Point. Because most residences are above the 10-foot contour line, potential inundation from a 100-year tsunami event will probably not generate any significant structural damage to residential and commercial buildings.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Stormwater runoff from steeper upland slopes is the primary source of sediment discharge into local streams of the watershed. Storm runoff drains into upland stream courses. Steeper stream gradients quickly carry transport turbid stormwater flows to the nearshore waters. Limited coastal plains virtually eliminate any potential opportunities for stormwater detention.

There is one opportunity for infiltration and a detention pond adjacent to a village drainage canal at Fatamafuti. This area is adjacent to the South Pacific International Christian Academy. This area could be used to detain some sheet runoff from upland slopes behind the village. However, the location of this area would negate any opportunities to detain flows from any nearby stream discharges.

In Avao, the steep watersheds generate intermittent, turbid storm flow via Auau Stream. A culvert below the roadway discharges storm runoff into the nearshore waters. In April, 1996, a low flow condition was observed. During this condition, stream discharges are filtered somewhat as discharges flow into a sandy beach area. During higher flows, this filtering probably does not occur.

Utulaina Stream carries storm flow through the east part of Avao. The box culvert under the road contained debris comprised of rock and sticks. A discharge of grey water from one home into Utulaina Stream was also observed in April, 1996.

Nearshore Water Quality and the Marine Environment

Nearshore water quality adjacent to the watershed is primarily influenced by the discharge of turbid waters and sediments from local streams.

A nutrient contribution is also occurring through the continued use of septic tanks, cesspools, or other soil-based, wastewater treatment systems in the watershed. Some bacterial contamination from these discharges may also be occurring in the nearshore waters. While the total volume of wastewater generation from the watershed is limited, the discharges are concentrated in four of five residential areas where housing densities are higher. Local soils are generally inadequate to provide effective treatment. Consequently, the exposure of bacteria to saline, marine waters probably provides the best treatment for wastewater effluent that reaches the nearshore waters.

The long-term input of turbid and nutrient-enriched waters into the nearshore waters represents an important concern. These inputs are potential detrimental to the quality and composition of the nearshore marine environment. However, the degree of impact upon water quality is also highly dependent upon currents and water exchange within the nearshore water environment.

Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of fringing reef environment. They provide shelter to fish, invertebrates, and other marine organisms, as well as a supplemental food source for some residents of the watershed and other nearby villages.

As the population of the watershed and West Tutuila grows, sediment, nutrient, and bacterial inputs will only increase. Aside from these resource management considerations, the future use of the nearshore waters for swimming and general recreation will also represent a more significant public health concern.

It is recommended that ASPA incorporate Fatamafuti, Matuu, Faganeanea, and adjoining residential areas into its wastewater collection system. However, until financial resources become available for this system expansion, areas that are unsuitable for soil-based, wastewater treatment should be more specifically identified. As recommended in the ASPA Utilities Master Plan, this identification process should be based upon a more detailed sanitation survey of Fatamafuti, Matuu, Faganeanea, and adjoining residential areas of the watershed. This survey would evaluate existing wastewater treatment practices, soil characteristics, the location and density of land uses, the distance to surface water supplies and the nearshore waters, topography, and other related factors. Using the conclusions and recommendations associated with this evaluation, ASPA and participating Project Notification and Review System (PNRS) agencies will be better equipped to:

- require the use of septic tanks and leachfields that provide a sufficient amount of additional soil-based treatment;
- provide greater technical assistance to building permit applicants; and/or,
- deny building applications in land areas that are unsuitable for soil-based treatment systems.

Groundwater and Surface Water Supplies

As stated earlier, Fatamafuti, Matuu, Faganeanea, and adjoining residential areas are already connected to the ASPA water system. While the use of surface water supplies is not recommended for potable use, it is desirable for existing surface catchments and storage tanks to be maintained by villages for non-potable uses and emergency consumption. In the event of a hurricane or other unanticipated event that disables ASPA water delivery for an extended period of time, it is desirable to have an emergency water supply that could be chemically disinfected for potable use, as well as used for non-potable purposes. Traditional leaders should be encouraged to continue or undertake this responsibility if adequate resources are available from the communities.

To facilitate the long-term conservation of these resources, it is also recommended that a 100-foot buffer or setback should be established around each surface supply, i.e., stream or spring catchment, in the watershed. In essence, the establishment of piggeries, new structural development, or other land uses would not be permitted within the 100-foot radius to prevent potential contamination of the surface supplies.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Matuu watershed will be to:

- expand the ASPA wastewater collection system to all residential and commercial areas in the watershed;
- perform a detailed evaluation of sanitation problems in all unsewered residential and commercial areas;
- conserve spring and stream catchments,
- maintain culverts underneath the primary shoreline roadway,
- conserve bat and seabird habitat, and,
- conserve coral communities.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting potential hazards or undesirable conditions, share potential solutions with designated residents of Fatamafuti, Matuu, and Faganeanea, and encourage village implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 26-7. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 26-7
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
MATUU WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.

TABLE 26-7 (Continued)
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
MATUU WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Monitor water quality of Afuelo, and Afu Streams, as well as the nearshore waters.	1. Measure changes in and total/fecal bacteria, sedimentation, and nutrients on a quarterly basis. 2. Make annual assessment of resource management program.
ASPA/ASEPA	Perform a detailed evaluation of community sanitation problems associated with the use of soil-based treatment systems.	1. Survey existing residential and commercial areas. 2. Evaluate existing treatment practices, soil characteristics, location and density of land uses, the distance to water supplies and nearshore waters, topography, and other factors. 3. Require use of septic tanks and leachfields that provide sufficient amounts of additional soil-based treatment; or, deny building applications in areas unsuitable for soil-based treatment.
ASPA	Expand wastewater collection system to all residential and commercial areas of the watershed.	1. Meet with traditional village leaders to consider wastewater collection system expansion. 2. If desired by village leaders, secure funding for the wastewater collection design and construction. 3. Design wastewater collection system improvements. 4. Construct proposed improvements.
ASEPA	Conserve surface water supplies	1. Identify village surface water supplies that are actively used. 2. Revise American Samoa GIS to delineate 100-foot buffers around each surface supply. 3. Restrict land uses within designated buffers.
DPW	Maintain culverts along the primary shoreline roadway	1. Establish a periodic storm culvert maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Clean debris and other material blocking culverts.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASCC Land Grant Program	Reduce sedimentation from agricultural activities	1. Determine locations where upslope agricultural activities may be generating some sedimentation. 2. Encourage soil conservation methods with resident growers of subsistence crops.
ASDMWR	Sustain bird habitats at Mataae Point, Fatu Rock, and Futi Rock.	1. Confirm presence of sheath-tailed bat near Mataae Point, reef herons on Fatu Rock, as well as blue-grey noddy on Fatu and Futi Rocks. 2. Monitor changes in bat and seabird populations and habitat at cave near Mataae Point, as well as Fatu and Futi Rocks.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) approximately every three years.

Source: Pedersen Planning Consultants, 1998

NUUULI PALA
Watershed 27

GEOGRAPHY

The Nuuuli Pala watershed is located along the southern coast of Tutuila. It generally incorporates Nuuuli, Malaeimi, Mesepa, the upper elevations of Mapusagafou, as well as portions of Tafunafou and Tafuna. The watershed comprises about 6.7 square miles of land area (Figure 27-1).

The inland boundary of the watershed represents a series of mountain peaks and ridges that include Matafao Peak, Leele Mountain, Taumata Mountain, Tuasivitasi Ridge, and Olotele Mountain. Amaile Ridge delineates the upper, east boundary of the watershed. The southeast slopes of Olotele Mountain represents the northwest boundary of the Nuuuli Pala watershed.

The watershed includes a number of drainage areas and approximately 13 fresh-water streams. Amaile Stream, which is situated between Amaile Ridge and Lesolo Ridge, carries surface runoff to the nearshore waters east of Coconut Point. The streams known as Sauino, Mataalii, Tauese, Leele, Papa, Sagamea, discharge surface runoff to the nearshore waters on the north and northwest side of Pala Lagoon. The Vaitele-Taumata Stream drainage lies near the center of the watershed and represents the largest drainage in the watershed. Mapusagatuai Stream, Leaveave Stream, and Puna Stream are located on the northwest side of the watershed and drain the southwest slopes of Tuasivitasi Ridge.

Along the shoreline, the Nuuuli Pala watershed extends between the east side of Coconut Point to the south side of the Pago Pago International Airport terminal and adjacent airport runway. Pala Lagoon and the adjoining Avatele Passage are important water bodies that are situated between the watershed's shoreline boundaries.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 27-2). Fifteen soil classifications were identified by the U.S. Soil Conservation Service for lands within the Nuuuli Pala watershed (Table 27-1).

Troporthents

Troporthents soils (SCS soil mapping unit 33) are found primarily at the Pago Pago International Airport, ASG Tafuna Housing, Lions Park, Tafuna Industrial Park, and the Congregational Church College complex in Tafunafou. These areas have been altered by filling, cutting, and smoothing. This soil unit also includes smaller areas of Urban land, rock outcrop, Iliili extremely stony mucky clay loam, and Tafuna extremely stony muck.

Troporthents are well drained soils that primarily consist of a mixture of cobbles, sand, gravel, and some fine textured materials. Coral sand, coral, cinders, and other materials also are found in some filled areas. Fragmental *aa* lava or bedrock is the underlying material (U.S. Soil Conservation Service, 1984).

Slow to moderately rapid permeability characterizes Troporthents soils. Stormwater runoff drains at a slow to medium rate. The potential for water erosion is slight (U.S. Soil Conservation Service, 1984).

NUUULI PALA
Watershed 27

GEOGRAPHY

The Nuuuli Pala watershed is located along the southern coast of Tutuila. It generally incorporates Nuuuli, Malaeimi, Mesepa, the upper elevations of Mapusagafou, as well as portions of Tafunafou and Tafuna. The watershed comprises about 6.7 square miles of land area (Figure 27-1).

The inland boundary of the watershed represents a series of mountain peaks and ridges that include Matafao Peak, Leele Mountain, Taumata Mountain, Tuasivitasi Ridge, and Olotele Mountain. Amaile Ridge delineates the upper, east boundary of the watershed. The southeast slopes of Olotele Mountain represents the northwest boundary of the Nuuuli Pala watershed.

The watershed includes a number of drainage areas and approximately 13 fresh-water streams. Amaile Stream, which is situated between Amaile Ridge and Lesolo Ridge, carries surface runoff to the nearshore waters east of Coconut Point. The streams known as Sauino, Mataalii, Tauese, Leele, Papa, Sagamea, discharge surface runoff to the nearshore waters on the north and northwest side of Pala Lagoon. The Vaitele-Taumata Stream drainage lies near the center of the watershed and represents the largest drainage in the watershed. Mapusagatuai Stream, Leaveave Stream, and Puna Stream are located on the northwest side of the watershed and drain the southwest slopes of Tuasivitasi Ridge.

Along the shoreline, the Nuuuli Pala watershed extends between the east side of Coconut Point to the south side of the Pago Pago International Airport terminal and adjacent airport runway. Pala Lagoon and the adjoining Avatele Passage are important water bodies that are situated between the watershed's shoreline boundaries.

RESOURCES OF THE WATERSHED

Soils

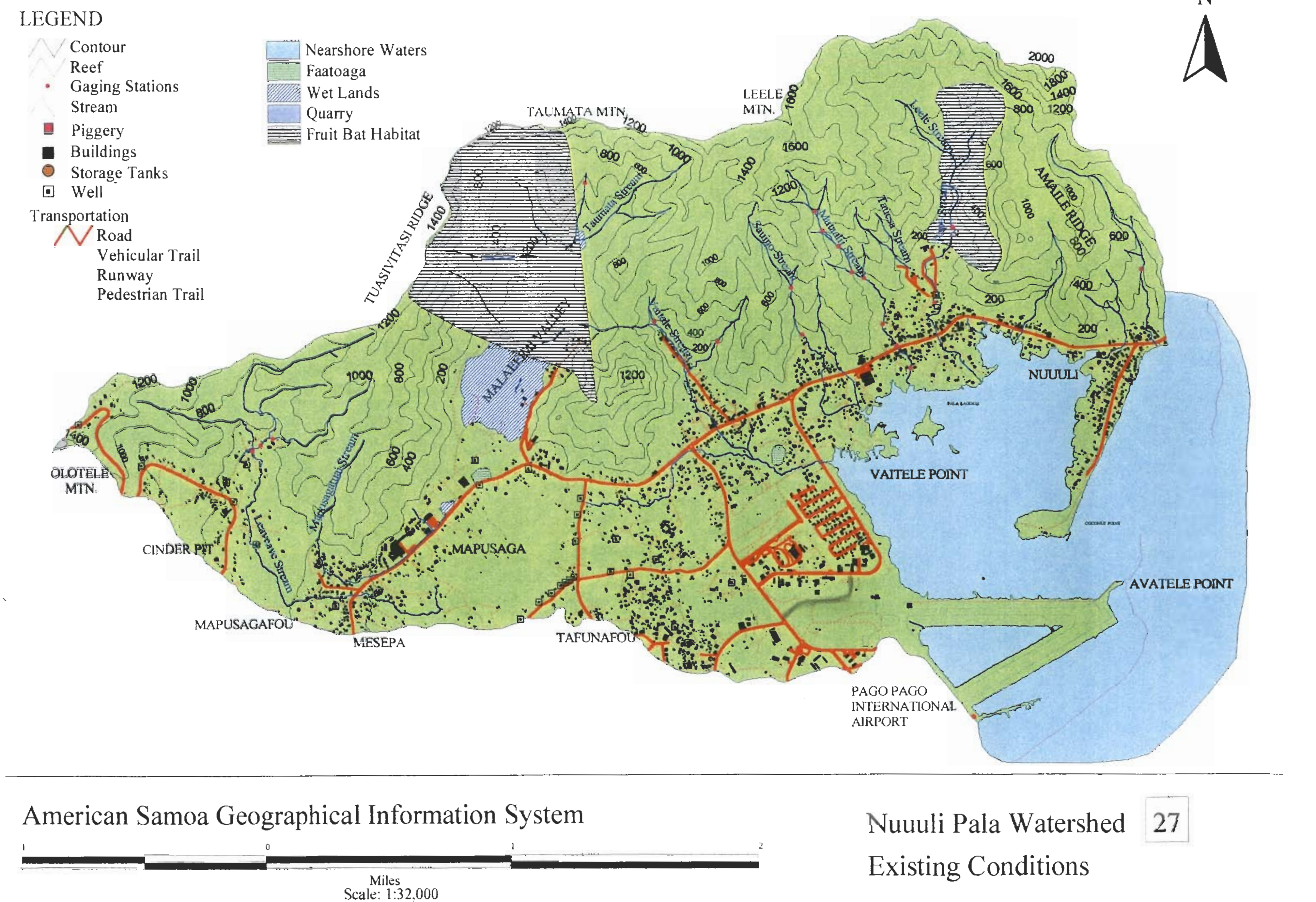
The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 27-2). Fifteen soil classifications were identified by the U.S. Soil Conservation Service for lands within the Nuuuli Pala watershed (Table 27-1).

Troporthents

Troporthents soils (SCS soil mapping unit 33) are found primarily at the Pago Pago International Airport, ASG Tafuna Housing, Lions Park, Tafuna Industrial Park, and the Congregational Church College complex in Tafunafou. These areas have been altered by filling, cutting, and smoothing. This soil unit also includes smaller areas of Urban land, rock outcrop, Iliili extremely stony mucky clay loam, and Tafuna extremely stony muck.

Troporthents are well drained soils that primarily consist of a mixture of cobbles, sand, gravel, and some fine textured materials. Coral sand, coral, cinders, and other materials also are found in some filled areas. Fragmental *aa* lava or bedrock is the underlying material (U.S. Soil Conservation Service, 1984).

Slow to moderately rapid permeability characterizes Troporthents soils. Stormwater runoff drains at a slow to medium rate. The potential for water erosion is slight (U.S. Soil Conservation Service, 1984).



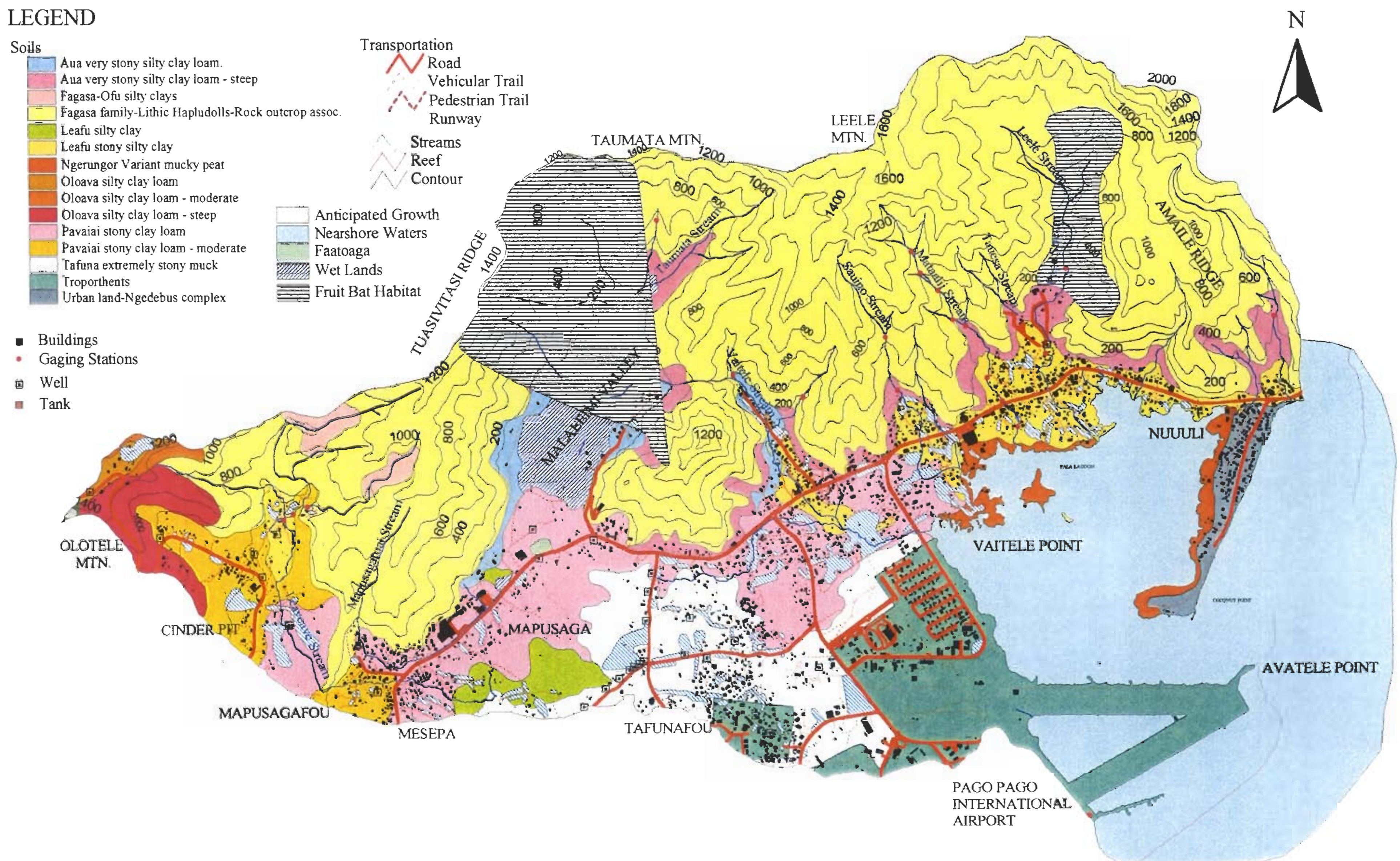
American Samoa Geographical Information System

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Nuuuli Pala Watershed 27

Existing Conditions

Figure 27-1



American Samoa Geographical Information System

Miles
Scale: 1:32,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Nuuuli Pala Watershed 27

Management Issues

Figure 27-2

TABLE 27-1
SELECTED SOIL CHARACTERISTICS
NUUULI PALA WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
1	Aua very stony silty clay loam	15-30	None	Med	Moderate	>6	<60	Severe Slope	Moderate
2	Aua very stony silty clay loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
3	Fagasa-Ofu silty clays	30-60	None	Med To Rapid	Moderate to Severe	>6	20-40	Severe Slope Depth	Moderate
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
8	Leafu silty clay	0-3	Occ	Slow	Slight	3-5	>60	Severe Flood Wet	Moderate
9	Leafu stony silty clay	0-3	Occ	Slow	Slight	3-5	>60	Severe Flood Wet	Moderate
13	Ngerungor variant mucky peat	0-1	Fre-quent	Slow	Slight	+1-1.0	>60	Severe Flood Ponding Poor Filter	Poor
19	Oloava silty clay loam	6-12	None	Slow	Slight	>6	>60	Severe Filter	Good
20	Oloava silty clay loam	12-25	None	Slow to Med	Slight to Moderate	>6	>60	Severe Filter Slope	Good
21	Oloava silty clay loam	40-100	None	Rapid	Severe	>6	>60	Severe Poor Filter Slope	Poor
23	Pavaiai stony clay loam	6-12	None	Slow to Med	Slight to Moderate	>6	38	Severe Depth To Rock	Moderate
24	Pavaiai stony clay loam	12-25	None	Med	Moderate	>6	38	Severe Depth To Rock Slope	Moderate
32	Tafuna extremely stony muck	0-6	None	Very Slow	Slight	>6	40-60	Severe Poor Filter Large Stones	Poor
33	Troporthents	0-6	N/A	Slow to Med	Slight	N/A	N/A	N/A	N/A
35	Urban land-Ngedebus complex	0-5	Occ. brief	Slow	Slight	>3.5	>60	Severe Flood Wet Poor Filter	Poor

Source: U.S. Soil Conservation Service, 1984

Troporthents is somewhat suited for residential and urban development. This soil represents a firm foundation for structural development. However, residential and urban uses are constrained by the limited depth to bedrock. Community wastewater systems are needed to prevent contamination of water supplies if the density of housing is moderate to high. The use of onsite sewage disposal systems in this soil would generate an undesirable discharge to the local basal aquifer (U.S. Soil Conservation Service, 1984).

Ngerungor Variant Mucky Peat

Ngerungor Variant mucky peat (SCS soil mapping unit 13) characterizes the western shoreline of Coconut Point. This soil type is also located within lower elevations between the primary shoreline roadway and the north margin of Pala Lagoon.

This poorly drained organic soil is characteristic of a coastal swamp environment in American Samoa and is typically covered by water.

The surface layer of the soil, which comprises a very dark, mucky peat, is about four inches thick. A very dark, grayish- brown layer of peat extends between 4 and 17 inches below ground elevation. The underlying soil contains very dark brown peat to a depth of 60 inches or more (U.S. Soil Conservation Service, 1984).

Ngerungor variant mucky peat is formed in organic material that is derived primarily from decomposing mangrove roots and litter. The permeability ranges from between six to 20 inches per hour. Runoff is very slow; the hazard of water erosion is slight (U.S. Soil Conservation Service, 1984).

This soil is not suitable for structural development, e.g., residential uses, due to its limited capacity to support foundations and the potential for frequent flooding around building structures. Ngerungor variant mucky peat is also not conducive for use with onsite wastewater disposal systems because of the soil's inability to adequately filter and treat wastewater.

Leafu Stony Silty Clay (0 to 3 percent slopes)

Leafu stony silty clay soils (SCS mapping unit 9) are found in three areas of the Nuuuli Pala watershed.

Between Amaile Stream and the Sauino Stream drainages, Leafu stony silty clay soils are general located on both sides of the primary shoreline roadway. These soils generally do not exist above the 200-foot contour.

A second area where the Leafu stony silty clay soils can be found is located east of Tau Mountain along the lower Vaitele Stream drainage.

A small area of Leafu stony silty clay soils is also situated along the southwest slopes of Tuasivitasi Ridge in the upper elevations of Mapusagafou. The Leaveave Stream drainage passes through this area near the 500-foot elevation.

Leafu stony silty clay soils represent a deep soil that typically extends up to 60 inches in depth. Its permeability ranges between 2 and 6 inches per hour. Runoff from these soils is generally slow and the potential for soil erosion is limited. However, these soils are typically subject to brief periods of flooding after heavier rainfall periods.

These soils are somewhat suitable for subsistence agriculture. However, this land use is constrained by occasional periods of flooding and general soil wetness. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these Leafu soils for residential land uses is not recommended by the U.S. Soil Conservation Service because of the inherent flood potential associated with this soil. The same characteristics also hamper the use of these soils for septic tank systems and related soil-based treatment.

Pavaiai Stony Clay Loam (6 To 12 Percent Slopes)

Most of Mesepa, the upper elevations of Mapusagafou, and the west part of Nuuuli contain Pavaiai stony clay loam soils (SCS soil mapping unit 23).

This soil is formed in volcanic ash and underlain by lava. The surface layer typically contains a very dark, grayish-brown, stony clay loam that is about 7 inches thick. In some cases, the surface layer contains a silty clay loam. The subsurface layer, approximately 5 inches thick, and is a very dark, grayish-brown, clay loam. The subsoil is characterized by a dark brown, very cobbly, sandy loam that is roughly 26 inches thick. A lava bedrock is encountered between 20 and 40 inches below ground elevation (U.S. Soil Conservation Service, 1984).

The permeability of this Pavaiai soil is moderately rapid. The potential for erosion is slight to moderate; the rate of stormwater runoff is generally slow to medium (U.S. Soil Conservation Service, 1984).

Pavaiai stony clay loam soils are moderately suitable for subsistence agriculture. The production of subsistence crops is constrained somewhat by the presence of stones, the limited depth to rock, and the hazard of water erosion. However, the content of stones in the surface layer in usually not significant enough to impact planting and other agricultural. The use of mulch, crop residue, and cross-slope farming can reduce the potential of erosion.

Pavaiai stony clay loam soils are moderately suitable for residential development. The presence of stones, the limited depth to bedrock, and slope represent constraints to residential land use. The design of access roads should incorporate measures to control of surface runoff and stabilize cut slopes.

Urban Land-Ngedebus Complex

With the exception of the western shoreline, Nuuuli's Coconut Point area primarily contains Urban land-Ngedebus complex soils (SCS mapping unit 35). These soils generally comprise coral fragments, sand, cinders and other material that have been graded or filled to support residential, commercial and public facilities.

The Ngedebus soil extends to a depth of 60 inches or more. The surface layer, which extends about 4 inches below ground elevation, typically contains light, brownish-gray and brown sand. The underlying material is characterized by pale brown and light yellow, brown sand. The permeability of Ngedebus soil ranges between six and 20 inches per hour. Surface drainage on this soil is generally slow, and the hazard of potential soil erosion is slight. In some places the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide (U.S. Soil Conservation Service, 1984).

These soils are generally suitable to support residential and commercial development in areas that are protected from flooding. However, this soil is poorly suited in unprotected areas.

Where moderate to higher housing densities occur, the U. S. Natural Resources Conservation Service recommends the use of community sewage systems prevent the potential contamination of groundwater and surface water supplies. Lower housing densities are present throughout most of the Coconut Point area.

The urban land consists of areas covered by streets, buildings and other structures that obscure or alter the soils so that identification is not feasible. Much of the area has been leveled and filled with coral fragments, sand, cinders and other material. Included in this unit are small areas of poorly drained soils adjacent to streams and narrow strips of sandy beaches.

The Ngedebus soil is typically very deep and somewhat excessively drained. It formed in sand derived dominantly from coral and sea shells. Typically, the surface layer is light, brownish-gray and brown sand that is about four inches thick. The underlying material to a depth of 60 inches or more is pale brown and light yellowish-brown sand. The permeability of Ngedebus soil is rapid. Available water capacity is low. Effective rooting depth is 60 inches or more.

Runoff is slow, and the hazard of water erosion is slight. In some places, the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide. Its permeability is between six and 20 inches per hour.

Ngedebus soils are moderately suited to residential development in areas protected from flooding. In unprotected areas, these soils are poorly suited to support residential land uses. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

Tafuna Extremely Stony Muck (3 To 15 Percent Slopes)

Most of the Tafunafou area is characterized by soils known as Tafuna extremely stony muck (SCS soil mapping unit 32).

This soil is characterized by a thin organic soil overlying fragmented *aa* lava. It is a deep, well-drained soil on lava flows. The surface layer, which typically contains black extremely stony muck, is approximately nine inches thick is typical of the surface layer. The subsurface layer represents a nine-inch layer of very dark, grayish-brown, and dark brown extremely stony muck. Fragmented aa lava is the underlying material that extends to a depth of 43 inches or more. The depth to bedrock is usually 40 to 60 inches or more. However, some areas are characterized by shallower bedrock depths that range between 24 to 40 inches below ground elevation.

Small areas of Iliili extremely stony mucky clay occasionally occur with these Tafuna soils. In these areas, soils are less than 10 inches deep and the underlying material is *pahoehoe* lava.

Tafuna extremely stony muck soil is characterized by rapid permeability. Its available water capacity is very low. The potential for water erosion is slight; stormwater runoff rates are typically very slow (U.S. Soil Conservation Service, 1984).

Despite continuing development in the Tafunafou area, these Tafuna soils are poorly suited for residential, commercial, and industrial land uses. The bedrock provides good, stable foundations for structures. However, the presence of stones and the limited depth to bedrock make this soil inadequate for the use of onsite wastewater disposal systems. Larger stones also hamper general site development and excavations.

Crop cultivation in Tafuna extremely stony muck soils is also undesirable because of the presence of stones throughout the soil. Crops that do not require cultivation, e.g., breadfruit, coconuts, and papaya, can be successfully grown.

Leafu Silty Clay (0 to 3 percent slopes)

Leafu silty clay soils (SCS mapping unit #8) are found in two areas of the Nuuuli Pala watershed:

- Malaeimi Valley; and,
- the northwest part of Tafunafou.

This soil is a deep soil that typically extends up to 60 inches in depth. Its permeability ranges between 2 and 6 inches per hour. Runoff from these soils is generally slow and the potential for soil erosion is limited. However, these soils are typically subject to brief periods of flooding during prolonged, heavier rainfall.

These soils are moderately suitable for subsistence agriculture. However, this land use is constrained by occasional periods of flooding and general soil wetness. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these Leafu soils for residential land uses is not recommended by the U.S. Soil Conservation Service because of the inherent flood potential associated with this soil. The same characteristics also hamper the use of these soils for septic tank systems and related soil-based treatment.

Pavaiai Stony Clay Loam (12 to 25 percent slopes)

Pavaiai stony clay loam (SCS mapping unit 24) are found in portions of Mapusagafou (Figure 27-2).

This moderately deep, well drained soil was formed in volcanic ash and is underlain by lava. The surface layer, which is about seven inches thick, is typically a very dark, grayish-brown, stony clay loam. In some areas, the surface layer is a stony silty clay loam. The subsurface layer is only about five inches thick and contains a very dark, grayish-brown, clay loam. A dark brown, very cobbly sand loam represents the subsoil that is about 26 inches thick. A lava bedrock occurs at a depth of about 20 to 40 inches.

Rock outcrops also occur in some small areas. Where they occur, the depth to bedrock is less than 20 inches.

The permeability is moderately rapid for this Pavaiai soil. The available water capacity is moderate, and effective rooting depth is 20 to 40 inches. The hazard of water erosion is moderate, since runoff is medium.

These Pavaiai soils are moderately suited to the production of subsistence crops. The primary constraints are slope, the potential for water erosion, the limited depth to bedrock, and the presence of stones. The presence of stones in the surface layer is not significant enough to affect the planting of subsistence crops. The control of erosion can be accomplished by the use of crop residues and mulch, as well as cross-slope farming.

Residential uses on these soils have moderate suitability. The design of access roads should incorporate measures to control of surface runoff and stabilize cut slopes.

Oloava Silty Clay Loam (6 to 12 Percent Slopes)

Oloava Silty Clay Loam (SCS mapping units 19) are located on the northwest slopes of Olotele Mountain.

In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a dark-brown, silty clay loam. Soft, weathered cinders are typically present between 12 to 40 inches in depth. However, the depth to weathered cinders sometimes extends to 60 inches or more.

The permeability of the Oloava soil is moderately rapid, i.e., 2 to 6 inches per hour, through the surface layer. However, permeability becomes very rapid, i.e., 6 to 20 inches per hour, through the cinder material that occurs between 12 to 60 inches in depth (U.S. Soil Conservation Service, 1984).

The rate of stormwater runoff through these Oloava soils is typically slow. The potential for water erosion is considered slight (U.S. Soil Conservation Service, 1984).

This soil is well-suited to the production of subsistence crops. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity. The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers (U.S. Soil Conservation Service, 1984).

Residential development on these Oloava soils is not considered desirable. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment (U.S. Soil Conservation Service, 1984).

Oloava Silty Clay Loam (12 to 25 Percent Slopes)

Oloava Silty Clay Loam (SCS mapping unit 20) is also located on the northwest slopes of Olotele Mountain.

In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a dark-brown, silty clay loam. Soft, weathered cinders are typically present between 12 to 40 inches in depth. However, the depth to weathered cinders sometimes extends to 60 inches or more.

The permeability of the Oloava soil is moderately rapid, i.e., 2 to 6 inches per hour, through the surface layer. However, permeability becomes very rapid, i.e., 6 to 20 inches per hour, through the cinder material that occurs between 12 to 60 inches in depth (U.S. Soil Conservation Service, 1984).

The rate of stormwater runoff through these Oloava soils is typically slow. The potential for water erosion is considered slight (U.S. Soil Conservation Service, 1984).

This soil is well-suited to the production of subsistence crops. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers.

Residential development is not desirable on these soils. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment.

Oloava Silty Clay Loam (40 to 100 percent slopes)

The Oloava silty clay loam soil (SCS soil mapping unit 21) is found along the northeast slopes of Olotele Mountain. in the western-most portion of the watershed.

The Oloava silty clay loam is a well-drained soil that was formed in volcanic ash and cinders. The surface layer is typically is a dark brown silty clay loam that is about six inches thick. A dark brown, clay loam is characteristic of the upper five inches of the subsoil while the lower three inches is a dark brown, gravelly-silt loam. Weathered cinders extending to a depth of 60 inches represent the substratum. Within 12 to 30 inches from ground elevation, weathered cinders gradually crush to very gravelly sandy loam.

Exposed cinders and small rock outcrops occasionally occur in conjunction with these Oloava soils.

The permeability of this Oloava soil ranges between 2 and 6 inches per hour above the cinder layer. However, permeability through the cinder layer, i.e., between 14 and 60 inches, increases to a rapid rate greater than 20 inches per hour.

These soils have a severe potential for water erosion. Stormwater runoff rates are rapid.

These soils are not suitable for the production of subsistence crops. These soils typically occur on steeper slopes and have a severe water erosion potential.

Similar soil characteristics also make these Oloava soils are unsuitable for residential and commercial structures.

Fagasa-Ofu Silty Clays

Two smaller areas along Tuasivitasi Ridge are characterized by soils known as Fagasa-Ofu silty clays (SCS mapping unit 3).

The soil ranges between 20 to 40-inches in depth. The permeability of this silty clay loam is moderately rapid (2 to 6 inches per hour). The potential for surface runoff from these soils is considered moderate to rapid. However, the potential for erosion is moderate to severe.

The U.S. Soil Conservation Service indicates that this soil type is somewhat suitable for the production of subsistence crops. The soil can annually sustain from one to 5 tons per acre of erosion without impacting crop productivity. However, the Soil Conservation Service recommends the use of mulch, crop residues, and cross-slope farming to reduce the potential for soil erosion.

Aua Very Stony Silty Clay Loam (15 to 30 percent slopes)

Moderate, upland slopes on the east and west sides of Malaeimi Valley contain Aua very stony silty clay loam soils (SCS mapping unit 1). These soils also occur in a small area of the Vaitele Stream drainage on the northeast side of Tau Mountain.

These soils typically occur up to about 60 inches in depth. The permeability of these soils ranges between 2 and 6 inches per hour. The potential for runoff or erosion from the Aua soils is believed to be moderate (U.S. Soil Conservation Service, 1984).

While moderately suited for agricultural production, the U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). However, the U.S. Soil Conservation Service also advises that the stony and erosive characteristics of these soils may limit production. While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that typically hamper installation and provide inadequate soil treatment.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

Some steeper slopes of the lower watershed, between Malaeimi Valley and the Amaile Stream drainage, contain Aua very stony silty clay loam soils (SCS mapping unit 2). These Aua soils are also found on the steeper upland slopes that are situated north, northeast, and northwest of Malaeimi Valley, as well as immediately west of Tau Mountain.

The Aua soils range between seven to 60 inches in depth. The permeability of these soils ranges between 2 and 6 inches per hour. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also unsuitable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). The soils contain a significant amount of larger stones that hamper installation and provide inadequate soil treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

The Nuuuli Pala watershed includes a number of drainage areas and approximately 13 fresh-water streams.

Amaile Stream, which is situated between Amaile Ridge and Lesolo Ridge, carries surface runoff to the nearshore waters east of Coconut Point. This stream drains surface runoff from the southern slopes of Matafao Mountain. Stream flows discharge to the nearshore waters via a box culvert underneath the primary shoreline roadway.

An unnamed stream, Stream 27A, is located along the seaward face of Lesolo Ridge. The stream, which originates at the 400-foot elevation, empties into the northeastern corner of Pala Lagoon.

Surface runoff from the west slopes of Lesolo Ridge is transported to Pala Lagoon via Sagamea Stream. The stream originates at about the 800-foot contour.

Leele Stream transports drainage from the east and northeast slopes of Leele Mountain and begins at approximately 1,400 feet above mean sea level. Four unnamed tributaries contribute surface runoff to Leele Stream before its confluence with Tauese Stream and Papa Stream. Papa Stream ultimately carries the combined flows to Pala Lagoon.

Between Tauese Ridge and Suaavamuli Ridge, Mataalii Stream transports surface runoff from the southern slopes of Leele Mountain. The stream begins at about the 840-foot contour. A small, unnamed tributary on the south side of Suaavamuli Ridge also contributes additional runoff before Mataalii Stream discharges along the north shoreline of Pala Lagoon.

Sauino Stream and two tributaries carry runoff from the west slopes of Suaavamuli Ridge, as well as urban runoff from a portion of the primary shoreline roadway and upland residential area of Nuuuli. The mouth of the stream is located northeast of the ASG Tafuna Housing area along the north margin of Pala Lagoon.

Vaitele Stream originates at about the 1,400-foot contour on the southwest slopes of Leele Mountain. The main stream system, which represents about two miles of stream bed, drains approximately 0.58 square miles of undeveloped and urban lands (U.S. Army Corps of Engineers, Pacific Ocean Division, 1994). Vaitele Stream ultimately discharges just northeast of the Tafuna Correctional Facility that is located on the west side of Pala Lagoon and Lion's Park.

A significant tributary of Vaitele Stream is Taumata Stream. Taumata Stream and its three tributaries intermittently carry surface runoff from the southern slopes of Taumata Mountain. Taumata Stream passes through Malaeimi Valley, the Island of Tutuila's primary groundwater recharge area, and meanders eastward to its confluence with Vaitele Stream. This confluence is southeast of the primary shoreline roadway intersection with the primary roadway to the Pago Pago International Airport.

Mapusagatuai Stream and Leaveave Stream are also part of the Vaitele Stream drainage. Mapusagatuai Stream begins at about the 880-foot contour and drains approximately 0.38 square miles. The upper reaches of the stream are steep and narrow. In the vicinity of Mapusaga, these flows are carried primarily by man-made drainage structures and basaltic-lined channels.

Leaveave Stream originates at an elevation of about 1,100 feet and flows along the south west slopes of Tuasivitasi Ridge. Near the 600-foot contour, Leaveave Stream is joined by Puna Stream. Upland of the primary shoreline roadway, Leaveave Stream has defined stream channels that contain an average slope of 1.9 percent. Southwest of the American Samoa Community College and the primary shoreline roadway in Mapusaga, *"Leaveave Stream virtually disappears due to heavy vegetation and flat terrain"* (U.S. Army Corps of Engineers, Pacific Ocean Division, 1994).

Stream Flows Within the Watershed

A low-flow, partial-record station (No. 16945000) was established on Amaile Stream, approximately 0.3 mile upstream from the mouth, between 1959 and 1976. Records from 14 measurements of stream flow enabled the U.S. Geological Survey to estimate a median flow 0.45 cubic feet per second (Wong, 1996).

Two gages have provided data for the Leele-Tauese-Papa Stream basin. A continuous-record stream gage (No. 16944200) was maintained 500 feet downstream from Tauese Stream intermittently between 1966 and 1976. These measurements provided the data necessary to estimate a median flow of 1.30 cubic feet per second (cfs). This gage was occasionally operated as a partial-record site between 1968 and 1983. The highest recorded flow was 1,640 cfs on April 29, 1975. The stream at the gage location is reportedly without flow for many days of each year.

A low-flow, partial record station (No. 16944000), located 0.3 mile upstream of the confluence with Tauese Stream, provided 30 measurements of stream flow between 1959 and 1990. The median flow estimated by the U.S. Geological Survey for this station was 1.48 cfs (Wong, 1996).

Between 1959 and 1976, a low-flow, partial-record station (No. 16943000) was operated on Mataalii Stream, approximately 0.6 mile upstream from its mouth along the north margin of Pala Lagoon. Gage station records provided 17 measurements of stream flow that were used by the U.S. Geological Survey to estimate a median stream flow of 0.60 cfs.

A low-flow, partial-record station (No. 16942000) on Sauino Stream, about 0.6 mile upstream from Pala Lagoon, provided 17 measurements of stream flow between 1959 and 1975. The median flow at this station was estimated by the U.S. Geological Survey to be 0.25 cfs.

Two low-flow partial-record gages provided data for Vaitele Stream. These gages were located in the following locations:

- USGS gage no. 16937000: approximately 1.1 mile upstream of the mouth at Lepine; and,
- USGS gage no. 16938000 on a left-bank tributary about 0.2 mile upstream of the confluence.

Vaitele Stream gage 16937000 provided 19 measurements of stream flow between 1958 and 1989. These measurements enabled the U.S. Geological Survey to estimate a median flow of 0.67 cfs. The second gage on the left-bank, unnamed tributary of Vaitele Stream, provided 17 measurements of stream flow between 1958 and 1976. A median flow of 0.26 cfs was estimated for this location (Wong, 1996).

Two water-flow gages provided stream flow data from the upper end of Malaemi Valley. One of the gages was established on Taumata Stream; a second gage was located on a tributary of Taumata Stream about 0.5 mile upstream from the confluence. A low-flow partial-record gage (No. 16939000) was maintained 2.2 miles upstream from the confluence with Vaitele Stream between 1959 and 1974. This gage provided 14 measurements of stream flow that led U.S. Geological Survey to estimated a median flow of 0.12 cfs. The second low-flow, partial-record station (No. 16940000) on a left-bank tributary of Taumata Stream provided 13 measurements of stream flow between 1959 and 1974. The median flow estimated from these measurements was 0.22 cfs (Wong, 1996).

Between 1959 and 1975, a low-flow, partial-record station (No. 16941000) was operated on Mapusagatuai Stream, approximately 1.2 mile upstream from the confluence with Taumata Stream. This station recorded 16 measurements of stream flow that enabled the U.S. Geological Survey to estimate a median flow of 0.23 cfs (Wong, 1996).

A gage and numerous miscellaneous measurements have provided stream flow data for Puna and Leaveave streams. A low-flow, partial-record station (No. 16936000) on Leaveave Stream, approximately 0.1 mile upstream from the confluence with Puna Stream at Mapusagafou, provided 15 measurements of stream flow between 1959 and 1975. The median flow was estimated by the U.S. Geological Survey to be 0.33 cfs. About four additional stream locations have been monitored in the past; however such records primarily provided single measurements from small tributaries that drain into Puna or Leaveave streams below the gage (Wong 1996).

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Papa Stream and Vaitele Stream was two of 37 streams in American Samoa that was inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

Papa Stream

Papa Stream was surveyed in four locations. Station 27a was located within a mangrove forest just inland of Pala Lagoon near the 5-foot elevation. Station 27b was situated immediately below a primary shoreline roadway bridge. Station 27c was located upstream near the 40-foot elevation. Station 27d was established near the 100-foot elevation approximately 1,200 feet upstream of station 27c.

Along the lower reach of Papa Stream, five species of gobie fish and two species of mountain bass were identified. One species of eel and pipefish were also documented; the pipefish were abundant. Three species of shrimp were also identified at station 27a. Three species of crab and one species of mollusks were also reported.

Below the primary shoreline roadway bridge, two species of gobie fish and two species of mountain bass were recorded (station 27b). No eels or pipefish were observed. Seven species of shrimp were reported; four species were abundant. One species of crab was also documented, but no mollusks were identified.

Station 27c was characterized by two species of gobie fish and one species of eel. Mountain bass and pipefish were not present. Three species of shrimp were also identified. No crabs or mollusks were noted.

Three species of gobie fish and one species of mountain bass were identified at upstream station 27d. One species of eel was common, but no pipefish were identified. Four species of shrimp and two species of mollusk were also observed.

Vaitele Stream

Vaitele Stream was surveyed in three locations. Station 28a was situated near the stream mouth. Station 28b was located just upstream of a primary shoreline bridge near the 40-foot elevation. Station 28c was established near the 200-foot elevation.

Two species of gobie fish and one species of mollusk were observed near the stream mouth (station 28a).

Below the primary shoreline bridge, an occasional abundance of *ulua* was documented; otherwise, no other fish were identified. Two species of shrimp were abundant. No mollusks were noted.

No species of gobie fish were identified at station 28c. Two species of shrimp were recorded; one specie was abundant. One species of mollusks were also documented.

Surface Water Quality

Streams

Data from two miscellaneous water samples (Table 27-2), which were collected along Vaitele Stream in May, 1970 and May, 1985 (STORET, 1996), reveal the presence of coliform bacteria in the 1970 sample and elevated nitrogen and total phosphorus levels in the 1985 sample. These results indicate degraded water quality conditions. At the same time, these results represent single samples on days that may not have been representative of typical conditions.

TABLE 27-2
MISCELLANEOUS WATER QUALITY SAMPLES
PAPA AND VAITELE STREAMS
AUGUST 5, 1970 AND MAY 2, 1985

Water Quality Parameter								
Stream	*TN (μg/l)*	*TKN (μg/l)*	*NO_3+NO_2 (μg/l)*	*TP (μg/l)*	*Turbidity (jtu)***	*TSS (mg/l)*	*pH*	*Total Coliform (#/100 ml)*
Papa 08/05/70	--	--	nd*	--	1.0	--	7.00	1,000
Vaitele 05-02-85	760	230	530	210	--	--	--	--

Notes:
*nd = not detectable ** note use of jtu (Jackson units) rather than ntu now used to measure turbidity.

Source: ASEPA, 1995

Nearshore Waters

A study performed by the University of Hawaii in Pala Lagoon in 1975 (Helfrich, 1975) reported chlorophyll α levels throughout the lagoon that were in excess of ASEPA criteria, i.e., 0.35 μg/l; in most cases, the levels were exceeded by more than an order of magnitude. The highest chlorophyll levels were recorded near the discharge sites of Vaitele Stream and Papa Stream. Elevated chlorophyll levels are indicative of eutrophication and low water quality conditions. Measurable amounts of total coliform bacteria were also found throughout Pala Lagoon during the 1975 study.

In 1978-1979, Aecos and Aquatic Farms observed that underwater visibility was "fairly good" in the outer portion of the borrow pit and along the inner consolidated margin of the reef flat off the reef runway. However, water became more turbid near the runway revetment.

An inner pond, which is enclosed on all sides by Pago Pago International Airport runway and taxiways, drains into the seaward lagoon. This causes water near the shoreline revetment to become very turbid and smelly in selected areas. Aecos and Aquatic Farms noted that these ponds were highly turbid between 1978 and 1979.

Along Avatele Passage, underwater visibility was documented as "poor". Marine biologists from Aecos and Aquatic Farms suspected siltation and related turbidity from dredging activities along the northern perimeter of the airport runway.

During the 1978-1979 period, the water quality of the Nuuuli reef area was considered by Aecos and Aquatic Farms as "quite good". Somewhat diminished water quality was observed near the borrow pit area adjacent to Amaile Stream where elevated turbidity, depressed dissolved oxygen, and lower salinity levels were documented. These conditions were attributed to proximity to the mouth of Amaile Stream, groundwater seepage at the shore, sluggish circulation of waters in the borrow pits, and stormwater runoff and related siltation from Amaile Stream.

Pala Lagoon

Measurements from a sample collected from Pala Lagoon on an unknown date in early 1995 are given in Table 27-3 (AECOS, 1995). The levels for nitrate-nitrite and total phosphorus were well within the ASEPA water quality criteria prescribed for Pala Lagoon. Total nitrogen and chlorophyll α levels, however, were in excess of the ASEPA water quality criteria on this sampling date. These levels suggest some water quality degradation.

TABLE 27-3
MISCELLANEOUS WATER QUALITY DATA
PALA LAGOON
EARLY, 1995

Parameter	***Station Pala 1***
Total Nitrogen (μg-N/l)	219
Total Kjeldahl N (μg-N/l)	208
Nitrate-Nitrite (μg-N/l)	11
Total Phosphorus (μg-P/l)	12
Chlorophyll α (μg/l)	0.54

Source: Aecos, 1995

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila on July 25 and August 2, 1992 (Table 27-4). The samples were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the outer waters of Pala Lagoon met American Samoa water quality standards in late July and early August of 1992. Laboratory results also suggest that stormwater runoff from undeveloped lands upland of Pala Lagoon may not generate significant discharge of nutrients.

TABLE 27-4
SURFACE WATER QUALITY
OUTER WATERS OF PALA LAGOON
JULY-AUGUST, 1992

Sample Depth	Nitrate/ Nitrite mg N/l	Total N mg N/1	Kjeldahl N mg N/l	Total P mg P/l	CHL a mg/m^3
3 feet	<0.0001	0.120	0.120	0.008	0.09
60 feet	0.005	0.102	0.097	0008	0.10

Source: ASEPA, 1992

Wetlands

Roughly 123 acres of wetland extend from the southern end of Coconut Point, along the northern margin of Pala Lagoon, to the northwest end of Lions Park. The wetland in Nuuuli also includes a small wetland area southeast of Tafuna Industrial Park. The wetland includes a combination of wetland environments that include mangrove swamp, fresh-water marsh, ruderal wetland, cultivated wetland, streams, and open water lagoon (Biosystems Analysis, Inc., 1992).

About 100 acres of the wetland in Nuuuli represents a well-developed mangrove swamp that is characterized by many larger, oriental mangrove trees. The largest area of undisturbed mangrove on Tutuila is situated east and seaward of Laufou Shopping Center.

Fresh-water wetland areas occur along the margin of mangrove swamps, along streams, as well as inland of tidal influences and mangrove areas. Many of these areas have been disturbed by residential uses and related land alterations. Some of the cultivated areas have been abandoned and are overgrown with wetland and upland plants.

"The dominant vegetation in the undisturbed mangrove swamp in Nuuuli is oriental mangrove. A strip of red mangrove grows at the outer edge of the swamp, and beach hibiscus is sometimes scattered in among the mangrove trees. The area around Coconut Point consists mostly of littoral trees mixed with hibiscus and an outer ring of red mangrove" (Biosystems Analysis, Inc., 1992).

Significance to Fish and Invertebrates

Nuuuli Pala is *"....an important nursery and spawning ground for fishes and invertebrates. Larval fish and egg concentrations indicate that Pala Lagoon serves as a nursery ground for certain species of fish. Larvae are present of those fish resident in the inner lagoon, such as gobies, and those which range in and out of the lagoon. Small fishes of several species, most notably mullet, frequent shallow areas of the lagoon"* (Aecos and Aquatic Farms, 1980).

In 1979, Aecos and Aquatic Farms observed that the bottom of Pala Lagoon primarily represented sand and mud flats that were covered by a dense growth of the red algae. Pala Lagoon contained a few echonoderms that were documented on the sandy flats near the lagoon's seaward entrance. Bivalve molluscs were also reported inside the Lagoon. One species of clam was abundant on the muddy bottom along the north shore of the Lagoon and reportedly was harvested by women and children. Colonies of small oysters were documented on rocks along the western shore. Along the north shore of the Lagoon, mangrove crab were commonly observed, particularly in the mangrove swamp.

Significance to Wildlife

Nuuuli Pala also provides significant habitat for wildlife such as the Australian gray duck (Biosystems Analysis, Inc., 1992).

Resource Management Issues

Despite its designation as a Special Management Area, the inland margins of Nuuuli Pala continue to be impacted by expanding residential uses between the primary shoreline roadway and the northern margin of Nuuuli Pala. Increased residential expansion and related site development bears close monitoring by ASCZM and ASEPA to ensure that significant changes are not made to the hydrology of the Nuuuli Pala.

With growing residential uses, an increased volume of solid waste material is found in most all streams that discharge into Nuuuli Pala. On April 26, 1996, one piggery was located along Papa Stream roughly mid-way the primary shoreline roadway and the northern margin of the wetland. A second piggery was located on the northern margin of the Nuuuli Pala; this piggery is generally north of Logome Point. The wetland is capable of absorbing a considerable amount of nutrient loading. However, increased nutrient loading should be monitored since the Lagoon waters are an important spawning area.

Marine Resources

Coral Communities

The inner portion of Pala Lagoon contains no corals. However, coral communities are found on the outer reef flat near Avatele Point where corals are exposed to heavy surf and strong currents. Corals are also found along the east side of Coconut Point.

Various private consultants have made various field investigations of the fringing reef along Avatele Passage, Pago Pago International Airport, and the east side of Coconut Point since the late 1970's. In a cumulative sense, the available survey information suggests that:

- Sometime between November 1972 and July 1973, a significant coral kill occurred on the reef flat east and southeast of the tip of Coconut Point. This coral kill impacted a nearshore area approximately 20 acres. About 15 acres of this area previously supported luxuriant coral growth.
- The crown-of-thorns starfish infested the coral reef communities on the outer reef flat and margin of Pago Pago International Airport in 1978 and part of 1979. By October, 1979, few starfish were present on the outer reef flat.
- In 1995, coral coverage along the east side of the Coconut Point peninsula ranged between 20-39 percent along the reef front in 1995.

<u>1978-1979</u>

Coral coverage on the submerged rock revetment, which borders the northeastern section of the reef runway, was about 5 percent. About 10 percent coral coverage was observed in the borrow pit. It was noted that this coverage represented a considerable increase from coverage in 1971. *"The seaward portion of the borrow pit was considered to be "...a rich coral bottom with cover approaching 90 percent"* (Aecos and Aquatic Farms, 1980).

Infestation by the crown-of-thorns starfish was documented on the outer reef flat and margin of Pago Pago International Airport in early 1978. By January 1979, numerous starfish occurred in scattered concentrations at depths of 10 to 20 feet off the eastern end of the runway. Many dead corals were documented; however, some areas of live coral were interspersed with concentrations of starfish. By October, 1979, very few starfish were observed on the reef flat.

Corals were nearly absent from the reef flat along Avatele Passage. Some corals were reported along walls or ledges of dredged areas where sediment was not accumulating. Coral rubble and boulder fields were evident along the bottom of the Passage. Marine biologists noted that living coral on the reef flat and reef front across Avatele Passage flourished in early 1972 when coral coverage ranged between 20 and 50 percent. It was suspected that this decline may have been caused by:

- the introduction of some substance into the nearshore waters somewhere north of Mulinuu Point during an ebb tide; and,
- sedimentation on the reef flat across Avatele Passage.

A boat channel parallels most of the east shoreline of Coconut Point. Coral coverage was observed to be low in this nearshore channel and less than 10 percent along the channel's seaward margin. Similar coral coverage was documented on the adjoining inner reef flat.

Southeast of Mulinuu (Coconut) Point, coral coverage averaged about seven to eight percent up to 660 feet offshore.

<u>1992</u>

Field investigations were also made in the nearshore waters of the Nuuli Pala watershed by Maragos, Hunter, and Meier in 1992. This team of marine ecologists examined two coral reef sites:

- Avatele Point, the south side of Pala Lagoon, and Mulinuu (Coconut) Point; and,
- the northeast side of Pala Lagoon.

Marine ecologists documented the continuous fringing reef that extended between Avatele Point and the shoreline fronting Nuuuli Village. It was noted that this reef was broken only by the entrance channel to Pala Lagoon.

Coral coverage in the Avatele Point area ranged between one and five percent at depths of 6 meters. A 10 percent coral coverage was observed at a depth of approximately 18 meters.

In contrast, the fringing reef along the northeast side of Coconut Point peninsula contained a live, stony coral coverage of 15 percent at 6 meters and 10 percent coral coverage at 18 meters in depth.

1995

A 1995 survey of various coral reefs throughout the Samoan Archipelago investigated the fringing reef seaward on the east side of the Coconut Point peninsula. Five transects were made along the front of the fringing reef. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Green documented that coral coverage ranged between 20 and 39 percent. The number of fish species observed included some 100-149 different species. Fish density ranged between 5,000 and 9,999 individuals per ha. Fish biomass represented less than 500 kilograms per ha.

Wildlife Resources

The area south of Taumata Mountain and east of Tuasivitasi Ridge represents a portion of Malaeimi Valley. Forest birds and bat counts are made in this area on a monthly basis. Former ASG wildlife biologist, Chris Solek, indicated in May, 1996 that the Malaeimi area was one of the more important habitats for forest birds on the Island of Tutuila.

Shoreline Protection

"The shoreline of Coconut Point is vulnerable to damage from storm waves. During the January 1966 hurricane, high waves damaged seawalls and caused extensive flooding in Nuuli. Many houses had to be rebuilt as a result of the hurricane and some of these have been built directly on the beach berm. Since the hurricane, a number of seawalls have been built seaward of the existing berm and fill placed behind them" (Aecos and Aquatic Farms, 1980).

Loose rock walls and dumped rock provide some marginal shore protection along the east side of the Coconut Point peninsula. This shoreline protection extends from the northern end of the peninsula for about 0.5 mile. A vertical grouted rock wall protects a small boat dock about 1,000 feet north of Mulinuu (Coconut) Point.

Between Avatele Point and Matautuotafuna Point, there is considerable protection for Pago Pago International Airport. A 2,800-foot long revetment was constructed by the U.S. Army Corps of Engineers in June, 1981 to replace the original shoreline protection. A second revetment, which extends about 1,500 feet, was constructed in 1984.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Nuuuli Pala watershed that were determined to be "critical", or "potentially critical" conditions:

North of Mulinuu (Coconut) Point

- Significant erosion has occurred along portions of the northern half of this shoreline. Protection is inadequate; the shoreline is susceptible to extensive damage.
- Erosion scarp is within five feet of the paved roadway.
- Two homes west of Coconut Point may be adversely impacted by continuing erosion in the vicinity of the homes.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

The villages in the Nuuuli Pala watershed rely upon a potable water supply that is supplied by the American Samoa Power Authority. There are, at least, 10 wells in the Nuuuli Pala watershed that are actively used by ASPA for the production of ground water (Table 27-5). These wells, which are located in Malaeimi, Mesepa, and Tafunafou, contribute a significant volume of groundwater to the Island of Tutuila's overall groundwater supply.

TABLE 27-5
GROUNDWATER WELLS IN THE FAGAALU WATERSHED
OPERATED BY ASPA

Pump Location	Well Number	Ground Elevation	Well Depth (feet)	Normal Discharge Rate (gpm)	Normal Head (psi)	Elevation Above Mean Sea Level
Malaeimi	88	149	300	280	40	-151
Malaeimi	89	140	184	370	40	-44
Malaeimi	67	128	155	270	35	-27
Mesepa	85	251	277	320	50	-26
Tafuna	33	74	95	200	25	-21
Tafuna	60	102	125	390	20	-23
Tafuna	61	109	125	170	15	-16
Tafuna	66	76	105	360	20	-29
Tafuna	72	118	155	340	35	-37
Tafuna	81	115	155	260	30	-40

Source: ASPA Draft Utilities Master Plan, 1995

The future conservation of groundwater quality remains an important concern of the Territory. Land use development and increased population pressures are most prominent in the Nuuuli and Central Tafuna Plains watersheds. While a significant expansion has been made of the ASPA wastewater collection system, the continued use of individual onsite wastewater disposal systems, e.g., septic tanks and cesspools, in these watersheds continues to contaminate Tutuila's basal aquifer. Frequent heavier rainfall periods transport a significant amount of bacteria and nutrients through a thin soil layer and the basaltic substrata. Consequently, a significant amount of the ground water used in the ASPA water system contains elevated levels of bacteria and turbidity (ASPA, 1995).

"ASPA regularly disinfects the groundwater supply at 11 wells by treatment with chlorine. The water is also chlorinated at two booster stations and at the chlorination station in Tafuna. The American Samoa Environmental Protection Agency (ASEPA), which monitors American Samoa's groundwater quality, reports that disinfection efforts are effective and chlorine residuals are maintained throughout the ASPA water system" (ASPA, 1995).

Surface Water Supply and Quality

There are no surface water supplies actively used by the several communities in the watershed.

Proposed Water System Improvements

The draft ASPA Utilities Master Plan points out that a desirable operational objective is for ASPA to produce water in the same area that it is consumed. The operation and maintenance of extensive water transmission systems throughout most of Tutuila are costly. In west Tutuila, the Master Plan recommends the drilling of exploratory wells in the Tafuna-Leone area.

ASPA plans to drill six-inch exploratory wells in Malaeimi, Nuuuli, Leone, Pavaiai, and Asili. Where adequate yields are found, permanent groundwater wells are recommended for subsequent use. Malaeimi is noted as one location where significant amounts of potable water may be discovered. No specific location in the watershed is identified for this improvement. However, it is recommended that the well head of the exploratory well should not exceed 150 feet above mean sea level to accommodate drill rig limitations.

USE OF THE WATERSHED

Resident Population

The resident population of the Nuuuli Pala watershed generally includes the villages of Nuuuli, Malaeimi, Mesepa, Mapusaga, and a portion of Tafuna. Since most of the Tafuna population is located in the Tafuna watershed, the resident population of Tafuna is discussed in the evaluation of the Central Tafuna Plains (watershed 28).

Nuuuli

Between 1980 and 1990, the resident population of Nuuuli Village increased from 2,585 to 3,893 residents. Such growth represented an average annual growth rate of about 5.06 percent. Development activity between 1990 and 1995 increased resident population to about 4,727 persons.

Malaeimi

Population trends reflected in the 1990 Census suggest that considerable in-migration gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa has more than doubled during the decade; the most significant growth occurred between 1980 and 1985.

The population of Malaeimi was approximately 830 residents in 1990. With the construction of some 26 new housing units during the 1990-1995 period, the resident population increased to an estimated 1,022 persons.

Mesepa

Between 1980 and 1990, the resident population of Mesepa Village increased from 346 to 483 residents. Such growth represented an average annual growth rate of about 3.96 percent. Development activity between 1990 and 1995 increased resident population to about 568 persons.

Population trends for Mesepa reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1985 and 1990. The proportion of 1990 residents who were born outside of the community increased 80 percent during this period.

Discussions with representatives from the ASG Department of Education and other ASG representatives indicate that most of the incoming residents to Mesepa probably arrived from Tonga and Western Samoa (Epati-Tanoi, 1994). In contrast to Pavaiai, onsite observations of the community indicate that in-migrants are scattered throughout the community rather than concentrated in specific areas of the community.

Mapusaga

Between 1980 and 1990, the resident population of Mapusaga Village increased from 758 to 1,133 residents. Such growth represented an average annual growth rate of about 4.95 percent. Development activity between 1990 and 1995 increased resident population to about 1,272 persons.

Population trends for Mapusaga reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1980 and 1985 and remained almost constant through 1990. The proportion of residents who were born outside of American Samoa increased 148 percent between 1980 and 1985.

Discussions with representatives from the ASG Department of Education and other ASG representatives indicate that most of the incoming residents to Mapusaga have probably arrived from Tonga and Western Samoa (Epati-Tanoi, 1994). For example, the same Tongan community northwest of Pavaiai Elementary School will soon urbanize north into Mapusaga. Existing residential densities in this community are already about 10 to 11 housing units per acre.

Land Uses

Residential

During the 1990-1995 period, about 127 new housing units were constructed in Nuuuli. In 1995, the total housing stock included approximately 678 homes. Primary housing concentrations are located in the Coconut Point area, the north and south sides of the primary shoreline roadway, and along the inland streams and valleys of Leele, Sauino and Vaitele.

The housing stock in Malaeimi increased from approximately 116 housing units in 1990 to about 142 homes in 1995.

In 1990, the 1990 U.S. Census documented 74 homes in Mesepa. Building permits were issued for 12 new housing starts. Consequently, the 1995 housing stock includes approximately 86 homes.

The 1990 U.S. Census documented 158 homes in the Mapusaga village census area. Residential expansion during the 1990-1995 period increased the housing stock to approximately 180 homes.

Agriculture

Several piggeries were observed in the watershed during a field survey in April, 1996. In most all cases, wastewater from these piggeries typically drained into Pala Lagoon or into local streams of the watershed. Such discharges generated increased nutrient loading into local streams and Pala Lagoon.

South of the primary shoreline roadway, one piggery was located in the Vaitele Stream drainage in Nuuuli. A second piggery was located along Papa Stream roughly mid-way between the primary shoreline roadway and the northern margin of Pala Lagoon. On the northern margin of the Nuuuli Pala, another piggery was located generally north of Logome Point. A piggery housing approximately 15 pigs was found in the Mapusagafou area along Puna Stream.

Commercial

<u>Nuuuli</u>

There are about 333 commercial enterprises that are based in Nuuuli; 13 of these enterprises were established between 1990 and 1995. The Village now contains more commercial businesses than any other village in American Samoa. Commercial businesses in Nuuuli offer a wide variety of retail shopping, technical and professional services, gambling and amusement centers, building suppliers and contractors, fast-food and coffee shops. Most of the enterprises are retail shops and grocery stores. Many of the professional and technical services represent home-based occupations since office space requirements are limited.

Malaeimi

In 1995, there were approximately 42 commercial enterprises operating in Malaeimi. These enterprises included retail shops, professional and technical services, fast-food operations, two laundromats, wholesale fish bait distributor, and a construction contractor. Four new commercial facility building permits were issued by the American Samoa Government during the 1990-1995 period.

Mesepa

Approximately 15 commercial enterprises operated in Mesepa in 1995. These enterprises included retail shops, technical and retail services, a fast-food operation, two bus operators, and a construction contractor. No new commercial facility building permits were issued by the American Samoa Government during the 1990-1995 period; however, a November, 1994 inspection of the village suggests that, at least, two or three businesses on the southeast side of the primary shoreline roadway were built during this period.

Mapusaga

In Mapusaga, approximately 18 commercial enterprises were in operation in 1995. These enterprises included retail shops, a grocery store, technical and retail services, three transportation companies, three construction contractors, two consultants, and a sales representative.. No new commercial facility building permits were issued by the American Samoa Government during the 1990-1995 period. A November, 1994 inspection of the village confirmed that no new commercial facilities were constructed during this period.

Industrial

In 1995, industrial activities in Nuuuli included five auto repair shops, a heavy equipment repair shop, one truck rental and hauling enterprise, as well as one metal fabrication business in 1995.

No light industrial activities were based in Malaeimi or Mesepa.

One building supply business was in operation in Mapusaga.

Public Facilities

Nuuuli

No public facilities were located in Nuuuli in 1995. Elementary school aged children attend Manulele Elementary School in nearby Tafuna Village. High school students attend Tafuna High.

The Early Childhood Education (ECE) program coordinates two sites in Nuuuli. While no public facility is involved, this public program utilizes village guest *fales* and/or private homes. The ECE programs, which serves children three and four years of age, enrolled 148 children in September, 1994.

Malaeimi

The ASG Department of Education's conducts an early childhood education program at a private residence in Malaeimi. The enrollment of the early childhood program, which serves children three and four years of age, was about 38 children during the 1994-1995 school year.

No public elementary or high school facilities are located in the Village. Elementary school students attend Manulele Elementary School in Tafuna. High school students are bussed to Tafuna High School.

Mesepa

The ASG Department of Education's conducts an early childhood education program at a private residence in Mesepa. The enrollment of the early childhood program, which serves children three and four years of age, was about 41 children during the 1994-1995 school year.

No public elementary or high school facilities are located in Mesepa Village. Elementary school students attend Pavaiai Elementary School. High school students are bussed to Leone High School.

The most prominent public facility in Mesepa is the American Samoa Community College. This facility, which is situated on the *mauga* side of Tutuila's primary roadway, had a enrollment of 417 full-time students and 757 part-time students in the fall semester of 1992. The College was administered during this period by 44 faculty members and 98 administrative staff (American Samoa Community College, Admissions and Records Office, 1992).

Mapusaga

No public early childhood education, elementary or high school facilities are located in Mapusaga Village. Elementary school students attend Pavaiai Elementary School. High school students are bussed to Leone High School.

Use of the Nearshore Waters

Recreational and Subsistence Fishing

A considerable use is made of the nearshore waters of the Nuuuli Pala watershed for recreational and subsistence fishing. Fishing methods typically include use of rod and reel, hand lines, bamboo poles, gleaning, spear diving, throw nets, and gill nets. The primary fishing areas are believed to be the wide reef flats on the east side of Coconut Point.

In this area, the ASG Department of Marine and Wildlife Resources recorded between 9,300 and 14,700 hours per year of fishing activity in the Nuuuli area during the 1991-1993 period. Fishing methods typically included gleaning, spear diving, rod and reel, hand lines, bamboo poles, throw nets, and gill nets. DMWR creel survey data for the 1991-1993 period reveals that gleaning and spear diving are the two more popular methods of fishing on the reef flats.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Nuuuli

Opportunities for future residential expansion in Nuuuli are primarily located in the area south of the primary shoreline roadway. Between Coconut Point and the access road to Tafuna Housing, about 92 single family units at the present variable housing density of about two to five units per acre. Between Tafuna Housing access road and the Airport Access road, the development of an additional 62 housing units can be expected with the assumed linking of a few interior trails. Considerably more homes could be constructed in this area with the construction of a more efficient interior road system. Significant expansion has already occurred south of the primary shoreline roadway during the 1990-1994 period.

Mauga of the primary shoreline roadway at Nuuuli, another 63 housing units could be developed within existing residential areas. This estimate assumes a variable residential density between three and five units per acre. Onsite observations in October, 1994 suggest that almost half of the available expansion area is found along Vaitele Stream.

The Coconut Point area has little room for expansion. Onsite observations of this area suggest that only two additional housesites and two vacant homes are available for future expansion. This assumption believes that the Village will attempt to maintain existing residential densities that range between two and five units per acre.

Nuuuli continues to be a desirable community to live in. The Village is close to employment and shopping opportunities in Nuuuli and the Pago Pago Harbor area. In addition, the quality of homes and general affluence of the community is evident in the Coconut Point area. In other portions of the Village, e.g., Vaitele Stream and south of the primary roadway, the construction of new rental units and smaller homes are being built by many Tongan families who have immigrated to American Samoa.

Continued expansion of Nuuuli can be anticipated during the next 20 years even though most developable lands have already been occupied. Pedersen Planning Consultants believes the following residential development will occur during this time period.

1996-2000 The remaining 63 housesites *mauga* of the shoreline roadway will be developed for single family homes.

Two new homes will be constructed in the Coconut Point area and two vacant homes will become occupied.

46 homes will be built between Coconut Point and Tafuna Housing access road south of the shoreline roadway.

31 homes will be constructed south of the shoreline roadway between Tafuna Housing access road and the Tafuna Airport access road.

Such growth will represent the beginning of a gradual decline of Nuuuli's average annual population growth rate of roughly five percent which has been sustained since 1980. Residential densities will continue to vary from two to five units per acre.

2001-2005 The remaining 46 undeveloped housesites between Coconut Point and the Tafuna Housing access road will be constructed.

Approximately 31 additional homes will be built south of the shoreline roadway between Tafuna Housing access road and the Airport access road.

2006 –2010 Some housing replacements and/or expansion will occur. However, no new single family residential construction will occur. Prospective homeowners and renters will seek other potential growth areas where developable land area is available for the construction of single family units.

During the same period, a growing number of younger households and new incoming residents will also begin to seek rental housing opportunities in multi-unit residential apartment buildings. It is anticipated that future housing demands in Nuuuli will be addressed through the gradual replacement or conversion of five percent of the total housing stock with two-story homes that will house an average of two families which will usually be culturally related. In terms of housing density, five percent of the total housing stock, or about 45 housing units, will double in density. Consequently, the conversions will add about 45 housing units to the Village during the 2006-2010 period.

2011-2015 During the 2011-2015 period, another 45 single family homes will be converted with two-story homes that will each provide two housing units.

These conversions will provide an additional 45 housing units in the community.

The cumulative effect of this prospective residential growth for Nuuuli is that the housing stock will increase to roughly 989 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.95 persons per household, the 2015 village population will include about 5,887 persons.

Malaeimi

Future residential expansion in the Village is expected to be limited even though there is considerable vacant land along existing dirt trails on the north and south sides of Tutuila's primary roadway. The importance of Malaeimi Valley to Tutuila's future groundwater supply will likely force ASPA to provide electrical and water service connections to only selected portions of the Valley, or existing homes in the Valley. As stated earlier, it is believed that such a policy is needed to ensure long-term conservation of the groundwater supply.

Potential residential expansion is expected to be permitted east of the primary access road to Tafunafou from Tutuila's primary two-lane Airport access roadway. The east boundary of the Malaeimi village census boundary is generally extends to the Airport access road. Pedersen Planning Consultants believes that such an expansion would include the construction of single family homes along existing dirt trails and/or limited extensions to existing trails. Pedersen Planning Consultants believes that about 57 new homes could be built in this area.

During the next 20 years, Pedersen Planning Consultants believes that such development will more specifically generate the following volume of residential construction:

1996-2000 20 single family homes east of the Tafunafou access road will be built;

2001-2005 20 single family homes will be built east of the Tafunafou access road;

2006-2010 no new single family home construction will occur except for replacements, extensions, and repairs; and,

2011-2015 17 single family homes east of the Tafunafou access road will be built;

The cumulative effect of this prospective residential growth is that the housing stock will increase to roughly 199 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.12 persons per household, the future village population will include about 1,217 persons.

Mesepa

Future residential expansion in Mesepa Village is expected to be limited because only infilling can occur within existing residential areas southwest and east of American Samoa Community College. Pedersen Planning Consultants believes that there are only about 18 single family housesites.

Further expansion might occur if the Apiolefaga Inn, which is situated on the west side of Mesepa, were renovated and converted to residential apartments.

Another potential avenue of expansion for Mesepa would be gradual renovation and expansion some of the existing single family housing to two-story, duplex units. Continued lifestyle trends away from faaSamoa are becoming increasingly evident on Tutuila. Extended families are frequently choosing to construct adjoining living units in order to gain greater privacy for each satellite family. A greater proportion of this type of home in Mesepa is very likely in light of the lack of available land the ongoing changes in lifestyle.

During the next 20 years, Pedersen Planning Consultants believes that such development will more specifically generate the following volume of residential construction within Mesepa:

1996-2000 4 single family homes will be built southwest of ASCC, north of the primary shoreline roadway;

5 single family homes on the southeast of ASCC and the primary shoreline roadway,

2001-2005 2 single family homes will be built southwest of ASCC, north of the primary shoreline roadway;

7 single family homes on the southeast of ASCC and the primary shoreline,

2006-2010 renovation of Apiolefaga Inn to provide 12 apartment units; other- wise, no new housing construction except for extensions and repairs; and,

2011-2015 conversion of 10 single family units to two-story, duplex homes.

The cumulative effect of this prospective residential growth is that the housing stock will increase in Mesepa to roughly 126 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.64 persons per household, the future village population will include about 710 persons.

Mapusaga

In Mapusaga Village, the same Tongan community northwest of Pavaiai Elementary School will soon urbanize north into Mapusaga. Existing residential densities in this community are already about 10 to 11 units per acre.

Future residential expansion in Mapusaga Village is expected to be moderate. A significant part of the community is affluent and apparently seeks a lower density environment that averages between two and four units per acre. Future densities are expected not to exceed four units per acre and many existing residential areas at two units per acre will be maintained.

Future residential expansion is expected to include primarily single family housing within Mapusaga. A high proportion of owner occupancy, the availability of more developable lands, spectacular views, and the affluence of most homeowners will drive this type of housing construction.

Residential expansion will occur almost exclusively along existing dirt trails and paved roads in Mapusaga where undeveloped housesites are still plentiful. There are five areas where future residential growth can be expected.

- north of the existing Tongan community (between 300 and 350-foot elevation) that is about 600 feet northwest of Pavaiai Elementary School;
- west of the Mapusagafou access road between the 325 and 500-foot elevation;
- east of the Mapusagafou access road between the 265 and 475-foot elevation;
- west of the Mapusagafou access road between the 575 and 765-foot elevation; and,
- east of the Mapusagafou access road between the 485 and 600-foot elevation.

During the next 20 years, Pedersen Planning Consultants believes that such development will more specifically generate the following volume of residential construction within Mapusaga:

1996-2000 six single family homes north of the existing Tongan community (between 300 and 350-foot elevation) that is about 600 feet northwest of Pavaiai Elementary School;

18 new homes west of the Mapusagafou access road between the 325 and 500-foot elevation;

12 new homes east of the Mapusagafou access road between the 265 and 475-foot elevation;

3 new homes west of the Mapusagafou access road between the 575 and 765-foot elevation; and,

5 new homes east of the Mapusagafou access road between the 485 and 600-foot elevation.

2001-2005 six single family homes north of the existing Tongan community (between 300 and 350-foot elevation) that is about 600 feet northwest of Pavaiai Elementary School;

18 new homes west of the Mapusagafou access road between the 325 and 500-foot elevation;

12 new homes east of the Mapusagafou access road between the 265 and 475-foot elevation;

3 new homes west of the Mapusagafou access road between the 575 and 765-foot elevation; and,

5 new homes east of the Mapusagafou access road between the 485 and 600-foot elevation.

2006-2010 six single family homes north of the existing Tongan community between 300 and 350-foot elevation) that is about 600 feet northwest of Pavaiai Elementary School;

18 new homes west of the Mapusagafou access road between the 325 and 500-foot elevation;

12 new homes east of the Mapusagafou access road between the 265 and 475-foot elevation;

3 new homes west of the Mapusagafou access road between the 575 and 765-foot elevation; and,

5 new homes east of the Mapusagafou access road between the 485 and 600-foot elevation.

2011-2015 six single family homes north of the existing Tongan community (between 300 and 350-foot elevation) that is about 600 feet northwest of Pavaiai Elementary School;

21 new homes west of the Mapusagafou access road between the 325 and 500-foot elevation;

12 new homes east of the Mapusagafou access road between the 265 and 475-foot elevation;

4 new homes west of the Mapusagafou access road between the 575 and 765-foot elevation; and,

8 new homes east of the Mapusagafou access road between the 485 and 600-foot elevation.

The cumulative effect of this prospective residential growth is that the housing stock within Mapusaga will roughly double in size to 363 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.04 persons per household, the future village population will include about 2,191 persons.

Commercial

Nuuuli

Expanding commercial enterprises in Nuuuli are expected to increase demands for commercial office space as some home-based services grow beyond the capacity of their home offices. These types of commercial facilities will occur along the north and south sides of the primary shoreline roadway. The poor condition of interior trails within much of the village would discourage commercial development and customer access north and south of the primary roadway. Consequently, it is expected that future commercial facilities along the primary shoreline roadway will increasingly incorporate upper story commercial offices with ground floor retail activities.

A review of 1990 topographic maps of Nuuuli and more recent onsite observations in October, 1994 suggest that about eight commercial sites remain along Tutuila's primary roadway. Onsite observations of village commercial facilities also indicate that one commercial building is presently vacant along the south side of the primary roadway.

Despite the demand for greater commercial expansion, the development of no more than seven new commercial building sites is expected to occur in Nuuuli during the next 20 years. Three of these sites will be developed between 1996 and the year 2000. Three additional sites will be developed between 2001 and 2005. One additional commercial site will be developed between 2006 and 2010. Concurrent with new development throughout the planning period, various one-story commercial buildings will be renovated, expanded, or replaced with larger, two and three-story structures. Such development is more specifically anticipated as follows:

2001-2005	One commercial building conversion that will add ten more commercial offices and five retail shops
2006-2010	Two commercial building conversions that will add 20 more commercial offices and ten more retail shops
2011-2015	No conversions anticipated

Malaeimi

Commercial enterprises in Malaeimi primary serve the consumer demands of the consumers that travel through the community via Tutuila primary roadway. However, various retail stores and services, e.g., fast-food operations, are also geared to attract village residents, as well as nearby students from ASCC. These services are expected to continue. The expansion of such services is expected to be limited if future expansion is limited to the area east of the Tafunafou access road. It is believed that there are about four potential retail sites along the south side of the primary roadway.

However, several additional commercial enterprises could be developed if some of the more recent commercial buildings were replaced with two-story structures that would contain ground floor retail and professional/technical stairs on the second floor.

Aside from commercial retail activities, home occupations will continue to serve a wide-variety of technical services. Some of the more successful home-based enterprises may relocate two a second floor office of potential commercial buildings along the primary roadway.

During the next 20 years, commercial expansion will include the following development:

1996-2000	two new retail stores will be constructed along the south side of the primary shoreline roadway and east of the Tafunafou access road;

2001-2005 two additional retail stores will be built along the south side of the primary shoreline roadway and east of the Tafunafou access road;

2006-2010 no new commercial facility construction; and,

2011-2015 replacement of a one-story commercial building with the construction of a new two-story commercial building along the south side of the shoreline roadway and southwest of the LDS church. This building will contain four ground floor retail stores and/or services, as well as two upstairs offices.

Consequently, the community is expected to have 10 new commercial operations by the year 2015.

Mesepa

Commercial enterprises in Mesepa are expected to primarily serve the consumer demands of the ASCC faculty and students. However, the availability of land for continued expansion along the roadway is limited. One or two commercial buildings will probably be built during the 1996-2015 period as the range of demands by ASCC consumer expands.

Secondarily, home occupations in Mesepa will continue to serve a wide-variety of technical services. Future commercial growth will occur entirely along Tutuila's primary roadway. Internal roads of the village are poor and will generally not attract potential customers from ASCC or potential consumer traffic that travels through the community. Some of the more successful home-based enterprises may relocate to a second floor office of potential commercial buildings along the primary roadway.

During the next 20 years, commercial expansion will include the following development within Mesepa:

1996-2000 two new retail stores will be constructed along the southeast side of the primary shoreline roadway;

2001-2005 development of a two-story commercial building with four ground floor retail stores and/or services, as well as two upstairs offices, along the southeast side of the shoreline roadway;

2006-2010 no new commercial facility construction;

2011-2015 development of a second two-story commercial building with four ground floor retail stores and/or services, as well as two upstairs offices, along the southeast side of the shoreline roadway;

Consequently, it is anticipated that the community will have 10 new commercial operations by the year 2015.

Mapusaga

Commercial enterprises in Mapusagafou are expected to focus upon providing convenience items to local consumers. Most other retail shopping by local residents will probably be made in Nuuuli, Pavaiai, or the Pago Pago Bay Area However, the availability of land for continued commercial facility expansion along the roadway is limited. Only eight commercial buildings will probably be built during the 1996-2015 period as the range of resident demands expands.

Secondarily, home occupations in Mapusaga will continue to serve a wide-variety of professional and technical services. Future commercial growth will occur entirely along Tutuila's primary roadway. Internal roads of the village are poor and will generally not attract potential customers from ASCC or potential consumer traffic that travels through the community.

During the next 20 years, commercial expansion will include the following development within Mapusaga:

1996-2000	two new retail stores will be built; the average employment at each store will be two persons
2001-2005	two new retail stores will be built; the average employment at each store will be two persons
2006-2010	no new retail stores will be built;
2011-2015	two new retail stores will be constructed.

Industrial

Nuuuli

It is believed that future industrial development in Nuuuli will be curtailed in future years. Expanded residential and commercial facilities will discourage the construction of future industrial facilities, as well as the operation of home-based light industrial activities. Related increases in population density, in essence, will make the general population less tolerant of more noisy industrial service activities.

Malaeimi, Mesepa, and Mapusaga

A modest increase in resident population may attract a few home-based activities of an industrial nature. However, the construction of new industrial facilities is not anticipated.

Public Facilities

Through the application of 1990 age characteristics to anticipated village populations in the year 2015, the general demand for future early childhood programs, elementary education, and high school education was quantified (Table 27-6). In some cases, these demands may generate the future development of expanded public school facilities within or outside the Nuuuli Pala watershed.

TABLE 27-6
POTENTIAL DEMAND FOR PUBLIC SCHOOL FACILITIES
YEAR 2015
NUUULI PALA WATERSHED
(NUMBER OF STUDENTS)

Village	Early Childhood	Elementary	Secondary
Nuuuli	353	1,236	647
Malaeimi	73	231	122
Mesepa	33	152	50
Mapusaga	143	502	270

Source: Pedersen Planning Consultants, 1995

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Nuuuli watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 27-7 and 27-8).

TABLE 27-7
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
NUUULI PALA WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Nuuuli	197,463	731,203
Malaeimi	55,100	124,456
Mesepa	16,239	90,475
Mapusaga	57,672	259,709

Source: Pedersen Planning Consultants, 1995

TABLE 27-8
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
NUUULI PALA WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Nuuuli	138,224	511,842
Malaeimi	38,570	87,119
Mesepa	11,367	63,333
Mapusaga	40,370	181,796

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of the several streams, as well as the nearshore waters and adjoining shoreline in the Nuuuli watershed.

100-Year Peak Discharges for Selected Streams

The Federal Emergency Management Agency (FEMA) calculated the size of drainage areas and estimated 100-year peak discharges for eleven streams in the Nuuuli watershed (Table 27-9):

TABLE 27-9
ANTICIPATED 100-YEAR PEAK DISCHARGES
SELECTED STREAMS IN THE NUUULI PALA WATERSHED

Flooding Source and Location	Drainage Area (Square Miles)	100-Year Peak Discharge {cubic feet per second (cfs)}
Unnamed Stream 14		
At mouth	0.14	510
Upstream Limit	0.06	230
Sagamea Stream		
At mouth	0.18	640
Papa Stream		
At mouth	0.86	2,290
Upstream limit	0.80	2,160
Mataali Stream		
At mouth	0.21	670
Upstream limit	0.18	580
Sauino Stream		
At mouth	0.33	1,010
Upstream limit	0.15	490
Vaitele Stream		
At mouth	4.00	5,020
Above confluence with Leaveave Drainageway	2.33	4,080
Above confluence with Taumata Stream	0.45	1,180
Above confluence with Unnamed Tributary	0.28	780
Leaveave Drainageway		
Above confluence with Vaitele Stream	1.59	2,920
10,500 feet above confluence with Vaitele Stream	0.70	1,560
Taumata Stream		
Above confluence with Vaitele Stream	1.86	3,580
1,000 feet above confluence with Taumata Stream	1.78	3,480
4,200 feet above confluence with Taumata Stream	1.61	3,270
Above confluence with Mapusagatuai Stream	1.17	2,590
Mapusagatuai Stream		
Above confluence with Taumata Stream	0.35	900
3,500 feet above confluence with Taumata Stream	0.13	360
Drainageway 1		
At mouth	0.38	540
Drainageway 2		
At mouth (Note: 700 cfs flows into 2A)	2.34	1,900
10,000 feet upstream of mouth	1.60	1,480

Source: Federal Emergency Management Agency (FEMA), 1991

Inland Flood Potential

The inland flood potential that would be generated from a 100-year flood would generally impact:

- the lower reaches of Sagamea Stream, Papa Stream, Mataalii Stream, and Sauino Stream that are located within urbanized areas of the watershed; and,
- portions of the Vaitele, Taumata, Mapusagatuai, and Leaveave Stream drainages that flow with the urbanized portion of the watershed.

A correlation of FEMA 100-year flood areas with developed areas suggest that potential flood damages could occur in each of these areas. More significant flood damage may be generated in the following areas:

- seaward of the primary shoreline roadway between Matalii Stream and Sagamea Stream;
- the east and west sides of Taumata Stream upland of the primary roadway;
- upstream of the Taumata and Vaitele Stream confluence.

The following areas within the Nuuuli watershed have been designated by FEMA as "zone x:"

- Pago Pago International Airport;
- Coconut Point;
- most upland areas above the primary shoreline roadway that are not adjacent to streams;
- Southwest of the mouth of Mataalii Stream

This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazards

The flood insurance rate map, which was prepared by FEMA for the nearshore waters of the Nuuuli watershed, indicate that there is a coastal flood hazard for much of the nearshore waters and adjoining shoreline in the watershed. A 100-year flood is expected to produce flood elevations along the shoreline that would range between two and three feet above mean sea level (MSL).

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Source of Stormwater Runoff and Sedimentation

Stormwater runoff that is carried by 13 streams in the watershed generates increased turbidity and sedimentation levels in Pala Lagoon and the adjoining nearshore waters east of Coconut Point. These conditions primarily occur during or following after heavier rainfall periods.

The source of runoff is from two primary sources. Soils from the Fagasa family- Lithic Hapludolls-Rock Outcrop Association, as well Aua very stony silty clay loam, represent two highly erosive soils that generate severe runoff. In addition, impermeable surfaces in the urbanized area of Nuuuli Village also make a significant contribution of turbid stormwater.

A recent stormwater model of Vaitele Stream (including all tributaries) was prepared by Pedersen Planning Consultants in July, 1998. Selected results of the model, which are summarized in Table 27-10, indicate a significant discharge of sediments from Vaitele Stream during more frequent storm events, i.e. 2-year storm. A 2-year storm represents a theoretical storm event that can occur approximately once every 2 years, or about 20 percent of the time.

TABLE 27-10
STORMWATER MODELING RESULTS
VAITELE STREAM
PEAK FLOW CONDITIONS
2,10,50, AND 100-YEAR STORM EVENTS

	2-Year	10-Year	50-Year	100-Year
Peak Flow (cfs)	2,978	4,553	7,447	8,338
Sediment Loading (tons per storm event)	173	278	479	545

Source: Pedersen Planning Consultants, 1998

Fortunately, Pala Lagoon detains and permits the deposition of most sediments that are discharged into the Lagoon. The stormwater detention capabilities of Pala Lagoon are indicative of a well-functioning wetland. However, other functions of Pala Lagoon include its role as an important spawning ground for aquatic fishes and invertebrates. In this role, the maintenance of water quality is important to foster this important aquatic function. Consequently, the development of inland stormwater detention opportunities are important to sustain Pala Lagoon's function as a spawning ground for aquatic fishes and invertebrates.

Potential Inland Detention Opportunities

Limited stormwater detention opportunities are available in the inland watershed since much of the lower watershed is already urbanized. The lower Vaitele Stream drainage, however, merits a potential feasibility evaluation and related conceptual plan which are being prepared at the time of this report. The widening of stormwater flows along a wider drainage area, combined with the use of appropriate grasses and other vegetation, may represent a viable detention option. Potential recreational opportunities may also be afforded with this development option.

A significant opportunity for stormwater detention and groundwater recharge is Malaeimi Valley. The restriction of new land uses in this area will enable the Valley environment to continue these valuable functions.

Other potential opportunities include a small depression south of ASCC Land Grant Office. This area contains hydric Leafu silty clay soils (SCS soil mapping unit 8); however, the lack of obligate plant species in this area suggests that it is not a wetland. Nevertheless, this area should be conserved to foster stormwater detention and groundwater recharge opportunities.

Along the lower Sauino Stream drainage, approximately 500-600 feet upstream of the stream mouth, the development a small stormwater detention area, may be feasible. This low area is undeveloped and adjacent to residential and agricultural land uses.

Nearshore Water Quality and the Marine Environment

The concern for continued turbidity and sedimentation in the nearshore waters east of Coconut Point and adjacent to the Pago Pago International Airport is also important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the Nuuuli Pala watershed. They provide shelter to fish, invertebrates, and other marine organisms. Some of these resources represent a supplemental food source for residents of the Nuuuli watershed and other areas in West Tutuila.

The future monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of Pala Lagoon. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters. Nutrient loading in Pala Lagoon is a potential concern for aquatic and marine habitat.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef front east of Coconut Point at least once every three years. Monitoring of this site should also include an evaluation of the potential impact of sedimentation and turbidity that may also be influencing the nearshore marine environment.

Groundwater and Surface Water Supplies

Enforcement of Regulations Associated With Connection to the ASPA Wastewater Collection System

While regular chlorination of the groundwater supplies remains effective, many homes and commercial facilities in the Nuuuli Pala watershed are not connected to ASPA's wastewater system. Local soils in the Nuuuli Pala watershed are generally ineffective to treat wastewater from septic tanks because of the limited depth to bedrock and other soil characteristics. Consequently, ASPA must remain committed to the enforcement of its regulations that require the connection of any residential and commercial facility that is within 300 feet of any ASPA wastewater collection system.

Coordination of Land Use and Wastewater Facility Planning by ASDOC and ASPA

It is essential that future land uses in the watershed occur where ASPA wastewater collection systems are available. Otherwise, the basal aquifer is unnecessarily exposed to long-term bacterial and nutrient contamination. It is recommended that no new residential and commercial development should be permitted in the Nuuuli Pala watershed without the concurrent expansion and/or connection to ASPA's wastewater collection system.

The ASG Department of Commerce should use, in part, its village master planning process in Tualauta County to encourage such development. ASPA should continue its aggressive wastewater capital improvement program to extend its Tafuna wastewater collection system to areas that can be cost-effectively developed, operated and maintained. Both ASPA and the ASG Department of Commerce must coordinate land use and infrastructure planning efforts in order to foster and facilitate the concurrent expansion of land uses with the expansion of wastewater collection system.

Conservation of Malaeimi Valley for Future Groundwater Recharge

The conservation of some land areas in the Nuuuli Pala must be conserved to ensure the long-term recharge of rainfall into Tutuila's basal aquifer. It is recommended that no new land uses be permitted within Malaeimi Valley. Existing land uses should be permitted to remain. Agricultural uses should also remain a permitted use in Malaeimi Valley. However, all future chemical applications associated with agricultural activities should require prior review and authorization by the ASG Department of Agriculture and the American Samoa Environmental Protection Agency.

Salt Water Intrusion

Groundwater levels are approximately three to six feet above mean sea level through most of the Tafuna-Leone Plain. *"Because saltwater underlies freshwater everywhere, saltwater upconing can occur where well depths and pumping rates are not matched to the aquifer hydraulic conductivity, rates of ground-water flow, and freshwater lens thickness"* (U.S. Geological Survey, 1989). The draft Utilities Master Plan recommends that future ASPA groundwater wells should be drilled no deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered. It is recommended that this policy be adopted by the ASPA Water Division.

Monitoring of Potential Groundwater Well Contamination

During the April, 1996 survey of the watershed, Pedersen Planning Consultants observed that chemical applications had apparently been made to a smaller faatoaga in Malaeimi that was immediately adjacent to ASPA well #67. Chemical applications to groundwater wells should not be made with a radius of, at least, 200 feet to any groundwater well in American Samoa. Groundwater well sites in the watershed should be regularly monitored by ASEPA to ensure that such applications are not made in the immediate vicinity of groundwater wells.

Revitalization of Waste Oil Collection and Recycling

Another source of continuing groundwater contamination is the indiscriminate discharge of petrochemical products, e.g., waste oil from vehicles, on lands and into streams within the watershed. A continuing, long-term objective of the American Samoa Government should be to significantly reduce these discharges into streams and lands of the watershed. An aggressive cooperative effort should be made by ASEPA, ASCMP, and ASPA to revitalize its waste oil collection and recycling program that was established in 1990. Greater publicity, community education, and more collection centers are needed in the Nuuuli Pala watershed to sustain an effective, long-term program. A regular pickup of waste oils should be made from various commercial and industrial sources in the Tafuna Industrial Park. In addition, collective centers need to be maintained by the owners of each site who, in turn, should be rewarded with the placement of advertising by ASG that mentions specific retail locations.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Nuuuli watershed will be to:

- Continue enforcement of ASPA regulations associated with connections to the ASPA wastewater collection system.
- Coordinate future land use and wastewater facility planning efforts of ASDOC and ASPA.
- Restrict the establishment of new land uses in Malaeimi Valley.
- Establish groundwater development policies that minimize the potential for saltwater intrusion into future groundwater supplies.
- Restrict herbicide and pesticide applications in the immediate vicinity of groundwater well sites.
- Revitalize waste oil collection and recycling efforts.
- Conserve and enhance inland stormwater detention areas for stormwater detention and groundwater recharge.
- Maintain the integrity of Pala Lagoon and its adjoining wetland to support functions that provide habitat for aquatic and marine life, wildlife habitat, and stormwater detention.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with designated residents of Nuuli, Malaeimi, Mesepa, and Mapusaga, and encourage the village's implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 27-11. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 27-11
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
NUUULI PALA WATERSHED

Participating Public agency	Resource Management Objective	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated residents from each village in the watershed. 4. Make annual assessment of resource management program.
ASEPA	Conserve groundwater quality	Restrict use of herbicides and pesticides in the immediate vicinity of groundwater wells and perform related monitoring of well sites.
ASEPA	Conserve and enhance potential inland stormwater detention and groundwater recharge opportunities	1. Investigate potential stormwater detention opportunities at Vaitele Stream, Sauino Stream, and ASCC property near Land Grant office. 2. Where feasible, prepare conceptual plans for storm-water detention and estimate order-of-magnitude costs.
ASEPA	Revitalize waste oil and recycling efforts.	1. Work cooperatively with ASPA and ASCMP to re-evaluate program objectives, strategies, and agency responsibilities for implementation. 2. Establish new collection stations in the watershed. 3. Select contractor to provide regular collection of waste oil from commercial sources and deliver to ASPA and canneries for recycling.
ASEPA	Enhance the function of Pala Lagoon and adjoining wetland for aquatic and marine habitat, wildlife habitat, and stormwater detention.	1. Investigate opportunities for wetland restoration and enhancement in Pala Lagoon and the adjoining wetland. 2. Develop implementation strategies for wetland restoration and long-term monitoring.
ASEPA	Detain stormwater runoff in future residential and commercial areas.	1. Require the use of onsite drywells for all new commercial facilities. 2. Require the use of onsite drywells for all new residential construction on steeper slopes of the watershed.

continued – next page

TABLE 27-11 (Continued)
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
NUUULI PALA WATERSHED

ASDOC	Encourage new land use development where wastewater collection systems are available or will be developed.	1. Incorporate the location of wastewater collection systems in village plans for Nuuuli, Malaeimi, Mesepa, and Mapusaga. 2. Coordinate the preparation of village plans with ASPA Wastewater Division.
ASDOC	Conserve Malaeimi Valley for stormwater detention and groundwater recharge opportunities.	3. Prepare resolution for the Territorial Planning Commission that enables ASDOC to restrict the establishment of new land uses in Malaeimi Valley for its approval. 4. Submit approved resolution to Governor and Fono for their approval.
ASDOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
ASPA	Reduce potential saltwater intrusion into groundwater wells of the watershed.	ASPA Board of Directors and Water Division should adopt a policy that no groundwater wells will be drilled no deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered.
ASDPW	Maintain stormwater culverts along the primary shoreline roadway.	1. Establish a periodic maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Maintain all culverts along the primary shoreline roadway.
ASDMWR	Maintain and enhance fish and wildlife habitat in Pala Lagoon.	1. Monitor and quantify changes in aquatic and marine fish and invertebrates, as well as wildlife of Pala Lagoon, every three years. 2. Identify stresses upon plant and animal communities.
ASDMWR	Restore marine communities in the nearshore waters east of Coconut Point.	1. Monitor and quantify changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) along the fringing reef front east of Coconut Pt. approximately every three years. 2. Identify stresses upon coral communities and marine life and evaluate potential impacts from sedimentation.

Source: Pedersen Planning Consultants, 1998

CENTRAL TAFUNA PLAINS
Watershed 28

GEOGRAPHY

The Central Tafuna Plains watershed is located in the western one-third of Tutuila Island. The watershed comprises about 5.5 square miles of land area (Figure 28-1).

The inland boundaries of the watershed generally include Olotele Mountain, the east slopes of Olovalu Crater, Logotala Hill, and Pago Pago International Airport.

Along the shoreline, the southwestern boundary of this watershed is Sail Rock Point, which is located on the east side of Larsen Bay. The northeast boundary is approximately 1,200 feet north of the radio facility that is adjacent to the Pago Pago International Airport runway. No embayments are adjacent to the shoreline of the watershed. However, five smaller coves indent the shoreline.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 28-2). Twelve soil classifications were identified by the U.S. Soil Conservation Service for lands within the Tafuna watershed (Table 28-1).

Iliili Extremely Stony Mucky Clay Loam (3 to 15 percent slopes)

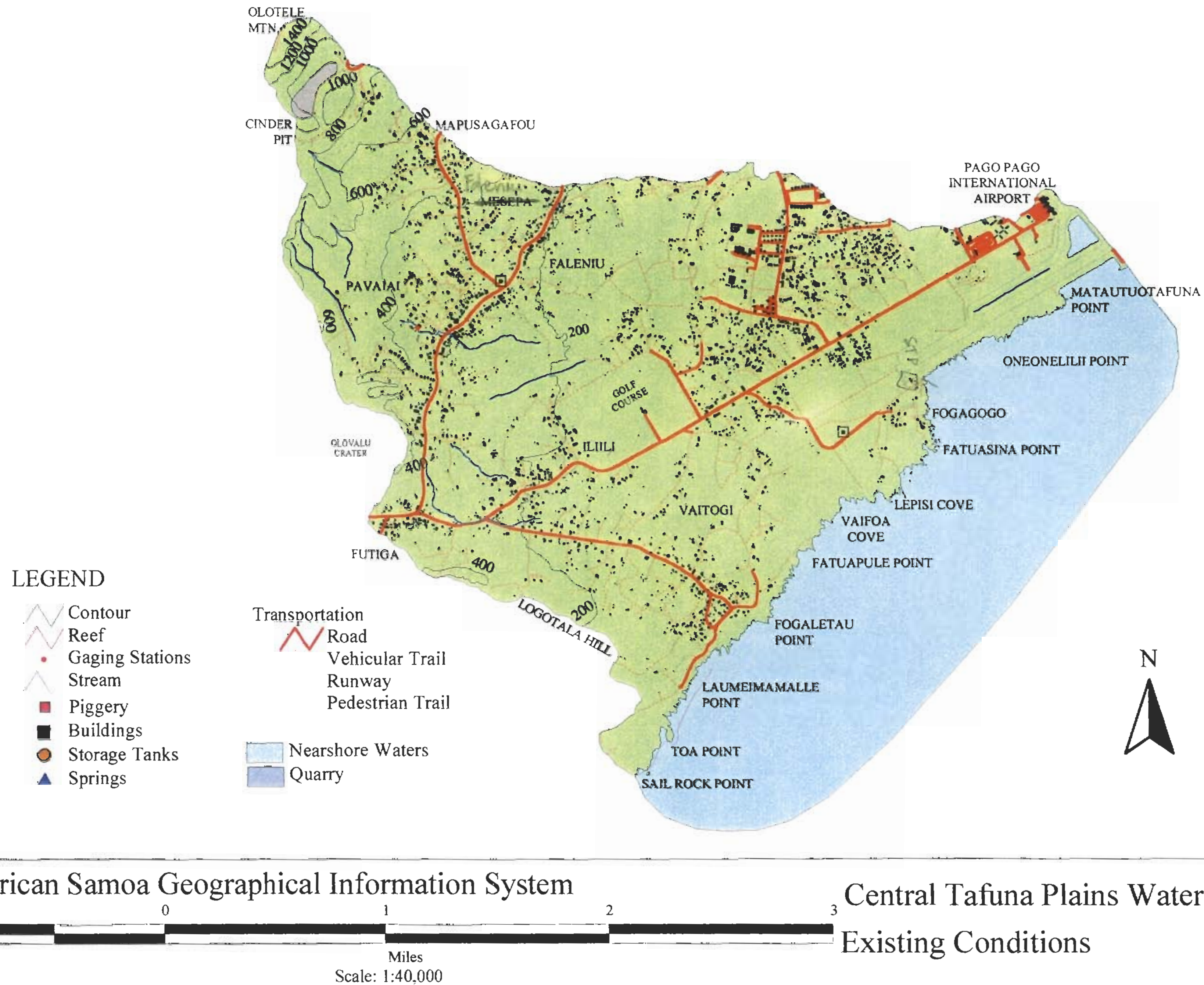
Iliili extremely stony mucky clay loam (SCS mapping unit 5) comprises most of the soils in the western one-third of the watershed. It extends north from the shore at Sail Rock Point to Pavaiai Village. This soil type is also found generally north and west of Vaitogi Village.

Iliili extremely stony mucky clay loam are underlain by lava and formed by volcanic ash. The surface layer represents a very dark, grayish-brown, clay loam that is about five inches thick. The subsoil includes about four inches of very dark, grayish-brown, clay loam that is extremely stony.

The permeability of the soil is rapid. This Iliili soil has a slight potential to generate water erosion; its runoff is slow.

The stony surface layer and limited depth to bedrock constrain cultivation, as well as residential development.

Iliili extremely stony mucky clay loam provides a stable building foundation; however, the soil is difficult to excavate. The treatment of sewage effluent from soil-based treatment systems is not recommended since the soil does not adequately treat wastewater. The use of community sewage systems is required to prevent groundwater contamination.



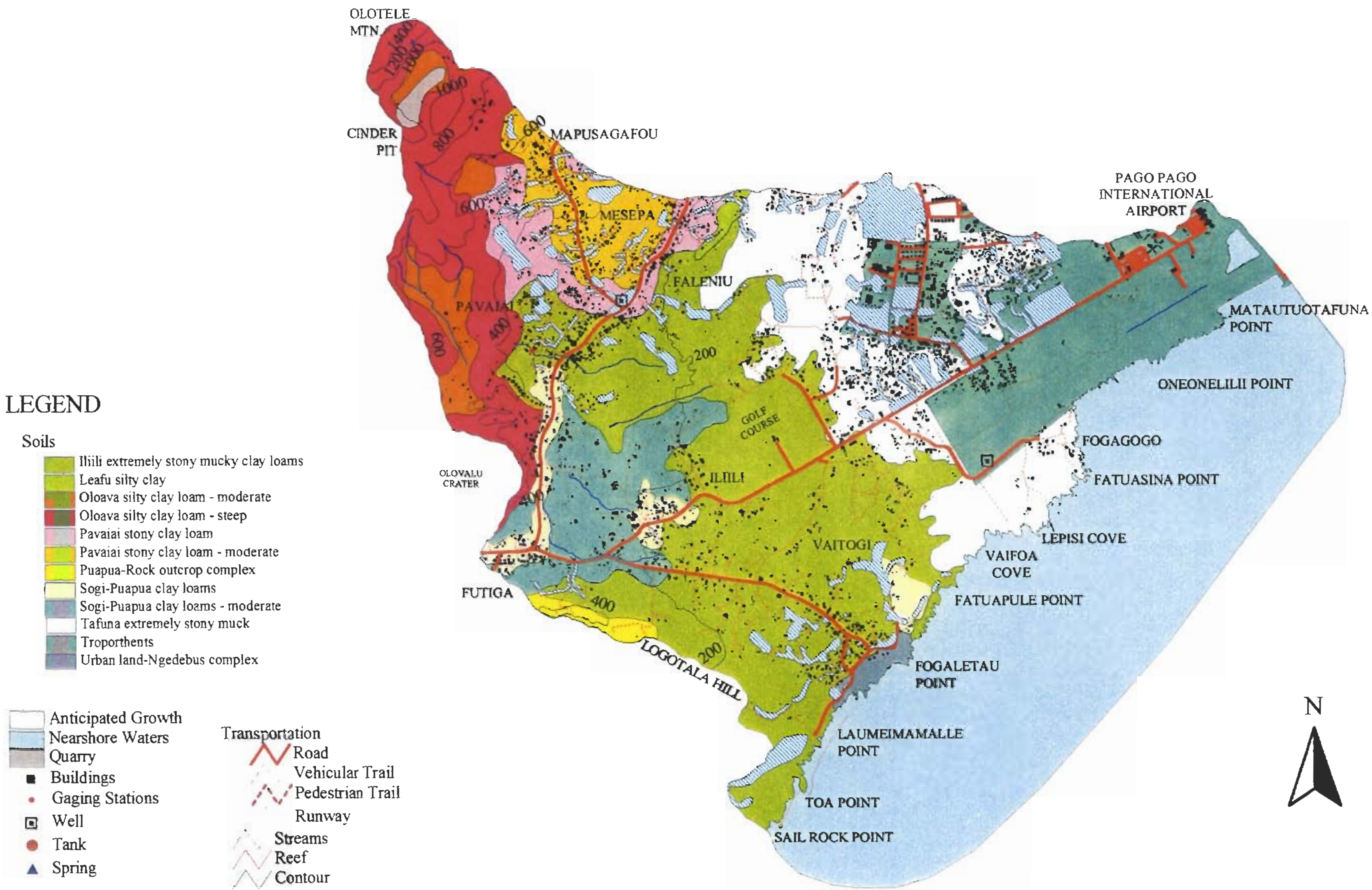
American Samoa Geographical Information System

Central Tafuna Plains Watershed 28

Existing Conditions

Figure 28-1

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434



American Samoa Geographical Information System

1 0 1 2 3

Miles
Scale: 1:40,000

Prepared by: Pedersen Planning Consultants   Tel: 307-327-5434

Central Tafuna Plains Watershed 28

Management Issues

Figure 28-2

TABLE 28-1
SELECTED SOIL CHARACTERISTICS
CENTRAL TAFUNA PLAINS WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
5	Iliili extremely stony mucky clay loam	3-15	None	Slow	Slight	>6	8-20	Severe Depth to rock, Large stones	Poor
8	Leafu silty clay	0-3	Occ	Slow	Slight	3-5	>60	Severe Flood Wet	Moderate
20	Oloava silty clay loam	12-25	None	Slow to Med	Slight to Moderate	>6	>60	Severe Poor Filter Slope	Good
21	Oloava silty clay loam	40-100	None	Rapid	Severe	>6	>60	Severe Poor Filter Slope	Poor
23	Pavaiai stony clay loam	6-12	None	Slow to Med	Slight to Moderate	>6	38	Severe Depth To Rock	Moderate
24	Pavaiai stony clay loam	12-25	None	Med	Moderate	>6	38	Severe Depth To Rock Slope	Moderate
26	Puapua-rock outcrop complex	40-100	None	Rapid	severe	>6	10-20	Poor Depth to Rock	Poor
28	Sogi-puapua clay loams	0-6	None	Slow	Slight	>6	10-40	Poor Depth to Rock	Moderate
29	Sogi-puapua clay loams	6-20	None	Slow to Med	Slight to Mod	>6	10-40	Poor Filter Depth to Rock	Moderate
32	Tafuna extremely stony muck	0-6	None	Very Slow	Slight	>6	40-60	Severe Poor Filter Large Stones	Poor
33	Troporthents	0-6	N/A	Slow to Med	Slight	N/A	N/A	N/A	N/A
35	Urban land-Ngedebus complex	0-5	Occ. brief	Slow	Slight	>3.5	>60	SevereFlood Wet Poor Filter	Poor

Source: U.S. Soil Conservation Service, 1984

Urban Land-Ngedebus Complex

Urban land-Ngedebus complex soils (SCS mapping unit 35) is situated along the shoreline of Vaitogi Village.

These soils generally comprise coral fragments, sand, cinders and other material that have been graded or filled to support residential, commercial and public facilities in the village areas.

The Ngedebus soil extends to a depth of 60 inches or more. The surface layer, which extends about 4 inches below ground elevation, typically contains light, brownish-gray and brown sand. The underlying material is characterized by pale brown and light yellow, brown sand. The permeability of Ngedebus soil ranges between six and 20 inches per hour.

Surface drainage on this soil is generally slow, and the hazard of potential soil erosion is slight. In some places, the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide (U.S. Soil Conservation Service, 1984).

These soils are generally suitable to support residential and commercial development in areas that are protected from flooding. However, this soil is poorly suited in unprotected areas.

Where moderate to higher housing densities occur, the U. S. Natural Resources Conservation Service recommends the use of community sewage systems prevent the potential contamination of groundwater and surface water supplies. Lower housing densities are present in Vaitogi.

Tafuna Extremely Stony Muck (3 To 15 Percent Slopes)

Tafuna extremely stony muck (SCS mapping unit 32) is located in much of the Tafuna area.

Tafuna extremely stony muck is a deep, well-drained, organic soil that overlays fragmented *aa* lava. The surface layer, characterized by a black, extremely stony muck that is about nine inches thick, is typical of the surface layer. A thin subsoil, approximately nine inches thick, consists of very-dark, grayish brown and dark brown muck that is extremely stony. Fragmental aa lava is the underlying material to a depth of 43 inches or more.

The depth of bedrock is primarily 40 to 60 inches or more. However, the depth to bedrock is 24 to 40 inches in some areas.

Tafuna soil has very rapid permeability. The potential for water erosion is slight; runoff is very slow.

The bedrock provides a good, stable foundation for building structures. However, site development and excavations are constrained by the presence of stones. In addition, this soil is unable to adequately treat wastewater effluent from soil-based treatment systems.

Troporthents

Troporthents (SCS soil mapping unit 33) is situated in the vicinity of Pago Pago International Airport. The Airport area has been altered by filling, cutting, and smoothing. This soil unit also includes smaller areas of Urban land, rock outcrop, Iliili extremely stony mucky clay loam, and Tafuna extremely stony muck.

Troporthents are well-drained soils that primarily consist of a mixture of cobbles, sand, gravel, and some fine textured materials. Coral sand, coral, cinders, and other materials also are found in some filled areas. Fragmental *aa* lava or bedrock is the underlying material (U.S. Soil Conservation Service, 1984).

Slow to moderately rapid permeability characterizes Troporthents soils. Stormwater runoff drains at a slow to medium rate. The potential for water erosion is slight (U.S. Soil Conservation Service, 1984).

Troporthents is somewhat suited for residential and urban development. This soil represents a firm foundation for structural development. However, residential and urban uses are constrained by the limited depth to bedrock. Community wastewater systems are needed to prevent contamination of water supplies if the density of housing is moderate to high. The use of onsite sewage disposal systems in this soil would generate an undesirable discharge to the local basal aquifer (U.S. Soil Conservation Service, 1984).

Pavaiai Stony Clay Loam (6 To 12 Percent Slopes)

Pavaiai stony clay loam soils (SCS soil mapping unit 23) are located immediately north of Pavaiai Village in the northern part of the watershed.

This soil is formed in volcanic ash and underlain by lava. The surface layer typically contains a very dark, grayish-brown, stony clay loam that is about 7 inches thick. In some cases, the surface layer contains a silty clay loam. The subsurface layer, approximately 5 inches thick, and is a very dark, grayish-brown, clay loam. The subsoil is characterized by a dark brown, very cobbly, sandy loam that is roughly 26 inches thick. A lava bedrock is encountered between 20 and 40 inches below ground elevation (U.S. Soil Conservation Service, 1984).

The permeability of this Pavaiai soil is moderately rapid. The potential for erosion is slight to moderate; the rate of stormwater runoff is generally slow to medium (U.S. Soil Conservation Service, 1984).

Pavaiai stony clay loam soils are moderately suitable for subsistence agriculture. The production of subsistence crops is constrained somewhat by the presence of stones, the limited depth to rock, and the hazard of water erosion. However, the content of stones in the surface layer in usually not significant enough to impact planting and other agricultural. The use of mulch, crop residue, and cross-slope farming can reduce the potential of erosion.

Pavaiai stony clay loam soils are moderately suitable for residential development. The presence of stones, the limited depth to bedrock, and slope represent constraints to residential land use. The design of access roads should incorporate measures to control of surface runoff and stabilize cut slopes.

Pavaiai Stony Clay Loam (12 to 25 percent slopes)

This soil (SCS soil mapping unit 24) is found in the vicinity of Faleniu Village.

This moderately deep, well-drained soil was formed in volcanic ash and is underlain by lava. The surface layer, which is about seven inches thick, is typically a very dark, grayish-brown, stony clay loam. In some areas, the surface layer is a stony silty clay loam. The subsurface layer is only about five inches thick and contains a very dark, grayish-brown, clay loam. A dark brown, very cobbly sand loam represents the subsoil that is about 26 inches thick. A lava bedrock occurs at a depth of about 20 to 40 inches.

Rock outcrops also occur in some small areas. Where they occur, the depth to bedrock is less than 20 inches.

The permeability is moderately rapid for this Pavaiai soil. The available water capacity is moderate, and effective rooting depth is 20 to 40 inches. The hazard of water erosion is moderate, since runoff is medium.

These Pavaiai soils are moderately suited to the production of subsistence crops. The primary constraints are slope, the potential for water erosion, the limited depth to bedrock, and the presence of stones. The presence of stones in the surface layer is not significant enough to affect the planting of subsistence crops. The control of erosion can be accomplished by the use of crop residues and mulch, as well as cross-slope farming.

Residential uses on these soils have moderate suitability. The design of access roads should incorporate measures to control of surface runoff and stabilize cut slopes.

Leafu Silty Clay (0 to 3 percent slopes)

The east side of Faleniu is characterized by Leafu silty clay soils (SCS mapping unit 8).

This soil is a deep soil that typically extends up to 60 inches in depth. Its permeability ranges between 2 and 6 inches per hour. Runoff from these soils is generally slow and the potential for soil erosion is limited. However, these soils are typically subject to brief periods of flooding during prolonged, heavier rainfall.

These soils are moderately suitable for subsistence agriculture. However, this land use is constrained by occasional periods of flooding and general soil wetness. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these Leafu soils for residential land uses is not recommended by the U.S. Soil Conservation Service because of the inherent flood potential associated with this soil. The same characteristics also hamper the use of these soils for septic tank systems and related soil-based treatment.

Oloava Silty Clay Loam (40 to 100 percent slopes)

Most of the south face of Olotele Mountain and all of Olovalu Mountain contain a soil known as Oloava silty clay loam (SCS soil mapping unit 21).

The Oloava silty clay loam is a well-drained soil that was formed in volcanic ash and cinders. The surface layer is typically is a dark brown silty clay loam that is about six inches thick. A dark brown, clay loam is characteristic of the upper five inches of the subsoil while the lower three inches is a dark brown, gravelly-silt loam. Weathered cinders extending to a depth of 60 inches represent the substratum. Within 12 to 30 inches from ground elevation, weathered cinders gradually crush to very gravelly sandy loam.

Exposed cinders and small rock outcrops occasionally occur in conjunction with these Oloava soils.

The permeability of this Oloava soil ranges between 2 and 6 inches per hour above the cinder layer. However, permeability through the cinder layer, i.e., between 14 and 60 inches, increases to a rapid rate greater than 20 inches per hour.
These soils have a severe potential for water erosion. Stormwater runoff rates are rapid.

These soils are not suitable for the production of subsistence crops. These soils typically occur on steeper slopes and have a severe water erosion potential.

Similar soil characteristics also make these Oloava soils are unsuitable for residential and commercial structures.

Oloava Silty Clay Loam (12 to 25 Percent Slopes)

Oloava silty clay loam (SCS soil mapping unit 20) is found along portions of the south face of Olotele Mountain.

In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a dark-brown, silty clay loam. Soft, weathered cinders are typically present between 12 to 40 inches in depth. However, the depth to weathered cinders sometimes extends to 60 inches or more.

The permeability of the Oloava soil is moderately rapid, i.e., 2 to 6 inches per hour, through the surface layer. However, permeability becomes very rapid, i.e., 6 to 20 inches per hour, through the cinder material that occurs between 12 to 60 inches in depth (U.S. Soil Conservation Service, 1984).

The rate of stormwater runoff through these Oloava soils is typically slow. The potential for water erosion is considered slight (U.S. Soil Conservation Service, 1984).

This soil is well-suited to the production of subsistence crops. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers.

Residential development is not desirable on these soils. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment.

Sogi-Puapua Clay Loams, 6 to 20 Percent Slopes

Sogi-Puapua clay loams (SCS soil mapping unit 29) are situated in the vicinity of Iliili Village.

This upland soil represents a combination of approximately 45 percent Sogi clay loam and about 40 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches.

The potential hazard for water erosion is slight to moderate. The U.S. Soil Conservation Services estimates that potential runoff is slow to medium.

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches. Potential runoff from this soil is considered to be slow to medium. Potential water erosion from this soil is estimated to be slight to moderate.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock and potential water erosion. However, potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

Sogi-Puapua Clay Loams, O to 6 Percent

Sogi-Puapua clay loams (SCS soil mapping unit 28) are situated in the vicinity of Iliili, Futiga, as well as southwest of Pavaiai.

This upland soil represents a combination of approximately 50 percent Sogi clay loam and about 35 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam, is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Potential runoff from this soil is considered to be slow. Potential water erosion from this soil is estimated to be slight (U.S. Soil Conservation Service, 1984).

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock. Potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

Puapua-Rock Outcrop Complex, 40 to 100 Percent Slopes

Soils identified by the U.S. Soil Conservation Service as Puapua-Rock Outcrop Complex (SCS soil mapping unit 26) are found on the slopes of Logotala Hill which are generally north of Larsen Bay and Fogamaa Crater.

About 50 percent of the Puapua-Rock outcrop complex soil comprise Puapua clay. About 30 percent of the soil include rock outcrop. The Puapua soil is typically found on the steeper slopes. The rock outcrop, which consists of exposed areas of lava and hard volcanic tuff, occurs primarily on crater rims, ridgetops, and the sides of smaller gullies (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

Soil permeability for Puapua soils range between two and six inches per hour above the tuff. However, permeability is slow through the tuff.

Potential soil runoff is considered to be rapid. The potential for water erosion is severe (U.S. Soil Conservation Service, 1984).

The Puapua-Rock outcrop complex soils are not well suited for agricultural uses. Steeper slopes constrain cultivation efforts. Subsistence crop production is hampered by the presence of rock outcrop areas. Any subsistence production should include the regular application of crop residues, mulch, or other ground cover materials.

Residential uses are impacted by steeper slopes and the inability to use septic tanks or other soil-based treatment systems. Roads must be designed to minimize the potential for erosion. However, road construction is influenced again by the presence of rock outcrop areas.

Streams

A 1994 Tafuna Plain Drainage Study, prepared by the U.S. Army Corps of Engineers, identifies four drainageways and one unnamed stream in the vicinity of Iliili (Figure 28-3). The size of the drainage areas is summarized in Table 28-2.

With the exception of the southeast slopes of Olotele Mountain and the east slopes of Olovalu Crater, the topography of the Central Tafuna Plains watershed contains little variation and lacks any well-defined drainage or stream channels.

Missing Figure 28-3

< INSERT FIGURE 28-3 >

TABLE 28-2
DRAINAGEWAY AND STREAM BASINS
CENTRAL TAFUNA PLAINS

Drainage Basins	Drainage Area (square miles)
Drainageway 2 and 2A	2.23
Drainageway 3	0.81
Drainageway 4	0.13
Drainageway 5	0.39
Unnamed Stream near Iliili	0.16

Source: U.S. Army Corps of Engineers, Pacific Ocean Division, 1994

Wetlands

There are no significant wetlands in the Tafuna watershed.

Marine Resources

Coral Communities

Pago Pago International Airport was built in the 1940's. The original airport and runway was constructed on the widest coral reef on the Island of Tutuila. In 1959, a second runway was built on the coral reef south of the original runway (Aecos and Aquatic Farms, 1980).

Between Matautuotafuna Point and Sail Rock Point, the nearshore waters contain limited fringing coral reef communities.

Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests that:

- An infestation of the crown-of-thorns starfish was evident northeast of Matautuotafuna Point in January, 1979. By October of the same year, few starfish were observed in this area.
- The 1992 survey found signs of damage from recent storms. Live stony coral coverage was reported to be less than one percent at a depth of 18 meters at both Vaitogi and Fogagogo.

<u>1978-1979</u>

In January 1979, numerous crown-of-thorns starfish were observed seaward of the radio facility at Pago Pago International Airport (northeast of Matautuotafuna Point). However, the abundance of the starfish was considerably less than the concentrations of starfish that were reported higher on the reef flat east of the Airport runway (see Nuuuli Pala watershed). By October, 1979, few starfish were observed on the outer reef flat seaward of the radio facility (Aecos and Aquatic Farms, 1980).

<u>1992</u>

Field investigations were made by Maragos, Hunter, and Meier in the vicinity of Vaitogi and Fogagogo in 1992. These sites represented offshore areas that were generally deep, flat, terraces that demonstrated signs of damage from recent storms.

Live stony coral coverage was less than one percent at a depth of 18 meters at both Vaitogi and Fogagogo. At six meters, coral coverage ranged between one and five percent at Fogagogo.

Wildlife Resources

In the 1970's, a small colony of the uncommon sheath-tailed bat was reported to roost in caves at Sail Rock Point (Aecos and Aquatic Farms, 1980).

Shoreline Protection

Lava sea cliffs, which average between 10 and 15 feet above mean sea level, characterize much of the shoreline between Matautuotafuna Point and Sail Rock Point. Limited development occurs along the shoreline of the watershed near Fogagogo and Vaitogi.

A few, small beach areas are located on this coastline. For example, one small beach is located on the northeast side of Matautuotafuna Point.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. No shoreline protection improvements were identified for the shoreline of the Central Tafuna Plains watershed.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

Operating Groundwater Wells

The villages in the Central Tafuna Plains watershed rely upon a potable water supply that is supplied by the American Samoa Power Authority. There are, at least, six wells in the Central Tafuna Plains watershed that are actively used by ASPA for the production of ground water (Table 28-3). These wells, which are located in Iliili and Tafuna, contribute a significant volume of groundwater to the Island of Tutuila's overall groundwater supply.

"ASPA regularly disinfects the groundwater supply at 11 wells by treatment with chlorine. The water is also chlorinated at two booster stations and at the chlorination station in Tafuna. The American Samoa Environmental Protection Agency (ASEPA), which monitors American Samoa's groundwater quality, reports that disinfection efforts are effective and chlorine residuals are maintained throughout the ASPA water system" (ASPA, 1995).

TABLE 28-3
GROUNDWATER WELLS IN THE CENTRAL TAFUNA PLAINS WATERSHED OPERATED BY ASPA

Pump Location	Well Number	Ground Elevation	Well Depth (feet)	Normal Discharge Rate (gpm)	Normal Head (psi)	Elevation Above Mean Sea Level
Iliili	62	204	226	96	Unknown	-22
Iliili	76	198	206	230	0	-8
Iliili	79	214	224	70	50	-10
Iliili	84	142	165	220	25	-23
Tafuna	46	72	92	165	25	-20
Tafuna	53	84	150	145	25	-66

Source: ASPA Draft Utilities Master Plan, 1995

Continued Use of Individual Wastewater Disposal Systems

The future conservation of groundwater quality remains an important concern of the Territory. Land use development and increased population pressures are most prominent in the Central Tafuna Plains and Nuuuli Pala watersheds. While a significant expansion has been made of the ASPA wastewater collection system, the continued use of individual onsite wastewater disposal systems, e.g., septic tanks and cesspools, in these watersheds continues to contaminate Tutuila's basal aquifer. Frequent heavier rainfall periods transport a significant amount of bacteria and nutrients through a thin soil layer and the basaltic substrata. Consequently, a significant amount of the ground water used in the ASPA water system contains elevated levels of bacteria and turbidity (ASPA, 1995).

Chloride Contamination

In recent years, groundwater quality data has generally not indicated the presence of any long-term contamination of groundwater wells in the Central Tafuna Plains watershed. One exception is the chloride content of American Samoa's ground water which exceeds the National Secondary Drinking Water Regulations standard in portions of ASPA's overall service area.

On August 8, 1994, ASPA's 32 main system wells were tested for chloride concentrations. Four of these wells, i.e., Iliili #84, Tafuna #53, Aua #97, and Craddick, exceeded the Secondary Regulations maximum contaminant level of 250 milligrams per liter. Each of these wells has, historically, been characterized by elevated chloride levels (ASPA, 1995).

"Higher chloride levels in wells has been a problem since wells were first drilled in American Samoa. During prolonged droughts, chloride levels rise and water rationing is required. Wells must be temporarily removed from service; on two occasions, the tuna canneries were shut down to conserve water. Some wells in the Tafuna-Leone area and in Aua have been permanently abandoned due to saltwater intrusion.

Elevated chloride levels are cause for concern since they indicate saltwater upconing in the wells. This condition can cause long-term damage to the aquifer. The potential impact from saltwater upconing may have already occurred in the Tafuna and Aua areas.

Two primary factors contribute to saltwater intrusion into basal lens wells, which are the more common type of well in American Samoa:

- *the elevation of the bottom of the well in relation to mean sea level; and,*
- *the rate of extraction from the aquifer.*

The Ghyben-Herzberg ratio developed for basal lens aquifers states that the freshwater lens is 40 times as deep as the head of water above the sea level. To minimize upconing of saltwater, wells should not be deeper than one-third of the thickness of the freshwater lens. In the Tafuna Plains area, the lens is believed to be approximately 120 feet thick and wells drilled in a lens of this thickness should be no deeper than 40 feet. Accurate vertical control must be used to determine the static elevation of the lens surface because this will dictate the maximum depth of the well.

The rate of extraction from the aquifer is significant because higher rates are much more likely to cause upconing. At the same time, dikes and layers of the older volcanics can trap freshwater at significant depths below sea level. In Pago Pago and Aua, wells have been drilled more than 100 feet below sea level before freshwater has been encountered. However, wells of this type must be monitored often for chloride content. If levels begin to rise, the pumping rate must be reduced" (ASPA,1995).

The chloride level, well bottom depth and discharge rates for the wells that are most affected by saltwater intrusion are summarized in Table 28-4.

TABLE 28-4
HIGH CHLORIDE WELL STATISTICS

Well Number and Location	Chlorides (ppm)	Elevation of Well Bottom Below Sea Level (feet)	Average Daily Withdrawal (mgd)
Well 84, Iliili	340	23	0.30
Well 53, Tafuna	560	66	0.00
Well 119, Malaeloa	240	34	0.44
Well 97, Aua	720	161	0.32
Well 99, Aua	560	153	0.34

Notes:
Chloride levels and average daily withdrawal statistics were derived from an August, 1994 ASPA Water Operations Report.

Source: ASPA, Water Division, 1994.

Surface Water Supply and Quality

In 1987, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. Two systems were identified in the Central Tafuna Plains watershed.

One small system was located in the Tafeta area (southeast of Olotele Mountain). This system relied upon a spring on the southeast side of Olotele Mountain that was located at approximately 1,320 feet above mean sea level. A water storage tank was located at about the 980-foot elevation. In January, 1987, this system contained about 15 service connections. It is unknown whether this system remains in use.

A second system served Faleniu and Mesepa (Nuuuli Pala watershed). A stream catchment along Mapusagatuai Stream, at about the 350-foot elevation, was the surface supply that supported this system. It is unknown whether or not this system remains in use.

Historical data from the 1981-1986 period indicates that both systems contained significant coliform contamination. A median of 79 to 80 coliforms per 100 milliliters was documented for both systems.

Proposed Water System Improvements

The draft ASPA Utilities Master Plan points out that a desirable operational objective is for ASPA to produce water in the same area that it is consumed. The operation and maintenance of extensive water transmission systems throughout most of Tutuila are costly. In west Tutuila, the Master Plan recommends the drilling of exploratory wells in the Tafuna-Leone area.

ASPA plans to drill six-inch exploratory wells in Malaeimi, Nuuuli, Leone, Pavaiai, and Asili. Where adequate yields are found, permanent groundwater wells are recommended for subsequent use. Pavaiai is noted as one location where some amounts of potable water may be discovered. No specific location in the watershed is identified for this improvement. However, it is recommended that the well head of the exploratory well should not exceed 150 feet above mean sea level to accommodate drill rig limitations.

USE OF THE WATERSHED

Resident Population

Faleniu

Faleniu experienced considerable population growth between 1980 and 1990. The average annual growth rate was 5.3 percent during this period. This growth can be attributed to significant in-migration. The proportion of residents who were born outside of the community rose from 30 to 52 percent during the 1980-1990 period and continued through, at least, 1995. Representatives from the ASG Department of Education indicate that most of the incoming residents have arrived from Western Samoa (Epati-Tanoi, 1994).

In 1990, the resident population was estimated to be 833 persons. New residential construction during the 1990-1995 period increased the resident population to about 1,168 persons.

Pavaiai

Between 1980 and 1990, the resident population of Pavaiai Village increased from 1,031 to 1,692 residents. Such growth represented an average annual growth rate of about 6.41 percent. Development activity between 1990 and 1995 increased resident population to about 2,147 persons.

Population trends for Pavaiai reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community during the past 15 years. The proportion of 1990 residents who were born outside of American Samoa has more than doubled since 1985; however, the rate of in-migration between 1985 and 1990 apparently slowed considerably since 1985.

Representatives from the ASG Department of Education indicate that most of the incoming residents to Pavaiai have arrived from Tonga (Epati-Tanoi, 1994). An example of this in-migration is demonstrated by a community of Tongans that live only 600 feet northwest of Pavaiai Elementary School in Mesepa. The number of housing in this area has almost doubled during the past five years. One of the village *matais* is married to a Tongan woman. This and other cultural connections have apparently generated in-migration into Pavaiai.

Futiga

Between 1980 and 1990, the resident population of Futiga Village increased from 322 to 720 residents. Such growth represented an average annual growth rate of about 12.36 percent. Development activity between 1990 and 1995 increased resident population to about 909 persons.

Population trends for Futiga reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa almost doubled between 1980 and 1985, but remained about the same between 1985 and 1990.

Iliili

Between 1980 and 1990, the resident population of Iliili Village increased from 970 to 1,790 residents. Such growth represented an average annual growth rate of about 8.45 percent. Development activity between 1990 and 1995 increased resident population to about 2,612 persons.

Vaitogi

Between 1980 and 1990, the resident population of Vaitogi Village increased from 664 to 1,302 residents. Such growth represented an average annual growth rate of about 9.61 percent. Development activity between 1990 and 1995 increased resident population to about 1,759 persons.

Population trends for Vaitogi reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1985 and 1990 when the number of persons born outside of American Samoa jumped from 20 to 53 percent. In 1990, this statistical indicator dropped to 47 percent which indicates a potential out-migration of existing residents or greater in-migration by native American Samoans returning from the continental United States after graduation from school or retirement. The latter is more likely since the village population grew approximately 9.6 per year between 1980 and 1990.

Tafuna

Between 1980 and 1990, the resident population of Tafuna Village increased from 1,086 to 5,147 residents. Such growth represented an average annual growth rate of about 37.39 percent. Development activity between 1990 and 1995 increased resident population to about 6,892 persons.

Population trends for Tafuna reflected in the 1990 Census statistics suggest that considerable in-migration has occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 27 percent. Between 1985 and 1990, the proportion increased to 49 percent. In 1990, the proportion rose slightly to 55 percent. These statistics generally confirm the present and past in-migration of various persons and families from Western Samoa, the continental United States, Tonga, Fiji, and other South Pacific Islands, as well as some out-migration by native American Samoans.

Land Uses

Residential

Faleniu

Residential expansion in Faleniu was also evident in Faleniu during the 1990-1995 period. The 1990 Census recorded 120 homes in Faleniu Village. Forty-five new housing units were added to the housing stock between 1990 and 1995. Consequently, the 1995 housing stock included approximately 165 homes.

Pavaiai

The 1990 U.S. Census documented 252 homes in Pavaiai. Approximately 74 percent of the homes were owner-occupied; 23 percent were rental units. The remaining three percent were vacant or used as vacation homes by absentee owners.

The housing stock in Pavaiai was expanded during the 1990-1995 period. Building permits were issued for 67 new housing starts. Consequently, the 1995 housing stock includes approximately 319 homes.

Futiga

In 1990, the 1990 U.S. Census documented 95 homes in Futiga. Approximately 75 percent of the homes were owner-occupied; 20 percent were rental units. The remaining five percent were vacant or used as vacation homes by absentee owners.

The housing stock was expanded during the 1990-1995 period within Futiga. Building permits were issued for 22 new housing starts. Consequently, the 1995 housing stock includes approximately 117 homes.

Iliili

In 1990, the U.S. Census recorded 297 housing units in Iliili. Roughly 65 percent were owner occupied; 29 percent were rental units. The remaining six percent were vacant or were used as vacation homes by absentee owners.

The total housing stock in Iliili increased to about 421 homes by the end of 1994. This growth is a slight increase over residential growth between 1980 and 1990 when the number of homes grew at the rate of about 8.5 percent per annum.

The expanded growth within Iliili in residential construction is influenced by several factors.

- the suitability of a large amount of land for residential development;
- a strong desire by a few chiefs or their heirs to sell and permit communal lands east and northeast of The Country Club golf course to be reclassified to individually-owned property; and,
- a speculative market for residential property in the village, which has already generated a number of real property re-sales and escalating property, prices for individually-owned land.

Vaitogi

In 1990, the 1990 U.S. Census documented 201 homes in Vaitogi. Approximately 80 percent of the homes were owner-occupied; 14 percent were rental units. The remaining six percent were vacant or used as vacation homes by absentee owners.

The housing stock in Vaitogi was expanded during the 1990-1995 period. Building permits were issued for 63 new housing starts. Consequently, the 1995 housing stock includes approximately 264 homes.

Tafuna

Tafuna has experienced significant growth during the past 15 years. Between 1980 and 1990, the resident population grew an average of 37 percent per year. Such growth has generated a significant increase in housing development. Significant residential expansion continues at the time of this report.

The 1990 Census documented 850 residential units for Tafuna. Roughly 62 percent were owner-occupied homes; 29 percent were rental units. The remaining nine percent of the housing stock represented vacant houses or housing units used as vacation homes by absentee owners.

Between 1990 and 1995, 247 building permits for new residential construction in Tafuna have been issued by the American Samoa Government. Such activity has increased the total village housing stock to approximately 1,097 homes and represents a 29 percent growth of the housing stock in only five years. While residential growth remains strong, new home construction has clearly fallen from the staggering growth of the past decade. The price of land in recent years, e.g., $150,000 for 0.25 acre of undeveloped land, and the diminished accessibility to lands available for sale, are believed to be the principal causes of a reduction in the rapid urbanization of Tafuna Village.

Agriculture

Agriculture in the Central Tafuna Plains watershed includes both piggeries and various types of subsistence and commercial crops.

Piggeries

Piggeries are primarily located in the upland areas of Pavaiai. One of three piggeries in this area was observed to have about 101 pigs in April, 1996. At least two of the three piggeries drained into a local drainage course.

Other smaller piggeries in the watershed are owned by individual families throughout the watershed. For example, two piggeries were discovered northeast and east of Olovalu Crater; another piggery was observed in the vicinity of Iliili.

In terms of subsistence and crop production, various types of faatoaga throughout the watershed were observed in April, 1996.

Subsistence and Commercial Crops

A variety of subsistence and commercial crops were located in the watershed. These areas generally included the production of tapioca, bananas, coconut, and breadfruit.

Faatoaga were scattered throughout the watershed. However, they were located primarily located in the upland areas of Pavaiai, south of Futiga, as well as Faleniu, Iliili, and Vaitogi.

Commercial

Faleniu

There are approximately 33 commercial enterprises that operate in Faleniu. These enterprises include janitorial and landscaping services, grocery stores, retail shops, fast-food operations, bus and taxi operators, construction contractors, one auto repair shop, and home-based sewing and music instruction services. Only one new commercial operation was established during the 1990-1995 period.

Pavaiai

There are approximately 38 commercial enterprises that operate in Pavaiai. These enterprises include retail shops, professional services, fast-food operations, a laundromat, bus operators, two auto repair shops, and a construction contractor. Four new commercial operations were established during the 1990-1995 period.

Futiga

There are approximately 20 commercial enterprises that are based in Futiga. These enterprises include commercial bus operators, landscaping and janitorial services, video and other retail shops, a grocery store, professional services, fast-food operations, a laundromat, bus operators, one auto repair shop, and a construction contractor. One new commercial operation was established during the 1990-1995 period.

Iliili

There are about 42 commercial enterprises that are based in Iliili. These businesses include several professional and technical services, several bus and taxicab companies, grocery stores, several retail shops, two auto repair shops, a construction contractor, and the Country Club golf course. Four of these enterprises have been established between 1990 and 1995.

Vaitogi

There are approximately 38 commercial enterprises that operate in Vaitogi. These enterprises provide a wide range of services to local residents. Commercial services based in the community include professional and technical services, retail shops, grocery stores, two laundromats, eight transportation companies, delivery services, wholesalers, four auto repair shops, and other diverse services. It is believed that a majority of these services are home-based occupations. Two of the 38 commercial operations were established during the 1990-1995 period.

Tafuna

There are about 274 commercial enterprises that are based in Tafuna Village. These businesses represent a variety of professional and technical services, retail establishments, grocery stores, and wholesalers that import a wide variety of products and foods to American Samoa.

Industrial

There is one popcorn manufacturing operation that is operated in Faleniu Village. However, no industrial operations were located in Pavaiai Village in 1995.

Four light industrial activities are operating in Futiga. These enterprises include a heavy equipment/truck rental business, an earthmoving contractor, and a sharkfin processing and export company.

Some light industrial activities are presently located at Tafuna Industrial Park. However, most of this area is occupied by commercial retail outlets. Existing light industrial facilities at the Park include BCTC manufacturing, construction company operations, heavy equipment suppliers and service companies.

One food processing operation was operating in Vaitogi Village in 1995. This operation probably represents a home-based industrial activity.

Public Facilities

Faleniu

Two early childhood education (ECE) facilities are located in Faleniu. The ECE programs, which serves children three and four years of age, enrolled 62 children for the 1994-1995 school year. Elementary school students are bussed to Pavaiai Elementary School, and the high school students from the village are bussed to Leone High.

Pavaiai

The ASG Department of Education's early childhood education program offers two sites in Pavaiai, which served 53 students in September, 1994. Pavaiai Elementary School, with an enrollment of 1,120 students from Kindergarten through grade 8, includes students who are bussed in from Faleniu, Futiga, Mapusagafou, and Mesepa. High school students from the Village are bussed to Leone High School.

Futiga

ASG Department of Education's early childhood education program operates in Futiga. This program was providing educational opportunities for six children in September, 1994.

Iliili

The ASG Department of Education offers an Early Childhood Education program in Iliili. In September, 1994, 49 students were enrolled in this program. Elementary school students attend Lupelele Elementary School in Iliili. In September, 1994 enrollment of the school was 1027 students. High school students are bussed to either Leone or Fagaitua High School.

Vaitogi

While there is no public facility in Vaitogi, an ASG Department of Education early childhood education program utilizes a local facility for this program which enrolled 31 three and four year olds in September, 1994. Elementary school students are bussed to Lupelele Elementary School in Iliili, while high school students are bussed either to Leone High or Fagaitua High Schools.

Tafuna

The ASG Department of Education offers an early childhood education program at three different sites in Tafuna. In September, 1994, this program was attended by combined total of 120 children between the ages of three and four.

Kindergarten through fifth grade students attend Manulele Elementary School near the northern boundary of Tafuna. In September, 1994, student enrollment at this facility was 1,046 students. Sixth through eighth grade students from the Village attend Tafuna Elementary School which had an enrollment of 432 students in September, 1994.

High school students attend Tafuna High School, which is, located northwest of Tafuna International Airport. Student enrollment in September, 1994 was 864 students.

Village Facilities

The most significant village facility in Tafuna is the CCCAS Kananafou complex. This facility includes a Bible College, which has an enrollment of about 60 full-time students, and eight faculty members that reside in the complex. In addition, an additional 10 students attend night classes at the CCCAS complex.

Within Kananafou, there are also two privately-operated preschool facilities. The EKFAS facility provided educational opportunities to 94 three and four-year-old children in September, 1994. Fatu-O-Aiga preschool had an enrollment of 170 two to four-year-old children during the same period.

A private elementary school is also operated at the CCCAS Kananafou complex. This school served 101 students in September, 1994.

In addition, several churches are located in Tafuna Village.

Use of the Nearshore Waters

The high sea cliffs and southerly wave exposure generally limit the type of recreational activities that occur along the shoreline of the watershed. For the most part, use of the nearshore waters revolves around fishing. However, some recreational snorkeling and diving also takes places in selected areas, e.g., Fogagogo, that have reasonable vehicular access.

An American Samoa Subsistence Fishing Survey was conducted by the University of Hawaii Sea Grant Program in the summer of 1992. This survey involved onsite interviews with shoreline users who were participating in fishing activities on selected days during that period. The results of the survey revealed, in part, that there is some use of the shoreline in the vicinity of Vailoa and Vaitogi.

Some 8 to 12 persons were documented fishing on the reef in the vicinity of Vailoa and Taputimu. Fishing methods that were observed included rod and reel, throw net, diving, gleaning, and poles.

On the reef at Vaitogi, some 8 to 14 persons were involved in fishing. These residents used rod and reel, fishing poles, and diving.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Faleniu

Future residential expansion in Faleniu Village is expected to increase because of a number of factors that will continue to influence future growth.

- the general suitability of accessible, vacant lands for residential development,
- the continued in-migration of new residents, primarily from Western Samoa and the continental United States, and
- the continued assignment of communal lands by family *matai* to incoming new residents.

The incoming population into Faleniu from Western Samoa will generally be seeking new homes to provide basic shelter. More affluent American Samoans from the continental United States are also seeking basic shelter and seeking a more relaxed lifestyle. These immigrants will also be seeking cash employment opportunities in the local economy. Such opportunities are expected to diminish with the closing of one cannery by the year 2005. Consequently, less in-migration can be expected to this community after the year 2005. Ironically, most of the developable land will probably be occupied by this time.

More affluent American Samoans from the continental United States are also seeking basic shelter in Faleniu, as well as a more relaxed lifestyle. A part of their relaxed lifestyle will also incorporate more household conveniences and amenities into their households. Household financial needs will be met through the use of professional and technical skills in the local economy, or their establishment of a new commercial enterprise. Many may attempt to operate commercial enterprises from their homes.

New housesites in the area are generally being built along existing dirt trails east of the primary shoreline roadway. Given the extent of this type of settlement, future residential expansion in Faleniu will likely conform to this trend.

An onsite inspection of Faleniu Village in November, 1994 and a review of 1990 topographic conditions suggest that residential expansion could include about 130 single family homes east of the primary roadway and about 10 west of the roadway. Initial development during the planning period will occur east of the primary shoreline roadway. As vacant developable lands are occupied along existing trails, some limited development will occur on moderate slopes above the west side of the Village.

During the next 20 years, ASPA believes that such development will more specifically generate the following volume of residential construction within Faleniu:

1996-2000 70 single family homes on the east side of the primary shoreline roadway;

2001-2005	60 single family homes on the east side of the primary shoreline roadway;
2006-2010	10 single family homes on moderate slopes west side of the primary shoreline roadway and upland of the existing residential area; and,
2011-2015	No new residential construction except for replacements, additions, and extensions of existing homes.

Faleniu is an attractive residential community to live in. However, its distance from cash employment opportunities will not encourage the construction of multi-story residential structures once the supply of vacant, developable land along existing trails is exhausted. In addition, the appointed Sao from each family will also not be inclined to develop additional roads within the village unless sufficient funds are obtained via prospective family members who desire to build a house and live on adjoining lands.

The cumulative effect of this prospective residential growth on Faleniu is that the housing stock will increase to roughly 305 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.17 persons per household, the 2015 village population will include about 1,881 persons.

Pavaiai

Future residential expansion in Pavaiai Village is expected to increase because of a number of factors that will continue to influence future growth.

- the general suitability of accessible, vacant lands for residential development,
- the continued in-migration of new residents, primarily from Tonga , Western Samoa, Hawaii and the continental United States, and
- the continued assignment of communal lands by family *matai* to incoming new residents

The incoming population to Pavaiai from Tonga will generally be seeking new homes to provide basic shelter. These immigrants will also be seeking cash employment opportunities in the local economy. Such opportunities are expected to diminish with the closing of one of American Samoa's two canneries by the year 2005. Consequently, less in-migration can be expected to this community after the year 2005.

More affluent American Samoans from the continental United States are also seeking basic shelter, as well as a more relaxed lifestyle in Pavaiai. A part of their relaxed lifestyle will also incorporate more household conveniences and amenities into their households. Household financial needs will be met through the use of professional and technical skills in the local economy, or their establishment of a new commercial enterprise. Many may attempt to operate commercial enterprises from their homes.

New housesites in Pavaiai are generally being built along existing dirt trails northwest and southeast of the primary shoreline roadway. Given the extent of this type of settlement, future residential expansion in Pavaiai will conform to this trend. However, the long term may also include the development of a small planned community on one of two vacant parcels of land on the southeast side of the community. Such a development will be prompted by the growing recognition of Pavaiai as a secondary commercial center in Tutuila's western district.

An onsite inspection of Pavaiai Village in November, 1994 and a review of 1990 topographic conditions suggest that residential expansion could include about 110 single family homes southeast of the primary roadway and about 65 homes northwest of the roadway. Future residential expansion during the planning period will occur simultaneously on both sides of the primary shoreline roadway.

During the next 20 years, ASPA believes that such development within Pavaiai will more specifically generate the following volume of residential construction:

1996-2000 5 single family homes on the northwest side of the primary shoreline roadway;

55 single family homes on the southeast side of the primary shoreline roadway,

2001-2005 30 single family homes on the east side of the primary shoreline roadway;

55 single family homes on the southeast of the primary shoreline roadway,

2006-2010 no new residential construction except for replacements, extensions and repairs to existing housing units,

2011-2015 development of a small planned community on the southeast side of the primary roadway that includes 50 housing units.

The cumulative effect on Pavaiai of this prospective residential growth is that the housing stock will increase to roughly 514 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.74 persons per household, the future village population will include about 2,953 persons.

Futiga

Some future residential expansion will occur in Futiga. However, future growth will continue to slow from the more rapid growth between 1980 and 1990. The decrease in future residential expansion is primarily tied to the decline in vacant developable lands that are reasonably accessible from existing dirt trails. The primary residential concentration adjacent to Tutuila's primary roadway is fully occupied except for about three potential housesites.

Additional developable land is vacant on the south side of Futiga's primary residential area between the 275 and 300-foot elevation. However, this area is not likely to attract future settlement because of odors and potential vector problems that might be derived from the nearby Futiga landfill that is situated downhill from this area.

Three other residential expansion areas within Futiga appear to be more attractive for future residential construction if they are available via respective family *sao*.

- Approximately 12 spectacular shoreline housesites are located along the northeast side of Larsen Bay between Let and Puatauapa Points (75-125 foot elevation);
- North of Logotala Hill, there are approximately 21 housesites that could be developed along the existing vehicular trails between the 250 and 300-foot elevation;.
- Along the road to the Futiga landfill, there are 13 sites that are situated between the landfill and the south end of the existing Futiga community (235-300 foot elevation).

During the next 20 years, ASPA believes that these potential development opportunities and the potential infilling of the existing residential community will generate the following volume of residential construction within Futiga:

1996-2000 three new single family homes inside the main village area;
six new single family homes on the northeast side of Larsen Bay;
six single family homes adjacent to the Futiga landfill road;

2001-2005 seven single family homes adjacent to the Futiga landfill road;
six new single family dwellings on the northeast side of Larsen Bay;
two single family homes north of Logotala Hill;

2006-2010 no new residential construction is anticipated except for home extensions, repairs, and renovations;

2011-2015 19 single family homes will be built north of Logotala Hill along existing dirt trails.

The cumulative effect on Futiga of this prospective residential growth is that the housing stock will increase to roughly 166 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.63 persons per household, the future village population will include about 1,101 persons.

Iliili

Iliili did not experience the rapid growth of Tafuna Village between 1980 and 1990. The difference apparently lies in the orientation of most local *matai* who presently favor keeping their titled land as communal property.

However, future cultural attitudes concerning communal lands are expected to change as older *matais* pass away and less tradition-oriented family representatives are selected by their *aigas* to manage the lands of their respective family titles.

Future residential expansion will occur and eventually represent significant growth. The annual rate of residential growth between 1990 and 1995 was slightly over 10 percent compared to seven percent in Tafuna. Consequently, more significant growth rates are on the horizon. However, such change will be gradual.

Within the short term (1996-2000), continued growth in Iliili will most likely occur in two places:

- immediately east and northeast of the Country Club golf course; and,
- southwest of Fogagogo and inland of Alatele Cove.

Most of the areas known as Kokoland and the southwest side of Ottoville in Iliili are situated east and northeast of the golf course. It is estimated that these areas can accommodate the construction of about 263 single family homes. This assumption assumes that future development will represent the infilling of lands, which are accessible and adjacent to existing vehicular trails. The construction of about 200 single family homes is anticipated between 1996 and the year 2000. Residential densities will range between four and six units per acre.

During the same period, it is believed that three eight-unit apartment buildings in Iliili are also expected to be constructed along the east side of Luisa's Store and Laundromat. Such development will provide 24 housing units during the 1996-2000 period.

Southwest of Fogagogo and inland of Alatele Cove, the development of about 28 single family units is anticipated within Iliili. Title holders in this area, e.g., the Liu family, anticipate selling single family lots that are about 0.25 acre in size.

Between 2001 and 2005, the remaining 63 single family housesites east and northeast of the golf course in Iliili will be developed. During the same period, it is believed that 34 townhouse units will be constructed on vacant lands that are immediately south of the Assembly of God's Samoa Bible College. Three eight-unit apartment buildings are also expected to be constructed along the south side of the primary access road to Ottoville.

Similar to Tafuna, the Iliili lands east and northeast of the golf course has the capacity to support a large amount of residential development. However, since anticipated development will occur primary along existing trails and/or limited extensions to existing vehicular trail, the supply of available developable lands for residential development will become exhausted by the year 2005. For this reason, Iliili lands south of the Country Club golf course will become the new target for future residential development along existing roads and dirt trails. New heirs to family titles will take a different approach to land management and use. The conversion of most communal land to individually-owned land in this area will bring a new approach to single family housing development that will be aimed increasingly toward the rental market. It is anticipated that 68 single family housing units will constructed in this area between 2001 and 2005; residential densities will probably range between three and four units per acre.

A number of persons have already purchased individually-owned land in Iliili that are inland of Vaifoa Cove and southeast of The Country Club. Single family residential construction of about 85 housing units is anticipated during the 2006-2010 period. This area will probably be settled by existing residents rather than by in-migrants from other international areas.

The 2011-2015 period will reflect a shift of development to other areas west of the Country Club in Iliili. Infilling adjacent to dirt trails will occur west of the golf course. Such development will involve the construction of about 74 housing units.

During this period, the potential development of a planned residential community in Iliili or subdivision is very likely north of the golf course. This area will probably attract more affluent property buyers. In addition, a primary roadway that will extend east to west is expected to be built between the Cost-U-Less complex and Tutuila's shoreline roadway. Such a roadway would place anticipated development between the golf course and the new roadway. With these assumptions, Pedersen Planning Consultants estimates that 100 single family homes will be constructed in this area.

The cumulative effect of anticipated residential growth in Iliili over the 1996-2015 period represents a significant urbanization of the Iliili community. By the year 2015, an additional 700 housing units will be added to the 1995 housing stock. Consequently, the total housing stock by the year 2015 will be about 1,121 housing units. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.30 persons per household. Consequently, the anticipated village population in 2015 will include about 5,938 persons.

<u>Vaitogi</u>

Future residential expansion in Vaitogi is expected to increase because of a number of factors that will continue to influence future growth.

- the general suitability of accessible, vacant lands for residential development,
- the apparent continued in-migration of new residents, primarily from Hawaii and the continental United States, and
- the scenic quality of vacant lands that will be attractive to both returning American Samoans who presently live outside of American Samoa, as well as some current American Samoan residents who live in other parts of Tutuila.

More affluent American Samoans are expected to return to Vaitogi in coming years. They will seeking to build moderate to expensive homes; retirees will also be in search of a more relaxed lifestyle. Their homes will include more household conveniences and amenities. Household financial needs will be met through the use of professional and technical skills in the local economy, or their establishment of a new commercial enterprise. Some will attempt to operate commercial enterprises from their homes.

New housesites are generally being built along existing dirt trails northwest of the Village, but newer homes are also found scattered along dirt trails north and east of Vaitogi's shoreline village *malae*. In addition, many of the outlying dirt trails adjacent to the more developed central village offer considerably better road conditions when compared with other villages on

Tutuila. Consequently, future residential expansion will occur northwest, north, and east of the central village area.

Even though residential expansion in Vaitogi is quite feasible upon development lands near the existing central village area, it is believed that the rate of future growth will decrease somewhat. The conversion of communal lands to individually-owned land is not a high priority of most local *matais.* This condition will discourage some American Samoans from returning from the continental U.S., Hawaii and other international areas, or encourage their settlement in Tafuna and portions of Iliili.

Community attitudes within Vaitogi toward the communal land system will eventually change as more traditional *matais* pass away and are replaced by younger family *sao* who will be more inclined to seek financial return from the land. This fundamental change in community attitudes is not expected for, at least, 10 more years. Ironically, most of the developable land will already be developed.

An onsite inspection of Vaitogi Village in November, 1994 and a review of 1990 topographic conditions suggest that residential expansion could include about 62 single family homes northwest of the village malae and surrounding residential area. About 30 more expensive homes will be developed along the west coast; housing densities will probably range between one and two units per acre. Another 50 units are very feasible north and east of the central residential and the village *malae* where residential densities will probably not exceed two units per acre. Future residential expansion during the planning period will occur simultaneously on both sides of the primary shoreline roadway; however, somewhat greater growth will occur northwest of the central village where more potential housesites are available.

During the next 20 years, Pedersen Planning Consultants believes that such development will more specifically generate the following volume of residential construction within Vaitogi:

1996-2000 32 single family homes on the northwest side of the central residential area and village *malae*;

25 single family homes north and east of the central residential area and village *malae*;

10 single family homes along west coast;

2001-2005 30 single family homes on the northwest side of the central residential area and village *malae*;

25 single family homes north and east of the central residential area and village *malae*;

20 single family homes along west coast;

2006-2010 no new residential construction anticipated except for home replacements, additions, or renovations.

2011-2015 no new residential construction anticipated except for home replacements, additions, or renovations.

The cumulative effect on Vaitogi of this prospective residential growth is that the housing stock will increase to roughly 406 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.69 persons per household, the 2015 village population will include about 2,309 persons.

Tafuna

Future residential expansion in Tafuna will continue to be significant in growth and become more diverse as the housing stock continues to grow. Several significant factors continue to influence this growth:

- the continued availability of undeveloped freehold property;
- the suitability of large amount of lands for residential development;
- a strong desire by various chiefs or their heirs to sell and permit communal lands to be reclassified to individually-owned property; and,
- a speculative market for residential property in the village, which has already generated a sizable number of real property re-sales and escalating property, prices.

A significant portion of future residential growth will include the infilling of areas that are accessible to vehicular traffic. In Tafuna, accessibility ranges from a rough dirt or basaltic trail to a two-lane paved roadway.

1996-2000 The center of the Village is generally north and south of the Congregational Community Church of American Samoa (CCCAS) complex between the 50 and 75-foot elevation. This will be the focal point of future residential growth. ASPA estimates that about 247 potential residential housesites are available in this area for single family home development given the layout of existing internal road and trails. Lower residential densities will be realized in many areas because of the random and inefficient layout of various roads and home locations. Considerably more residential could be accommodated if road and subdivision design standards were adopted.

The housing stock is also expected to include about 12 two-story apartment buildings that will be scattered at various sites throughout the community. Approximately eight of the apartment buildings are expected to be developed in the area immediately north of the Cost-U-Less project site.

Each apartment building will contain an average of six housing units. Consequently, the construction of 72 apartment units is anticipated.

The combined development of new single family homes and apartment buildings will add a total of 319 housing units during the 1996-2000 period.

2001-2005 Expanded residential development will include the construction of approximately 94 townhouses at a density of about eight units per acre, as well as about 135 single family homes at a density of about four units per acre. Such property will occur on relatively undeveloped lands that are situated immediately north and south of Haleck West Dairy. Residential growth during this period will add 229 housing units in Tafuna; however, such growth will represent the last significant surge of residential development because most all of the developable, accessible land will be occupied.

2006-2010 Seven more exclusive single family lots will be developed adjacent to future sites of the Cornerstone Assembly of God and the Community Christian Church. South of the future Cornerstone Assembly of God site, another 34 townhouse units will be built.

2011-2015 This period will primarily include additions to the housing stock except for housing replacements, additions, and renovations. The lack of developable and accessible land, as well as a more crowded urban environment, will steer much of the single family residential market to other smaller villages on the east and west side of Tutuila.

However, it is anticipated that 15 single family housesites will be replaced with small apartment buildings that will average about four units per building. In effect, these conversions will add 45 new housing units to the overall Village housing stock. The conversion of a small number of single family homes to apartment buildings will be driven by a growing rental housing market within Tafuna.

The cumulative effect of this prospective residential growth is that the Tafuna Village housing stock period will increase to roughly 1,731 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.36 persons per household, the future village population will include about 9,284 persons.

Commercial

Faleniu

Commercial retail expansion can be expected in Faleniu. Other than grocery stores, it is believed that the focus of commercial services will be directed primarily toward consumers from other villages that travel through Faleniu. With this perspective, it is expected that future commercial growth will be entirely along Tutuila's primary roadway. Internal roads of the village are poor and will generally not attract potential customers that pass through the village.

During the next 20 years, three new retail stores are expected to open every five years in Faleniu. Consequently, it is anticipated that the community will have 12 new commercial operations by the year 2015.

New commercial facilities in Faleniu will typically be one and two-story buildings. Onsite observations in November, 1994 indicate there are several potential sites that may be available along the primary roadway through the Village.

Pavaiai

Pavaiai is expected to become increasingly recognized as the second commercial center in the Tutuila's western district. This area will continue to serve the growing needs of communities immediately adjacent to Pavaiai, as well all other villages west of Pavaiai. Future commercial growth will occur entirely along Tutuila's primary roadway. Internal roads of the village are poor and will generally not attract potential customers that pass through Pavaiai.

Expanded commercial retail in Pavaiai is anticipated in the vicinity of Tualauta Center. It is believed that the Haleck West complex will eventually be renovated and become a two or three story facility that will include ground floor retail, as well as professional and technical services on upper floors.

During the next 20 years, commercial expansion will include the following development within Pavaiai:

1996-2000 a new retail store or gas station will be constructed at the primary road's intersection with the Mapusagafou Village access road;

2001-2005 expansion of the Haleck West complex to include four additional retail stores and four office spaces;

2006-2010 no new commercial facility construction;

2011-2015 development of an expanded Tualauta Center that will add two retail stores and two office spaces.

Consequently, Pavaiai is expected to have 13 new commercial operations by the year 2015.

Futiga

Commercial facility expansion in Futiga is expected to be limited. Such expansion will probably include the establishment of a new laundromat between 1996 and the year 2000. Three additional three retail stores are expected to begin operation between 2001 and 2005. Consequently, the community will have four new commercial operations by the year 2015. Otherwise, local residents will depend heavily upon the growing services that will be available in Pavaiai.

Iliili

Future commercial expansion within Iliili is expected to be limited. A small shopping center is anticipated to be located east of Luisa's Store and Laundromat and the anticipated apartment buildings along the Futiga-Iliili Road. Pedersen Planning Consultants believes that this development will occur between 2001 and 2005.

A small village shopping area in Iliili will likely be included as part of any planned community north of the golf course. This commercial development is anticipated during the construction of the planned community between 2011 and 2015. It is believed that this shopping center will include seven retail stores.

Vaitogi

During the next 20 years, it is expected that three new retail stores and two additional village grocery stores will emerge in Vaitogi to serve the community's growing residential population. The three retail stores will probably locate in the vicinity of the village *malae*. One village grocery store will likely establish within each of the two primary residential expansion areas.

Twenty or thirty new home-based professional and technical services will also emerge with the influx of new residents into Vaitogi. These businesses will be scattered throughout the residential expansion areas.

Tafuna

The future expansion of the residential community in Tafuna will likely generate an expansion in commercial retail stores and offices. The Cost-U-Less complex, which was developed by Ottoville Development Corporation, is expected to mark the beginning of more substantive investments in commercial facility development in Tafuna. A new service station operation is anticipated to be constructed on the east side of F. & C. Moor's Store during the 2001-2005 period.

Between 2006 and 2010, six other retail stores within Tafuna are anticipated to be built east of the Cost-U-Less complex. These stores will likely represent two or three story buildings that contain ground floor retail and offices for professional and technical services on the upper floors of each commercial building. The six commercial buildings will provide a total of 24 retail stores and 24 commercial offices.

A growing number of successful home-based professional services in Tafuna will require more office space and will be forced to seek office space outside of the home. Since the commute to the Pago Pago Harbor area will likely be undesirable, several businesses are expected to seek office space closer to home.

Between 2011 and 2015, the development of a second small village shopping center will be made on the south side of Ottoville to meet an increased demand for various home conveniences within a short distance of home. A small grocery store, video store, a gas station, and four other retail stores are expected to be developed at this location.

Industrial

<u>Faleniu, Pavaiai, Futiga, and Vaitogi</u>

The gradual increase in resident population will likely attract some small, home-based activities of an industrial nature within Faleniu, Pavaiai, Futiga, and Vaitogi. However, the construction of new industrial facilities is not anticipated.

<u>Iliili</u>

As the population increases in Iliili, several new industrial enterprises will be established. Such enterprises may include steel fabrication, additional auto repair shops, two or three heavy equipment repair shops. These businesses are expected to be home-based operations that will be gradually established during the 1996-2020 period.

More specifically, Pedersen Planning Consultants believes that three home-based industrial enterprises in Iliili will be established between 1996 and the year 2000. Four additional businesses will start-up during the 2001-2005 period. Four additional companies are expected to establish smaller industrial operations at their homes between 2011 and 2015.

<u>Tafuna</u>

It is expected that existing commercial and light industrial activities will remain in Tafuna to, at least, the year 2000 Potential investors continue to be sought by ASG's Department of Commerce and the Governor's Office to increase the number of industrial activities at the Park. This has been a long term effort of both agencies since the establishment of the Industrial Park in the early 1960's. The number of actual industrial activities at the Park that have been attracted to the Industrial Park have been few. However, the recent attraction of two garment manufacturing operations provide some reason for greater optimism.

ASPA believes that other small industrial activities will eventually emerge in Tafuna via the continuing efforts of the American Samoa Government. The type of potential industrial activities cannot be envisioned at this time. However, for planning purposes, it is assumed that one small industrial enterprise will be established during the 1996-2000 period that will employ approximately 10 persons. Between 2001 and 2005, a second small industrial company will establish at the Park with an anticipated workforce of 15 persons. Another small industrial concern with 10 employees is anticipated between 2006 and 2010. No additional industrial companies will be established between 2011 and 2015.

Public Facilities

Through the application of 1990 age characteristics to anticipated village populations in the year 2015, the general demand for future early childhood programs, elementary education, and high school education was quantified (Table 28-5). In some cases, these demands may generate the future development of expanded public school facilities within or outside the Central Tafuna Plains watershed.

TABLE 28-5
POTENTIAL DEMAND FOR PUBLIC SCHOOL FACILITIES
YEAR 2015
CENTRAL TAFUNA PLAINS WATERSHED
(NUMBER OF STUDENTS)

Village	Early Childhood	Elementary	Secondary
Faleniu	132	409	177
Pavaiai	202	625	328
Futiga	66	242	132
Iliili	49	119	56
Vaitogi	150	508	254
Tafuna	557	2,041	928

Source: Pedersen Planning Consultants, 1995

Village Facilities

At least two other churches have plans to build new churches in Ottoville by the year 2000.

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Central Tafuna Plains watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 28-6 and 28-7).

TABLE 28-6
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
CENTRAL TAFUNA PLAINS WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Faleniu	119,494	234,645
Pavaiai	184,803	387,688
Futiga	66,689	107,983
Iliili	124,220	718,660
Vaitogi	176,067	237,014
Tafuna	764,296	1,188,136

Source: Pedersen Planning Consultants, 1995

TABLE 28-7
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
CENTRAL TAFUNA PLAINS WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Faleniu	83,646	164,252
Pavaiai	129,362	271,382
Futiga	46,682	75,588
Iliili	86,954	503,062
Vaitogi	123,247	165,910
Tafuna	535,007	831,695

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of four drainageways and one stream within the watershed.

100-Year Peak Discharge Areas and Drainage Area Descriptions

The Federal Emergency Management Agency (FEMA) estimated the 100-year peak discharges for four drainageways and one stream in the Tafuna watershed (Table 28-8).

TABLE 28-8
ESTIMATED 100-YEAR PEAK DISCHARGES
CENTRAL TAFUNA PLAINS WATERSHED

Flooding Source and Location	Drainage Area (Square Miles)	100-Year Peak Discharge (cubic feet per second (cfs)
Stream 28A At mouth	0.39	560
Drainageway 2 10,000 feet upstream of mouth	1.60	1,480
Drainageway 3 At mouth	0.83	960
Drainageway 4 At mouth	0.19	290
Drainageway 5 At mouth	0.35	510

Source: U.S. Army Corps of Engineers, Pacific Ocean Division, 1994

The unnamed stream that flows east and southeast of Iliili would incur 100-year flood elevations that would range between 20 and 100 feet above mean sea level. Lower residential densities in the lands that would potentially be affected suggest that limited structural damage would occur in these areas. Since some residential expansion is anticipated east of Vaitogi, structures within the 100-year flood plain should not be permitted unless they are flood proofed above the 100-year flood elevation.

Along drainageway 5, potential 100-year flood elevations would range between 40 and 95 feet above mean sea level. No significant residential expansion is anticipated in this area. Nevertheless, the construction of building structures should again not be permitted without flood proofing above the 100-year flood elevation.

Drainageway 4, which flows through Fogagogo Village, is expected to incur 100-year flood elevations that would range between 10 and 50 feet above mean sea level. It is recommended that future development in this area should be located outside of the 100-year flood plain.

Drainageways 2 and 3 will discharge stormwater flows through more highly urbanized areas of the watershed. Future residential, commercial, and industrial development should be setback from the 100-year flood plain to minimize potential impacts upon future buildings and personal property.

The remaining areas within the Central Tafuna Plains watershed have been designated by FEMA as "zone x:" This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Tafuna watershed indicates that there is a coastal flood hazard through much of the nearshore waters and adjoining shoreline. A potential 100-year flood is estimated to generate flood levels in this area of two feet above mean sea level (MSL).

The presence of higher sea cliffs, which average 10 to 15 feet above mean sea level along much of the watershed's shoreline, suggest that there is limited potential for structural damage to occur from a 100-year storm. At the same time, all individuals who desire to construct residences along the shoreline should be advised of potential coastal hazards before the issuance of a building permit.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

The hydrologic characteristics and topography of the Central Tafuna Plains watershed do not generate significant discharges of stormwater runoff and sedimentation into the nearshore waters. While there are limited shoreline discharges that impact the water quality of the nearshore waters, residential and commercial development in many areas of the watershed generate localized sedimentation in various village areas.

Developers of future residential and commercial development projects in the watershed should be strongly encouraged to incorporate stormwater detention facilities such as swales, drywells, ponds, and other improvements. Similarly, traditional village leaders should also be encouraged to direct village residents to construct similar facilities in areas where future residential and commercial expansion is being directed.

Stormwater detention facilities will reduce the amount of sedimentation that is discharged into local drainageways. Further, greater stormwater detention will also provide needed opportunities for groundwater recharge.

Nearshore Water Quality and the Marine Environment

No significant deterioration in nearshore water quality is expected to the year 2015. Increased shoreline development will introduce limited volumes of nutrients via the seepage of wastewater effluent from septic tanks. However, such contamination will pose little risk to the limited coral communities in the nearshore waters.

Groundwater and Surface Water Supplies

Enforcement of Regulations Associated With Connection to the ASPA Wastewater Collection System

While regular chlorination of the groundwater supplies remains effective, many homes and commercial facilities in the Central Tafuna Plains watershed are not connected to ASPA's wastewater system. Local soils in the Central Tafuna Plains watershed are generally ineffective to treat wastewater from septic tanks because of the limited depth to bedrock and other soil characteristics. Consequently, ASPA must remain committed to the enforcement of its regulations that require the connection of any residential and commercial facility that is within 300 feet of any ASPA wastewater collection system.

Coordination of Land Use and Wastewater Facility Planning by ASDOC and ASPA

It is essential that future land uses in the watershed occur where ASPA wastewater collection systems are available. Otherwise, the basal aquifer is unnecessarily exposed to long-term bacterial and nutrient contamination. It is recommended that no new residential and commercial development should be permitted in the Central Tafuna Plains watershed without the concurrent expansion and/or connection to ASPA's wastewater collection system.

The ASG Department of Commerce should use, in part, its village master planning process in Tualauta County to encourage such development. ASPA should continue its aggressive wastewater capital improvement program to extend its Tafuna wastewater collection system to areas that can be cost-effectively developed, operated and maintained. Both ASPA and the ASG Department of Commerce must coordinate land use and infrastructure planning efforts in order to foster and facilitate the concurrent expansion of land uses with the expansion of wastewater collection system.

Salt Water Intrusion

Groundwater levels are approximately three to six feet above mean sea level through most of the Tafuna-Leone Plain. *"Because saltwater underlies freshwater everywhere, saltwater upconing can occur where well depths and pumping rates are not matched to the aquifer hydraulic conductivity, rates of ground-water flow, and freshwater lens thickness"* (U.S. Geological Survey, 1989). The draft Utilities Master Plan recommends that future ASPA groundwater wells should be drilled no deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered. It is recommended that this policy be adopted by the ASPA Water Division.

Detention of Stormwater Flows for Increased Groundwater Recharge

The American Samoa Government needs to make a concerted effort to increase stormwater detention in the Central Tafuna Plains watershed. Increased stormwater detention will increase groundwater recharge and facilitate the long-term conservation of groundwater supplies.

The topographic and hydrologic characteristics of the watershed, combined with expanding urbanization, limit potential stormwater detention opportunities. Where feasible, potential detention opportunities should be developed in combination with existing and future land uses.

The CCCAS facility, for example, contains a large, open *malae* that is primarily used for recreation. Some stormwater runoff from this complex already is detained in this area. Some site improvements of this area may be able to be constructed without losing the recreational and other uses of this area. ASEPA should evaluate this potential opportunity.

Three small natural depressions, or low areas, are situated between the north side of the CCCAS complex and the north side of Haleck West Dairy. These and other natural depressions in the watershed should be conserved and integrated with any future residential or commercial expansion. It is recommended that that the ASG Department of Commerce stipulate the conservation of these natural depressions along with the issuance of future building permits.

Where natural depressions are not present, the development of man-made swales and ponds can also help detain future stormwater flows. Drywells also represent another opportunity to reduce localized flooding, and, at the same time, permit the recharge of stormwater runoff. The ASG Department of Commerce should encourage the use of these stormwater detention options for future residential and commercial development projects. Projects that require a PNRS review may offer the best opportunity for implementation.

Revitalization of Waste Oil Collection and Recycling

Another source of continuing groundwater contamination is the indiscriminate discharge of petrochemical products, e.g., waste oil from vehicles, on lands and drainageways within the watershed. A continuing, long-term objective of the American Samoa Government should be to significantly reduce these discharges into streams and lands of the watershed. An aggressive cooperative effort should be made by ASEPA, ASCMP, and ASPA to revitalize its waste oil collection and recycling program that was established in 1990. Greater publicity, community education, and more collection centers are needed in the Central Tafuna Plains watershed to sustain an effective, long-term program. A regular pickup of waste oils should be made from various commercial and industrial sources in the Tafuna Industrial Park. In addition, collective centers need to be maintained by the owners of each site who, in turn, should be rewarded with the placement of advertising by ASG that mentions specific retail locations.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Central Tafuna Plains watershed will be to:

- Continue enforcement of ASPA regulations associated with connections to the ASPA wastewater collection system.
- Coordinate future land use and wastewater facility planning efforts of ASDOC and ASPA.
- Establish groundwater development policies that minimize the potential for saltwater intrusion into future groundwater supplies.
- Encourage inland stormwater detention areas for stormwater detention that will help reduce localized sedimentation and facilitate groundwater recharge.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with designated residents of Faleniu, Pavaiai, Futiga, Iliili, Vaitogi, and Tafuna, and encourage the village's implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 28-9. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 28-9
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
CENTRAL TAFUNA PLAINS WATERSHED

Participating Public Agency	**Resource Management Objective**	**Focus of Technical Assistance**
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated residents from each village in the watershed. 4. Make annual assessment of resource management program.
ASEPA	Conserve and enhance potential inland stormwater detention and groundwater recharge opportunities	1. Investigate potential stormwater detention opportunities at CCCAS complex. 2. Where feasible, prepare conceptual plans for storm-water detention and estimate order-of-magnitude costs.
ASEPA	Revitalize waste oil and recycling efforts.	1. Work cooperatively with ASPA and ASCMP to re-evaluate program objectives, strategies, and agency responsibilities for implementation. 2. Establish new collection stations in the watershed. 3. Select contractor to provide regular collection of waste oil from commercial sources and deliver to ASPA and canneries for recycling.
ASDOC	Detain stormwater runoff in future residential and commercial areas.	1. Encourage the use of onsite drywells, swales, ponds for all new residential, commercial, and industrial facilities. 2. Encourage traditional leaders, land developers and landholders to conserve natural depressions with future residential and commercial development.
ASDOC	Encourage new land use development where wastewater collection systems are available or will be developed.	1. Incorporate the location of wastewater collection systems in village plans for Pavaiai, Faleniu, Iliili, Vaitogi, and Tafuna. 2. Coordinate the preparation of village plans with ASPA Wastewater Division.
ASDOC	Discourage land use development within 100-year flood plains	Restrict future structural development within 100-year flood plain areas and/or require structural elevations above FEMA 100-year flood elevations.
ASPA	Reduce potential saltwater intrusion into groundwater wells of the watershed.	ASPA Board of Directors and Water Division should adopt a policy that no groundwater wells will be drilled any deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered.
ASDOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
ASDPW	Maintain stormwater culverts along the primary shoreline roadway.	1. Establish a periodic maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Maintain all culverts along the primary shoreline roadway.

Source: Pedersen Planning Consultants, 1998

FAGATELE-LARSEN BAY
Watershed 29

GEOGRAPHY

The Fagatele-Larsen Bay is a small watershed that is located in West Tutuila. The watershed comprises about 1.23 square miles of land area (Figure 29-1).

The inland boundaries of the watershed include Seumalo Ridge, Logotala Hill, and the southeast slopes of Fogamaa Crater. Matautuloa Ridge defines the east side of Fagatele Bay and the west side of Larsen Bay.

The shoreline of the watershed lies between Sail Rock Point and Fagatele Point. The most prominent shoreline features include two embayments known as Larsen Bay and Fagatele Bay. Fagatele Bay is situated between Steps Point and Fagatele Point. Larsen Bay extends between Sail Rock Point and Steps Point; this embayment includes two small coves: Fagalua Cove and Fogamaa Cove.

The watershed includes 10 unnamed streams (Streams 29A through Stream 29J).

RESOURCES OF THE WATERSHED

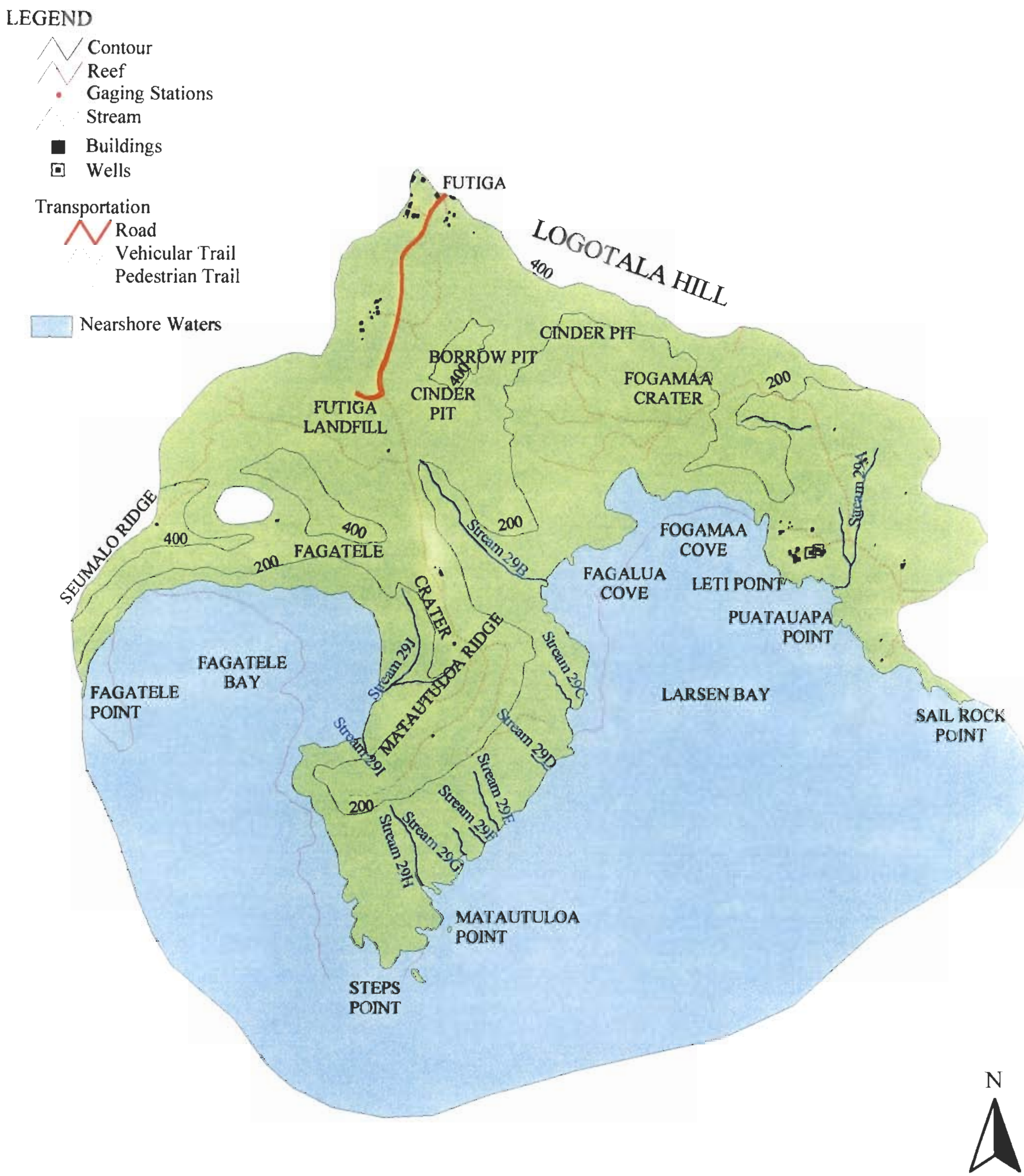
Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 29-2). Five soil classifications were identified by the U.S. Soil Conservation Service for lands within the Fagatele-Larsen Bay watershed (Table 29-1).

TABLE 29-1
SELECTED SOIL CHARACTERISTICS
FAGATELE-LARSEN BAY WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
5	Iliili Extremely Stony Mucky Clay Loam	3-15	None	Slow	Slight	>6	8-20	Severe Depth To Rock Large Stones	Poor
26	Puapua-Rock Outcrop Complex	40-100	None	Rapid	Severe	>6	16	Severe Depth to Rock Slope	Poor
28	Sogi-Puapua Clay Loams	0-6	None	Slow	Slight	>6	26	Severe Depth to Rock Poor Filter	Moderate
29	Sogi-Puapua Clay Loams	6-20	None	Slow to Med	Slight to Mod	>6	26	Severe Depth to Rock Poor Filter	Moderate
30	Sogi-Puapua Clay Loams	20-40	None	Med To Rapid	Mod To Severe	>6	27	Severe Depth to Rock Poor Filter Slope	Moderate

Source: U.S. Soil Conservation Service, 1984



American Samoa Geographical Information System

0.5 0 0.5 1

Miles

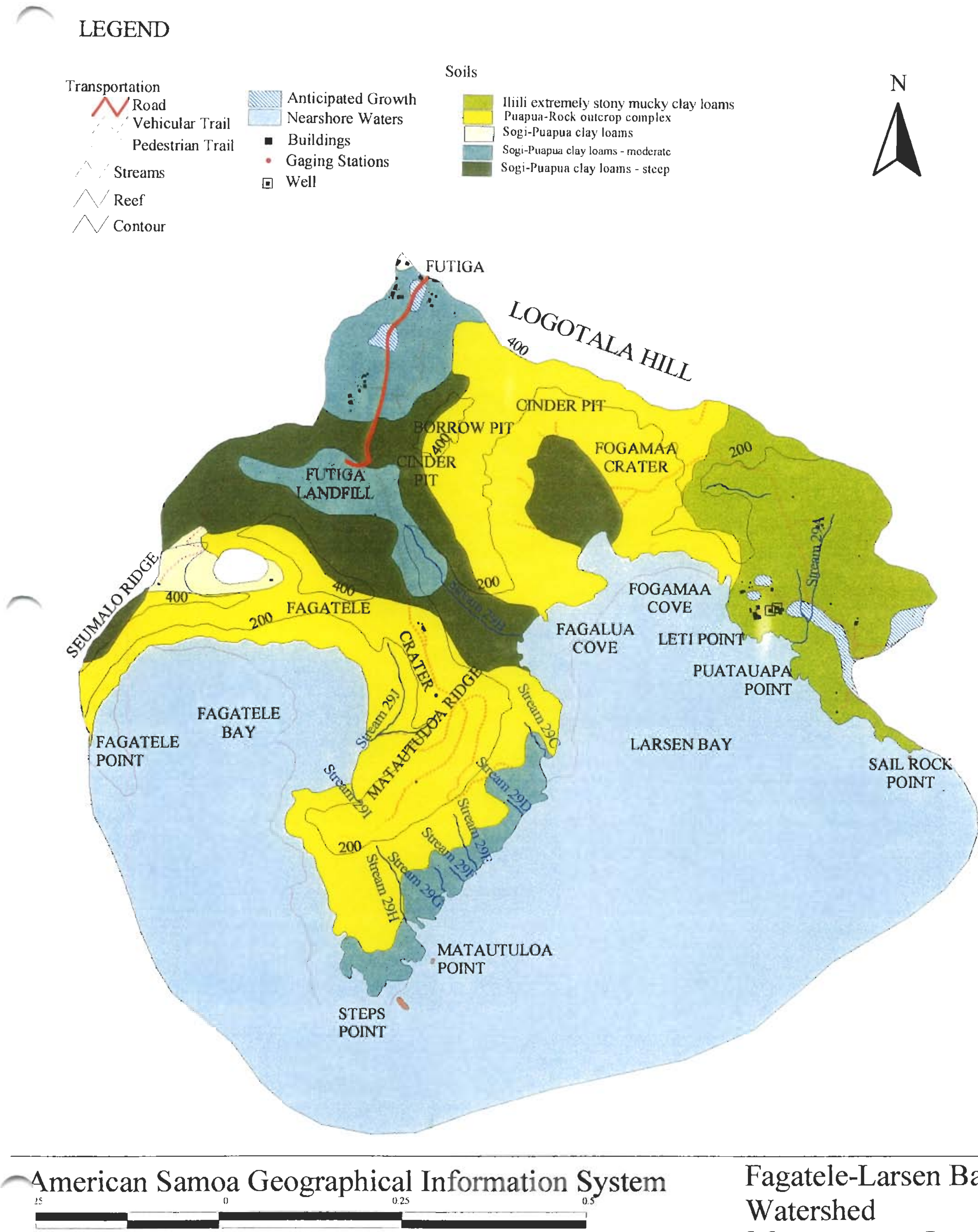
Scale: 1:20,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Fagatele-Larsen Bay Watershed Existing Conditions

29

Figure 29-1



American Samoa Geographical Information System

.25 0 0.25 0.5

Miles

Scale 1:12,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Fagatele-Larsen Bay Watershed Management Issues

29

Figure 29-2

Puapua-Rock Outcrop Complex, 40 to 100 Percent Slopes

Soils identified by the U.S. Soil Conservation Service as Puapua-Rock Outcrop Complex (SCS soil mapping unit 26) are found along the steeper slopes and crater rims of Fagatele and Fogamaa Crater.

About 50 percent of the Puapua-Rock outcrop complex soil comprises Puapua clay. About 30 percent of the soil includes rock outcrop. The Puapua soil is typically found on the steeper slopes. The rock outcrop, which consists of exposed areas of lava and hard volcanic tuff, occurs primarily on crater rims, ridgetops, and the sides of smaller gullies (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

Soil permeability for Puapua soils range between two and six inches per hour above the tuff. However, permeability is slow through the tuff.

Potential soil runoff is considered to be rapid. The potential for water erosion is severe (U.S. Soil Conservation Service, 1984).

The Puapua-Rock outcrop complex soils are not well suited for agricultural uses. Steeper slopes constrain cultivation efforts. Subsistence crop production is hampered by the presence of rock outcrop areas. Any subsistence production should include the regular application of crop residues, mulch, or other ground cover materials.

Residential uses are impacted by steeper slopes and the inability to use septic tanks or other soil-based treatment systems. Roads must be designed to minimize the potential for erosion. However, road construction is influenced again by the presence of rock outcrop areas.

Sogi-Puapua Clay Loams, O to 6 Percent

A large depression on the north side of Fagatele Crater contains Sogi-Puapua clay loams (SCS soil mapping unit 28). This area was used during the late 1970's for the disposal of cannery wastes.

This upland soil represents a combination of approximately 50 percent Sogi clay loam and about 35 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam, is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Potential runoff from this soil is considered to be slow. Potential water erosion from this soil is estimated to be slight (U.S. Soil Conservation Service, 1984).

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock. Potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

Sogi-Puapua Clay Loams, 6 to 20 Percent Slopes

Sogi-Puapua clay loams (SCS soil mapping unit 29) are present in an area between Fogamaa Crater and Fagatele Crater. The west part of this area includes the Futiga landfill.

This upland soil represents a combination of approximately 45 percent Sogi clay loam and about 40 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches.

The potential hazard for water erosion is slight to moderate. The U.S. Soil Conservation Services estimates that potential runoff is slow to medium.

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches. Potential runoff from this soil is considered to be slow to medium. Potential water erosion from this soil is estimated to be slight to moderate.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock and potential water erosion. However, potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

This soil is also poorly suited for sanitary landfill operations. The U.S. Soil Conservation Service indicates that this use is primarily constrained by the limited depth to bedrock and its susceptibility to seep leachate material.

Sogi-Puapua Clay Loams, 20 to 40 Percent Slopes

Sogi-Puapua clay loams (SCS soil mapping unit 30) are found on steeper slopes within the lower elevations of Fogamaa Crater, the west side of Fogamaa Crater, and the north side of Fagatele Crater.

This upland soil represents a combination of approximately 45 percent Sogi clay loam and about 40 percent Puapua clay loam. Some smaller areas of tuff outcrops characterize knolls and ridgetops.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam is usually about 10 inches thick. The subsoil includes a five-inch layer of dark brown clay loam. The substratum represents dark brown and very dark brown loamy sand which extends about 12 inches in depth over hard tuff. The depth to hard tuff ranges between 20 and 40 inches.

Soil permeability ranges between two and six inches per hour in the first 15 inches of soil. Between 15 and 27 inches of soil depth, the permeability increases to a rapid rate of 6 to 20 inches per hour.

The U.S. Soil Conservation Services estimates that potential runoff is medium to rapid. The potential hazard for water erosion is moderate to severe.

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches. Potential runoff from this soil is considered to be slow to medium.

The soil permeability of the Puapua soil ranges between two and six inches per hour. Potential soil runoff from this soil type is considered to be medium to rapid. The Puapua soil has a slight to moderate potential for water erosion.

Sogi-Puapua soils are moderately suited for the production of subsistence crops. Potential water erosion and the limited depth to bedrock are potential constraints.

The limited depth to bedrock and restrictive clay layer does not enable adequate filtering of wastewater effluent. Consequently, this soil is not suited for the use of septic tanks and other soil-based treatment systems.

Iliili Extremely Stony Mucky Clay Loam (3 to 15 percent slopes)

Iliili extremely stony mucky clay loam (SCS mapping unit 5) comprises upland soils that are east of Larsen Bay and north of Sail Rock Point.

Iliili extremely stony mucky clay loam are underlain by lava and formed by volcanic ash. The surface layer represents a very dark, grayish-brown, clay loam that is about five inches thick. The subsoil includes about four inches of very dark, grayish-brown, clay loam that is extremely stony.

The permeability of the soil is rapid. This Iliili soil has a slight potential to generate water erosion; its runoff is slow.

The stony surface layer and limited depth to bedrock constrain cultivation, as well as residential development.

Iliili extremely stony mucky clay loam provides a stable building foundation; however, the soil is difficult to excavate. The treatment of sewage effluent from soil-based treatment systems is not recommended since the soil does not adequately treat wastewater. The use of community sewage systems is required to prevent groundwater contamination.

Streams

Stream Locations

As stated earlier, there are 10 unnamed streams in the Fagatele-Larsen Bay watershed.

Stream 29A originates at approximately 130 feet above mean sea level. Surface runoff from this stream and an adjoining tributary discharge into the nearshore waters of Larsen Bay between Leti Point and Puatauapa Point.

Stream 29B begins near the 200-foot contour on northwest side of Larsen Bay. This stream drains the steeper slopes of Fogamaa Crater before discharging into Larsen Bay's Fagalua Cove.

There are six unnamed streams (Stream 29C through Stream 29H) between Fagalua Cove and Matautula Point. All of these streams are short and drain the southeast side of Matautuloa Ridge. Each of the stream originates at elevations between the 95 and 175-foot contour.

Along the northwest side of Matautuloa Ridge, Stream 29I begins at approximately the 200 foot elevation and flows into Fagatele Bay. Stream 29J and one tributary originate at about the 215 foot elevation and drains the southeastern end of Fagatele Crater. Both streams derive surface runoff from the northwest slopes of Matautuloa Ridge and discharge into the east side of Fagatele Bay.

Stream Flows Within the Watershed

No stream flow data is available for the Fagatele-Larsen Bay watershed.

Surface Water Quality

Streams

No surface water quality data is available for the 10 streams of the watershed, Fagatele Bay, or Larsen Bay. Available satellite photography that was taken by the U.S. National Oceanographic and Atmospheric Administration (NOAA) on June 18, 1994 indicate the presence of no significant turbidity in the surface waters of Fagatele or Larsen Bay.

Nearshore Waters

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila on July 25 and August 2, 1992. The samples were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the outer waters of Larsen Bay and Fagatele Bay met American Samoa water quality standards in late July and early August of 1992 (Table 29-2). Laboratory results also suggest that stormwater runoff from undeveloped lands upland of these embayments do not generate any significant discharge of nutrients.

During the June 12-18, 1994 period, only 23 millimeters of rainfall (approximately 0.9 inch) was recorded at NOAA's monitoring station which is situated upslope of the Tula's primary village area (Mefford, 1998). A correlation of these rainfall records with available satellite photography on June 18, 1994 suggest that lower flow stream conditions in the watershed probably have little influence upon nearshore water quality. However, some increased turbidity and sedimentation within the nearshore waters may be generated during medium and higher streamflow conditions.

TABLE 29-2
SURFACE WATER QUALITY
OUTER LARSEN BAY AND FAGATELE BAY
JULY-AUGUST, 1992

STATION	Sample Depth (feet)	Nitrate/ Nitrite mg N/l	Total N mg N/l	Kjeldahl N mg N/1	Total P mg P/1	CHL a mg/m^3
Larsen Bay	3	<0.001	0.141	0.141	0.010	0.19
	60	<0.001	0.115	0.115	0.016	0.23
Fagatele Bay #1	3	0.008	0.119	0.111	0.015	0.14
	60	0.002	0.116	0.114	0.011	0.12
Fagatele Bay #2	3	<0.001	0.119	0.119	0.012	0.26
	60	<0.001	0.130	0.130	0.012	0.20

Source: ASEPA, 1995

Wetlands

There are no significant wetlands in the Fagatele-Larsen Bay watershed.

Marine Resources

Coral Communities

A coral reef extends from approximately 150 to 650 feet seaward of the shoreline of Larsen Bay. In Fagatele Bay, the reef ranges from approximately 100 to 1,100 feet wide.

The Fagatele Bay National Marine Sanctuary was established in August, 1986 (Le Vaomatua, Inc., 1992). The U.S. National Oceanic and Atmospheric Administration is sponsoring long term coral reef monitoring programs in Fagatele Bay as part of its National Marine Sanctuary operations. Fagatele Bay is also used by Le Tausagi's Enviro-Discoveries Program to provide educational opportunities to children of American Samoa via its Marine Discovery Program. The Fagatele Bay National Marine Sanctuary also sponsors a Marine Science Summer Camp that visits Fagatele Bay during its summer program.

Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests that the crown-of-thorns starfish infestation in the late 1970's, as well as the influence of hurricanes in the late 1980's and early 1990's, damaged much of the reef and kept overall coral development low.

Fagatele Bay Marine Sanctuary coordinator, Nancy Daschbach, confirmed in May, 1996 that the coral communities in Fagatele Bay have sustained significant damage from Hurricane Ofa in February, 1990 and Hurricane Val in December, 1991. In addition, a major coral bleaching occurred in the South Pacific between December, 1993 and April, 1994. During this period, Daschbach observed the beaching of algae and corals as deep as 130 feet. Smithsonian coral specialist, Tom Gorreau, concluded that this event was the most severe bleaching he had seen. As a result, Fagatele Bay continues to remain in recovery from hurricanes, coral bleaching, the use of dynamite during fishing activities, and other environmental changes (Daschbach, 1996).

1978-1979

In Larsen Bay, the reef seaward of Fagalua Cove was characterized by a coral cover that ranged between one and three percent within 60 feet from the shoreline October, 1979. However, near the reef margin, coral coverage was up to 20 percent (Aecos and Aquatic Farms, 1980).

Coral coverage along the reef front was highly variable. Some areas contained no coverage; other areas contained up to 50 percent (Aecos and Aquatic Farms, 1980).

Infestation by the crown-of-thorns starfish was reported in deeper portions of Larsen Bay in early 1978. However, no starfish infestation was observed on forereef slopes of Fagalua Cove in January and February 1978. However, Fagalua Cove and other parts of Larsen Bay were infested by the crown-of-thorns starfish later in 1978 (Aecos and Aquatic Farms, 1980).

In Fagatele Bay, the reef flat along the east margin of Fagatele Bay supported a 10 percent coral coverage in October, 1979.

In early 1978, Fagatele Bay contained no infestation by the crown-of-thorns starfish. A December 1978 survey of the reef recorded coral cover at less than 25 percent along the fringing reef flat at a depth of 10 feet. In October, 1979, the crown-of-thorns starfish was relatively common on the reef and more abundant in shallow water (Aecos and Aquatic Farms, 1980).

Along the reef front, coral coverage was documented to be roughly five percent in October, 1979. Dead coral heads accounted for about 95 percent of the bottom cover.

1985 and 1988

During the month of April in 1985 and 1988, Birkeland and Randall investigated the coral communities in Fagatele Bay. Five transects were established in Fagatele Bay that were used for all three surveys. Observations were generally made on the reef flat, as well as depths of roughly 10, 16, 30, and 40 feet.

Birkeland concluded in a related coral and reef-fish assessment that the coral community in Fagatele Bay made substantial progress towards recovery. New coral recruits accumulated in the community; consequently, the surface cover of the substrata did not increase as rapidly as coral abundance.

In 1988, the surface cover and abundance of corals were greater in the center of Fagatele Bay and generally decreased near the east and west margins of the Bay. Available data for 1985 and 1988 indicate that the greatest coral coverage was about 44 percent along the reef flat near the center of Fagatele Bay.

1992

Field investigations were also made by Maragos, Hunter, and Meier in 1992. Surveys were made at Larsen Bay and Fagatele Bay.

In Larsen Bay, live stony coral coverage was documented to be less than one percent at a depth of six meters. At the 18 meter depth, 40 percent coral coverage was recorded.

At Fagatele Bay, one to five percent of coral coverage was observed at a depth of 18 meters. No documentation was made at shallower depths.

Marine biologists noted that shallow water areas in Fagatele Bay were once characterized by high coral cover and diversity. The crown-of-thorns starfish infestation in the late 1970's, as well as the influence of hurricanes in the late 1980's and early 1990's, damaged much of the reef and kept overall coral development low (Maragos, Hunter, and Meier in 1992).

1995

A 1995 survey of various coral reefs throughout the Samoan Archipelago included a survey of the reef front of the east side of Fagatele Bay. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Coral cover was observed to be “low,” or less than 20 percent. Fish species richness was observed to be greater than 150 species; fish density was observed to be represent between 5,000 and 9,999 individuals. Fish biomass was reported to be less than 500 kilograms per ha.

Wildlife Resources

Aecos and Aquatic Farms noted in its 1980 Coral Reef Inventory that the blue-gray noddy, a resident seabird uncommon in American Samoa, roosts and nests along the perimeter of Larsen Bay, as well as at Sail Rock Point. Slopes that surround Fagatele Bay also provide nesting and roosting habitat for several seabirds such as the brown booby, blue-gray noddy, brown noddy, gray-backed tern, and white tern (Engbring and Ramsey, 1989).

Bat roosts in the vicinity of Fagatele Point and the adjoining coastal forest have been used since, at least, 1982 (Brooke, 1997). More recently, the fruit bat population in Fagatele Bay was estimated to be 904. This estimate was based upon exit counts between October, 1996 and September, 1997 (Utzurrum, 1998).

Shoreline Protection

There are no man-made shoreline protection facilities along the shoreline of the watershed. Any shoreline erosion along the watershed is derived from natural coastal processes.

Groundwater and Surface Water Supplies

There are groundwater supplies located in the watershed. Surface supplies represent individual roof catchment systems at residences in the watershed.

USE OF THE WATERSHED

Resident Population

There are about two families that reside in the watershed. One family that resides on north side of the watershed helps control access to Fagatele Bay. Another family lives on the east side of Larsen Bay.

Land Uses

Residential

There are approximately two dwelling units in the watershed. One is located on the north side of the watershed and is part of Futiga Village. The second residence on the east side of Larsen Bay is situated on the far west side of Vaitogi.

A part-time or “second home” residence is located upslope of Matautuloa Ridge. It is believed that this residence is owned by the Malae family.

Industrial

A solid waste landfill is situated in the northwest part of the watershed. The site contains approximately six acres of land.

This facility is operated by the American Samoa Power Authority. Most of the wastes transported to this disposal site are collected by a local solid waste collection company, which is under contract to ASPA. Between 50 and 75 percent of the resident population is served by this company.

Based upon time and motion studies that were conducted by CalRecovery, Incorporated in July, 1995, it was estimated that the Island of Tutuila generates approximately 57 tons per day of solid waste material (CalRecovery, 1996).

Use of the Nearshore Waters

Recreational and Subsistence Fishing

There is some limited use of the nearshore waters for subsistence and recreational fishing. Some of the nearshore fishing activity in Fagatele Bay includes the use of dynamite which is clearly detrimental to marine populations and habitats for fish and other marine organisms. It is believed that most fishing along the shoreline is made by fishermen who occasionally operate small fishing vessels in the nearshore waters.

Limited use of the nearshore waters is primarily a result of fishing regulations and restricted vehicular access. Spear fishing is prohibited in Fagatele Bay. In addition, gleaning and pole fishing are restricted from the inner part of Fagatele Bay. The private vehicular trail leading to Fagatele Bay sometimes has a chain across the trail to restrict use.

Future use of the nearshore waters in Fagatele Bay could be increased if regulations associated with the Marine Sanctuary were revised to permit gleaning and pole fishing. These restrictions are not necessary for effective resource management.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Restrictions associated with access to Fagatele Bay and the presence of steeper slopes throughout much of the watershed will discourage future development of lands on the north side of the Fagatele Bay and Larsen Bay.

However, the east side of Larsen Bay is accessible via a dirt trail from Vaitogi. While only one full-time residence is located in this area, other “second homes” are located along the road from Vaitogi.

The construction of 12 new residences are anticipated along east shoreline of Larsen Bay between 1996 and the year 2015.

Industrial

The capacity of the Futiga landfill to support future solid waste disposal requirements for the Island of Tutuila has not been determined.

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Anticipated residential growth on the east side of Larsen Bay will increase potable water consumption, as well as the generation of wastewater and solid wastes. These impacts are included in forecasts presented for Vaitogi in Table 28-6 and Table 28-7 (see evaluation for Central Tafuna Plains, Watershed #28).

Because of the distance of these anticipated homes from Vaitogi, it is expected that water supplies will represent individual roof catchment systems. Wastewater disposal will likely be accomplished through the use of septic tanks and leachfields.

It is important that any septic tank and leachfield installations contain adequate soil treatment. Otherwise, wastewater effluent discharges may generate potential discharges of bacteria and nutrients in the nearshore waters of Larsen Bay. ASPA should make a careful evaluation of proposed wastewater treatment facilities in this area since local Iliili extremely stony mucky clay loam soils, do not adequately treat wastewater. As this area becomes more developed, a small community sewage system may be required to prevent contamination of the nearshore waters in Larsen Bay.

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. However, no detailed study was made of the streams in the watershed.

Inland Flood Hazards

All inland areas of the Fagatele-Larsen Bay watershed have been designated by the Federal Emergency Management Agency as "zone x." This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazards

The flood insurance rate map for the shoreline of the Fagatele-Larsen Bay watershed indicates that there is a coastal flood hazard through much of the nearshore waters and adjoining shoreline. A potential 100-year flood is estimated to generate flood levels in this area of approximately two feet above mean sea level (MSL).

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

There is no available data that indicates the amount of runoff that is being transported into Fagatele or Larsen Bay. The discharge of eight streams into Larsen Bay suggests that this embayment likely receives the greatest impact from surface water runoff. Significantly less surface runoff probably is generated from the two streams that discharge into Fagatele Bay.

More significant runoff likely occurs during and following periods of heavier rainfall. Turbid water conditions in the nearshore waters probably do not remain for any significant amount of time because of the southerly wave exposure of both embayments.

Considerably greater volumes of stormwater runoff and sedimentation could be generated and transported into Fagatele Bay and Larsen Bay if steeper upland slopes were developed. For this reason, it is recommended that a Territorial Park should be established within most of the lands in the watershed. Lands in the vicinity of the Futiga landfill should not be incorporated into the proposed Park.

The American Samoa Coastal Management Program and Fagatele Bay Marine Sanctuary coordinator should initiate discussions with representatives of the Fuimaono and Satele families to determine potential options for the establishment of a Territorial Park. It is believed that ongoing recreational and agricultural land uses by these families could be effectively integrated into a larger Territorial Park area. Reasonable resource and land use management regulations associated with the Park could:

- reduce long-term potential for increased stormwater runoff and sedimentation in Fagatele Bay and Larsen Bay;
- ensure the conservation of wildlife and nearshore coral communities; and,
- increase public recreational opportunities.

The designation of a Territorial Park will facilitate greater public access and use of Fagatele Bay and Larsen Bay for both recreational and educational purposes. Through greater exposure to the resources of these areas to the general public, it is believed that resource management objectives will become better understood and appreciated by American Samoa residents.

Nearshore Water Quality and the Marine Environment

The concern for continued turbidity and sedimentation in the nearshore waters of the watershed is important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the Fagatele-Larsen Bay watershed. They provide shelter to fish, invertebrates, and other marine organisms. Some of these resources represent a supplemental food source for some residents of West Tutuila.

The continued monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of Fagatele and Larsen Bay. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters of the watershed. The collection of water samples and/or the use of water quality monitoring equipment could be accomplished during the performance of some educational programs in the watershed.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef flat and reef front east of Fagatele Bay and Larsen Bay at least once every three years. Long-term monitoring of this site should also include an evaluation of the impact of sedimentation and turbidity that may also be influencing the nearshore marine environment. Such efforts should be integrated into the ongoing coral reef monitoring program that is being accomplished in Fagatele Bay by consultants to the National Oceanic and Atmospheric Administration.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Fagatele-Larsen Bay watershed will be to:

- expand recreational and educational opportunities at Fagatele Bay and Larsen Bay;
- establish a Territorial Park within most of the watershed, but exclude lands in the vicinity of the Futiga landfill;
- carefully evaluate any future wastewater systems that are proposed along the east side of Larsen Bay;
- conserve the wildlife habitats located upslope of Fagatele Bay and Larsen Bay; and,
- conserve coral communities in the nearshore waters of Fagatele Bay and Larsen Bay.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with a designated representative of the Futiga Village council and the Fuimaono and Satele families, and encourage cooperative resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 29-3. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 29-3
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
FAGATELE-LARSEN BAY WATERSHED

Participating Public agency	Resource Management Objective	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders in Futiga, as well as representatives of the Malae and Satele families. 4. Make annual assessment of resource management program.
ASEPA	Monitor long-term water quality of Fagatele Bay and Larsen Bay.	1. In cooperation with FBNMS and ASCMP, collect water samples from selected locations in Fagatele Bay and Larsen Bay. 2. Analyze samples for TSS and nutrients.
ASCMP/ FBNMS	Increase educational opportunities.	1. Develop and increase expanded educational opportunities for resource management. Programs should target both children and adults. 2. Budget and obtain funds for program implementation.
ASCMP/ FBNMS	Establish a Territorial Park in most of the watershed.	1. Initiate discussions with Malae and Satele families concerning the establishment of a Territorial park in portions of the watershed. 2. Prepare an integrated plan for park development and resource management and draft modifications to existing use restrictions. 3. Coordinate plan with landowners and NOAA's Marine and Estuarine Management Division. 4. Revise draft plan and present final plan to Fono and NOAA for approval and funding of improvements.
ASDOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
ASDMWR	Conserve wildlife habitat of seabirds and fruit bats in the watershed.	1. Monitor and quantify changes in nesting and roost sites for seabirds and fruit bats on an annual basis. 2. Identify potential stresses upon habitat.
ASDMWR	Conserve marine communities of Fagatele Bay and Larsen Bay.	1. Monitor and quantify changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) along the fringing reef flat and reef front of Fagatele Bay and Larsen Bay approximately once every three years. 2. Identify stresses upon coral communities and marine life and evaluate potential impacts from sedimentation.

Source: Pedersen Planning Consultants, 1999

LEONE
Watershed 30

GEOGRAPHY

The Leone watershed is located in the western one-third of Tutuila Island. The watershed comprises about 5.67 square miles of land area (Figure 30-1).

The upland boundaries of the Leone watershed an unnamed peak at about the 1,268 elevation and an adjoining plateau, as well as the southwest end of Faleselau Ridge. The east side of the watershed is bounded by Seumalo Ridge along the northwest side of Fagatele Crater, Olovalu Crater, and the southwest slopes of Olotele Mountain. Masinaoleafiafi Ridge, which is situated on the west side of Amaluia, represents the western boundary of the Leone watershed. Within the watershed, there are four additional volcanic ridges (Tutu, Mulimauga, Malaloto, and Lesui) that define three drainage areas.

Along Tutuila's southwest coast, the watershed extends between Fagatele Point and Sinamanoo Point. Leone Bay is the primary embayment that adjoins the watershed. However, a smaller embayment also fronts Amaluia. Pala Lagoon lies within the central portion of Leone Bay. Papafaasee Cove is located southwest of Vailoatai Crater.

Within the three general drainages of the watershed, there are five primary stream courses. These include Faalogo, Fuafua, Leafu, Aualii, and Vaipuna streams.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 30-2). Twelve soil classifications were identified by the U.S. Soil Conservation Service for lands within Leone watershed (Table 30-1).

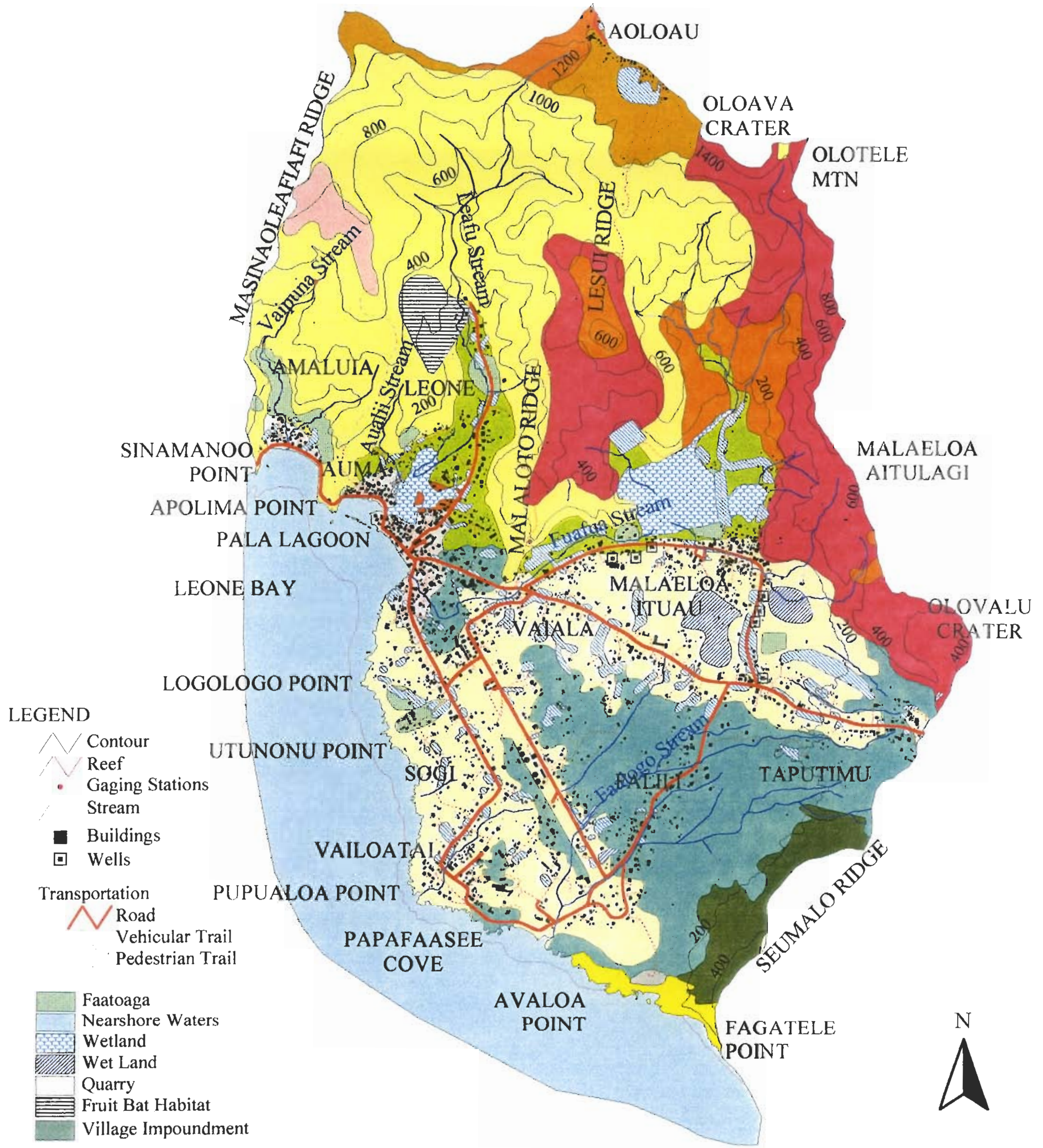
Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

Along the shoreline of Leone Bay, the inhabited areas of Amaluia, Auma, and Leone contain soils known as Urban Land-Aua-Leafu complex (SCS mapping unit 34).

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. The soil has limited to moderate potential for runoff. The erosion potential is slight to moderate.

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, do not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and cesspools in areas that contain these soils may be making a contribution of nutrients and bacteria into the nearshore waters of Leone Bay.



American Samoa Geographical Information System

0.5 0 0.5 1 1.5

Miles

Scale: 1:32,000

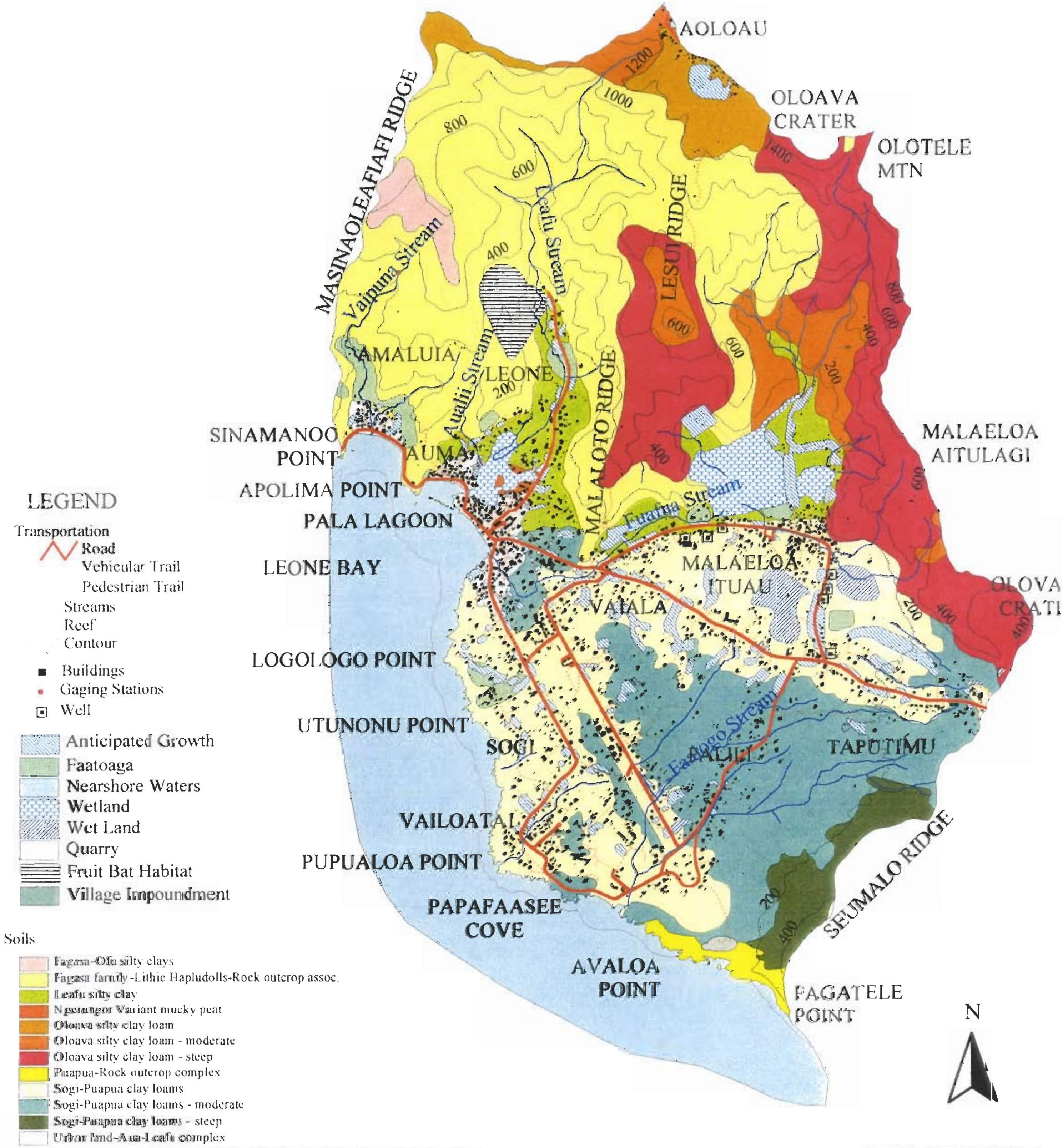
Prepared by: Pedersen Planning Consultants

Tel: 307-327-5434

Leone Watershed
Existing Conditions

30

Figure 30-1



American Samoa Geographical Information System

0.5 0 0.5 1 1.5

Miles

Scale: 1:32,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Leone Watershed Management Issues

30

Figure 30-2

TABLE 30-1
SELECTED SOIL CHARACTERISTICS
LEONE WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
3	Fagasa-Ofu silty clays	30-60	None	Med to Rapid	Mod to Severe	>6	20-40	Severe Slope Depth	Moderate
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
8	Leafu silty clay	0-3	Occ	Slow	Slight	3-5	>60	Severe Flood Wet	Moderate
13	Ngerungor variant mucky peat	0-1	Fre-quent	Slow	Slight	+1-1.0	>60	Severe Flood Ponding Poor Filter	Poor
19	Oloava silty clay loam	6-12	None	Slow	Slight	>6	>60	Severe Filter	Good
20	Oloava silty clay loam	12-25	None	Slow to Med	Slight to Mod	>6	>60	Severe Filter Slope	Good
21	Oloava silty clay loam	40-100	None	Rapid	Severe	>6	>60	Severe Poor Filter Slope	Poor
26	Puapua-Rock Outcrop Complex	40-100	None	Rapid	Severe	>6	10-20	Severe Depth To Rock Slope	Poor
28	Sogi-Puapua Clay Loams	0-6	None	Slow	Slight	>6	10-40	Severe Depth To Rock Poor Filter	Moderate
29	Sogi-Puapua Clay Loams	6-20	None	Slow To Med	Slight To Mod	>6	10-40	Severe Depth To Rock Poor Filter	Moderate
30	Sogi-Puapua Clay Loams	20-40	None	Med to Rapid	Mod to Severe	>6	10-40	Severe Depth to Rock Poor toFilter	Moderate
34	Urban Land-Aua-Leafu Complex	0-30	A. None L. Occ	A.Slow to Med L. Slow	A.Slight to Mod L. Slight	A. >6 L. 3-5	>60	Severe A. Slope L. Flood Wet	Limited

Notes:
1. A.= Aua soils found on mountain foot slopes 6-30 percent
2. L.= Leafu soils found on coastal plains & valley floors 0-6 percent

Source: U.S. Soil Conservation Service, 1984

Sogi-Puapua Clay Loams, 20 to 40 Percent Slopes

Sogi-Puapua clay loams (SCS soil mapping unit 30) are found on the east side of Taputimu.

This upland soil represents a combination of approximately 45 percent Sogi clay loam and about 40 percent Puapua clay loam. Some smaller areas of tuff outcrops characterize knolls and ridgetops.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam is usually about 10 inches thick. The subsoil includes a five-inch layer of dark brown clay loam. The substratum represents dark brown and very dark brown loamy sand which extends about 12 inches in depth over hard tuff. The depth to hard tuff ranges between 20 and 40 inches.

Soil permeability ranges between two and six inches per hour in the first 15 inches of soil. Between 15 and 27 inches of soil depth, the permeability increases to a rapid rate of 6 to 20 inches per hour.

The U.S. Soil Conservation Services estimates that potential runoff is medium to rapid. The potential hazard for water erosion is moderate to severe.

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches. Potential runoff from this soil is considered to be slow to medium.

The soil permeability of the Puapua soil ranges between two and six inches per hour. Potential soil runoff from this soil type is considered to be medium to rapid. The Puapua soil has a slight to moderate potential for water erosion.

Sogi-Puapua soils are moderately suited for the production of subsistence crops. Potential water erosion and the limited depth to bedrock are potential constraints to agricultural production.

The limited depth to bedrock and restrictive clay layer does not enable adequate filtering of wastewater effluent. Consequently, this soil is not suited for the use of septic tanks and other soil-based treatment systems.

Sogi-Puapua Clay Loams, 6 to 20 Percent Slopes

South of the primary shoreline roadway, Sogi-Puapua clay loams (SCS soil mapping unit 29) are present in portions of Malaeloa/Ituau, Taputimu, Vailoatai, and the east part of Leone.

This upland soil represents a combination of approximately 45 percent Sogi clay loam and about 40 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches.

The potential hazard for water erosion is slight to moderate. The U.S. Soil Conservation Services estimates that potential runoff is slow to medium.

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches. Potential runoff from this soil is considered to be slow to medium. Potential water erosion from this soil is estimated to be slight to moderate.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock and potential water erosion. However, potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

Sogi-Puapua Clay Loams, O to 6 Percent

A number of areas on the southwest side of the watershed contain Sogi-Puapua clay loams (SCS soil mapping unit 28). These areas generally include:

- the lower portions of Malaeloa/Aitulagi;
- the Sogi area;
- southwest part of Taputimu; and,
- the upper portions of Malaeloa/Ituau.

This upland soil represents a combination of approximately 50 percent Sogi clay loam and about 35 percent Puapua clay loam.

The Sogi soil is moderately deep to tuff and well-drained. This soil is formed in volcanic ash and underlain by hard, volcanic tuff. The surface layer, which is characterized by a dark brown clay loam, is usually about 10 inches thick. The subsoil includes another 11-inch layer of dark brown clay loam. The substratum contains a very dark grayish-brown, loamy sand, about five inches thick, that lies over hard tuff. The depth to hard tuff ranges between 20 and 40 inches (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

The first 21 inches of soil depth have a soil permeability that ranges between two and six inches per hour. Between 21 and 26 inches in depth, the soil permeability of the Sogi soils range between six and 20 inches per hour. In Puapua soils, soil permeability remains between two and six inches per hour to a depth of 26 inches.

Potential runoff from this soil is considered to be slow. Potential water erosion from this soil is estimated to be slight (U.S. Soil Conservation Service, 1984).

Sogi-Puapua clay loams are moderately suited to the production of subsistence and truck crops. These agricultural uses are somewhat constrained by the depth to rock. Potential erosion can be addressed through the use of crop residues and mulch.

Residential development on these soils is not desirable. The limited depth to bedrock does not enable effective treatment of wastewater effluent from soil-based treatment systems.

Puapua-Rock Outcrop Complex, 40 to 100 Percent Slopes

Soils identified by the U.S. Soil Conservation Service as Puapua-Rock Outcrop Complex (SCS soil mapping unit 26) are found along the Taputimu Village shoreline between Fagatele Point and Avaloa Point.

About 50 percent of the Puapua-Rock outcrop complex soil comprises Puapua clay. About 30 percent of the soil includes rock outcrop. The Puapua soil is typically found on the steeper slopes. The rock outcrop, which consists of exposed areas of lava and hard volcanic tuff, occurs primarily on crater rims, ridgetops, and the sides of smaller gullies (U.S. Soil Conservation Service, 1984).

The Puapua soil is shallow to tuff and well-drained. The surface layer includes a very dark, brown clay loam approximately 11 inches thick. The substratum represents a five-inch layer of dark brown sandy loam over hard tuff. The depth to hard tuff ranges from 10 to 20 inches.

Soil permeability for Puapua soils range between two and six inches per hour above the tuff. However, permeability is slow through the tuff.

Potential soil runoff is considered to be rapid. The potential for water erosion is severe (U.S. Soil Conservation Service, 1984).

The Puapua-Rock outcrop complex soils are not well suited for agricultural uses. Steeper slopes constrain cultivation efforts. Subsistence crop production is hampered by the presence of rock outcrop areas. Any subsistence production should include the regular application of crop residues, mulch, or other ground cover materials.

Residential uses are impacted by steeper slopes and the inability to use septic tanks or other soil-based treatment systems. Roads must be designed to minimize the potential for erosion. However, road construction is influenced again by the presence of rock outcrop areas.

Ngerungor Variant Mucky Peat

Ngerungor Variant mucky peat (SCS mapping unit 13) is located near the Leafu Stream mouth within Leone's Pala Lagoon.

This poorly drained organic soil is characteristic of a coastal swamp environment in American Samoa and is typically covered by water. Ngerungor Variant mucky peat is formed in organic material that is derived primarily from decomposing mangrove roots and litter.

The surface layer of the soil, which comprises a very dark, mucky peat, is about four inches thick. A very dark, grayish- brown layer of peat extends between 4 and 17 inches below ground elevation. The underlying soil contains very dark brown peat to a depth of 60 inches or more (U.S. Soil Conservation Service, 1984).

Ngerungor variant mucky peat is formed in organic material that is derived primarily from decomposing mangrove roots and litter. The permeability ranges from between six to 20 inches per hour. Runoff is very slow; the hazard of water erosion is slight (U.S. Soil Conservation Service, 1984).

This soil is not suitable for structural development, e.g., residential uses, due to its limited capacity to support foundations and the potential for frequent flooding around building structures. Ngerungor variant mucky peat is also not conducive for use with onsite wastewater disposal systems because of the soil's inability to adequately filter and treat wastewater.

Leafu Silty Clay (0 to 3 percent slopes)

Leafu silty clay soils (SCS mapping unit 8) are found in the lower elevations of the Leafu and Fuafua Stream drainages.

This soil is a deep soil that typically extends up to 60 inches in depth. Its permeability ranges between 2 and 6 inches per hour. Runoff from these soils is generally slow and the potential for soil erosion is limited. However, these soils are typically subject to brief periods of flooding during prolonged, heavier rainfall.

These soils are moderately suitable for subsistence agriculture. However, this land use is constrained by occasional periods of flooding and general soil wetness. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these Leafu soils for residential land uses is not recommended by the U.S. Soil Conservation Service because of the inherent flood potential associated with this soil. The same characteristics also hamper the use of these soils for septic tank systems and related soil-based treatment.

Oloava Silty Clay Loam (6 to 12 Percent Slopes)

Oloava Silty Clay Loam (SCS mapping units 19) soils are located along most of the higher elevations of the Leone watershed. They are generally located on the mountain plateau and steeper slopes along the north and northwest watershed boundaries.

In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a dark-brown, silty clay loam. Soft, weathered cinders are typically present between 12 to 40 inches in depth. However, the depth to weathered cinders sometimes extends to 60 inches or more.

The permeability of the Oloava soil is moderately rapid, i.e., 2 to 6 inches per hour, through the surface layer. However, permeability becomes very rapid, i.e., 6 to 20 inches per hour, through the cinder material that occurs between 12 to 60 inches in depth (U.S. Soil Conservation Service, 1984).

The rate of stormwater runoff through these Oloava soils is typically slow. The potential for water erosion is considered slight (U.S. Soil Conservation Service, 1984).

This soil is well-suited to the production of subsistence crops. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity. The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers (U.S. Soil Conservation Service, 1984).

Residential development on these Oloava soils is not considered desirable. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment (U.S. Soil Conservation Service, 1984).

Oloava Silty Clay Loam (12 to 25 Percent Slopes)

Oloava Silty Clay Loam (SCS mapping unit 20) is also located on a portion of the upper elevations of the watershed near the 1,200-foot contour, as well as the upper elevations of the Fuafua Stream drainage.

In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a dark-brown, silty clay loam. Soft, weathered cinders are typically present between 12 to 40 inches in depth. However, the depth to weathered cinders sometimes extends to 60 inches or more.

The permeability of the Oloava soil is moderately rapid, i.e., 2 to 6 inches per hour, through the surface layer. However, permeability becomes very rapid, i.e., 6 to 20 inches per hour, through the cinder material that occurs between 12 to 60 inches in depth (U.S. Soil Conservation Service, 1984).

The rate of stormwater runoff through these Oloava soils is typically slow. The potential for water erosion is considered slight (U.S. Soil Conservation Service, 1984).

This soil is well-suited to the production of subsistence crops. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers.

Residential development is not desirable on these soils. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment.

Oloava Silty Clay Loam (40 to 100 percent slopes)

The Oloava silty clay loam soil (SCS soil mapping unit 21) is found along the east slopes of Malaloto Ridge, as well as the north and west slopes of Lesui Ridge.

The Oloava silty clay loam is a well-drained soil that was formed in volcanic ash and cinders. The surface layer is typically is a dark brown silty clay loam that is about six inches thick. A dark brown, clay loam is characteristic of the upper five inches of the subsoil while the lower three inches is a dark brown, gravelly-silt loam. Weathered cinders extending to a depth of 60 inches represent the substratum. Within 12 to 30 inches from ground elevation, weathered cinders gradually crush to very gravelly sandy loam.

Exposed cinders and small rock outcrops occasionally occur in conjunction with these Oloava soils.

The permeability of this Oloava soil ranges between 2 and 6 inches per hour above the cinder layer. However, permeability through the cinder layer, i.e., between 14 and 60 inches, increases to a rapid rate greater than 20 inches per hour.

These soils have a severe potential for water erosion. Stormwater runoff rates are rapid.

These soils are not suitable for the production of subsistence crops. These soils typically occur on steeper slopes and have a severe water erosion potential.

Similar soil characteristics also make these Oloava soils are unsuitable for residential and commercial structures.

Fagasa-Ofu Silty Clays

A small area of soils known as Fagasa-Ofu Silty Clays (SCS mapping unit 3) is situated along Masinaoleafiafi Ridge, the west boundary of the watershed.

The soil ranges between 20 to 40-inches in depth. The permeability of this silty clay loam is moderately rapid (2 to 6 inches per hour). The potential for surface runoff from these soils is considered moderate to rapid. However, the potential for erosion is moderate to severe.

The U.S. Soil Conservation Service indicates that this soil type is somewhat suitable for the production of subsistence crops. The soil can annually sustain from one to 5 tons per acre of erosion without impacting crop productivity. However, the Soil Conservation Service recommends the use of mulch, crop residues, and cross-slope farming to reduce the potential for soil erosion.

The limited depth to bedrock and steeper slopes indicate that this soil is poorly suited for septic tank installations and other forms of soil-based treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

There are generally three drainage areas in the Leone watershed that contain five primary streams and various tributaries.

East Drainage Area

The east drainage area generally includes the lands east of Malaloto Ridge to the east boundary of the watershed. The primary stream in this drainage is Fuafua Stream. There are approximately 13 tributaries to Fuafua Stream which rise as high as 1,080 feet above mean sea level. This a complex drainage that passes through the fresh-water swamp at Malaeloa Aitulagi. Fuafua Stream continues west of the fresh-water swamp along the north side of the loop road that provides access to Vaiala and Malaeloa Aitulagi. The stream passes the east side of Faasao High School before turning southwest. Fuafua Stream meanders through the south part of Leone Village before its discharge into the east side of Leone Bay.

In Taputimu, there is another complex drainage that is not well represented on the U.S. Geological Survey map of Tutuila. A considerably more accurate representation can be reviewed in the geographical information system developed for the Watershed Protection Plan. Faalogo Stream is an intermittent stream that contains, at least, six branches. The main stream and its primary branch originate near the 250-foot contour north of the Futiga landfill. Stream flows disappear and reappear through swales and natural depressions in Taputimu. Ultimately, surface flows are discharged into the shoreline at Papafaasee Cove.

A second, unnamed drainage is situated west of Faalogo Stream. This drainage begins just south of Faasao High School and the primary shoreline roadway, and continues to just north of the WVUV radio station. At this point, the stream disappears; however, it soon reappears downslope of WVUV as the stream course continues through the heart of Vailoatai. This stream course discharges seaward of Vailoatai near Pupualoa Point.

Central Drainage Area

The central drainage area of the watershed is situated between Tutu Ridge and Malaloto Ridge. Mulimauga Ridge is located just east of Tutu Ridge. The primary stream in this drainage is Leafu Stream which begins near the 1,200-foot elevation. Intermittent stream flows carry down the center of a narrow valley on the north side of Leone Village that is bounded by Mulimauga Ridge and Malaloto Ridge. The stream course passes through the residential area on the north side of Leone before its discharge into Leone's Pala Lagoon.

Aualii Stream is a relatively short stream that originates at about the 210-foot contour. This stream drains surface runoff between Tutu Ridge and Mulimauga Ridge. Stream flows pass through the north part of Auma before emptying into Pala Lagoon.

West Drainage Area

The west drainage area of the Leone watershed is located between Tutu Ridge and Masinaoleafiafi Ridge. The primary stream in this drainage is Vaipuna Stream which has about three tributaries. The main stem of the stream begins at about the 775-foot elevation. This stream and its lower tributary flow through Amaluia. The main step discharges into the nearshore waters of Leone Bay that front Amaluia Village.

Stream Flows Within the Watershed

A continuous and partial-record station (No. 169335000) was established on Leafu Stream, approximately 900 feet upstream from the village water system intake. Continuous flows were recorded between October, 1977 and September, 1986. Between 1987 and 1990, only partial records were taken. Available data enabled the U.S. Geological Survey to estimate a median flow of 2.50 cubic feet per second (Wong, 1996).

Between 1959 and 1963, a low-flow, partial record station (No. 16935000) was maintained by U. S. Geological Survey approximately 2.1 miles upstream from the Fufua Stream mouth in Malaeloa, Fourteen historical measurements of stream flow enabled the U.S. Geological Survey to estimate a median flow of 0.79 cubic feet per second.

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Fuafua Stream, Leafu Stream, and Vaipuna Stream were three of 37 streams in American Samoa that was inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

Fuafua Stream

Fuafua Stream in Malaeloa was surveyed in two locations. Station 23a was located underneath a bridge near the mouth of the stream at an elevation of about 15 feet above mean sea level. Station 23b was situated immediately above a primary shoreline roadway bridge near the 100-foot elevation.

Near the mouth of Fuafua Stream, one abundant species of gobie fish and two species of shrimp were identified.

Two species of gobie fish were recorded at station 23b; one species was abundant. Only one species of shrimp was reported.

Leafu Stream

Leafu Stream in Leone was surveyed in four locations. Station 24a was situated along Aualii Stream about 200 feet upstream of the terminal estuary. Station 24b was located in a shallow cobble, stone riffle located about 1,300 feet upstream of Punaloa Spring. Station 24c was established in a boulder riffle that was situated immediately below a water catchment near the 110-foot elevation. Station 24d was located above the falls at a catchment situated near the 360-foot elevation.

Two species of gobie fish, one species of mountain bass, and one other species of fish were observed at station 24a. One species of shrimp was also recorded.

At station 24b, four species of gobie fish were identified; three were abundant. One species of mountain bass and one other species of fish were also documented. One species of shrimp and crab were also recorded.

Near the 110-foot elevation, four species of gobie fish, two species of gobie mountain bass, and one species of eel were documented (station 24c). Five species of shrimp were also identified.

The most upstream location (station 24d) contained only one species of goby fish. No other fish or invertebrates were present.

Vaipuna Stream

Vaipuna Stream in Amaluia Village was surveyed in two locations. Station 7a was situated in a stony riffle immediately above the primary shoreline roadway bridge. Station 7b was established along a gravel and cobble streambed upland of Amaluia Village.

Two species of goby fish and two species of mountain bass were identified near the shoreline (station 7a). Three shrimp were also documented; two of these species were abundant.

Three species of goby fish and two species of mountain bass were observed at station 7b. Two of the goby species were abundant; one of species of eel was also abundant. One abundant species of eels was reported. Four abundant and one common specie of shrimp were also identified at station 7b.

Surface Water Quality

Streams

The results of a single water quality sample collected in May 1985 at Leafu Stream demonstrate that water quality was satisfactory on the date of water sample collection (Table 30-2).

TABLE 30-2
MISCELLANEOUS WATER QUALITY DATA
LEAFU STREAM
MAY, 1985

	Water Quality Parameter							
Stream *Leafu*	TN (μg/l)	TKN (μg/l)	NO_3+NO_2 (μg/l)	TP (μg/l)	Turbidity (jtu)**	TSS (mg/l)	pH	Total Coliform (#/100 ml)
05-02-85	180	76	100	142	--	--	--	--

Notes:
The use of jtu (Jackson units) was used rather than "ntu". The latter is now more commonly used to measure turbidity.

Source: ASEPA, 1995

More recently, ASEPA is making a more detailed evaluation of selected streams in Leone, Asili, and Afono to better ascertain the source of sedimentation that impacts surface water quality and the nearshore marine environment. Monitoring includes the weekly collection of water quality samples from stream locations adjacent to developed lands, a *faatoaga*, and undeveloped lands. Subsequent laboratory analyses are made for total suspended solids, turbidity, total nitrogen, and total phosphorus. Selected monitoring locations were chosen, in part, because of the availability of long-term stream flow data for these streams (Wiegman, 1996).

In terms of Leafu Stream, data collected between October and December, 1995, as well as in April and May, 1996, indicate that surface waters occasionally exceed the Territory's water quality standards for fresh surface waters (Table 30-3). However, available data suggests that there is no significant difference in the water quality at the three stream locations. Somewhat greater turbidity and total suspended solid levels were documented at the stations adjacent to developed and agricultural lands in April-May, 1996.

TABLE 30-3
WATER QUALITY MONITORING
LEAFU STREAM
OCTOBER, 1995-MAY, 1996

Stations	LEO1R				LEO2PL				LEO3UND			
Date	*TSS* *(mg/L)*	*Turb-idity* *(NTU)*	*TN* *(mg/L)*	*TP* *(mg/L)*	*TSS* *(mg/L)*	*Turb-idity* *(NTU)*	*TN* *(mg/L)*	*TP* *(mg/L)*	*TSS* *(mg/L)*	*Turb-idity* *(NTU)*	*TN* *(mg/L)*	*TP* *(mg/L)*
10/31/95	4.9	4.0			6.0	6.0			5	3.3		
11/2/95	5.0	3.7			5.0	4.0			4	3.4		
11/7/95	5.0	3.7			6.0	5.8			5	3.4		
11/9/95	13.0	7.4			4.0	6.8			3	5.7		
11/14/95	13.0	7.1			7.0	6.0			6	3.2		
11/21/95	4.0	6.0	0.318	0.093	2.0	2.0	0.119	0.139	3	3.0	0.131	0.790
11/24/95	6.0	8.6	0.514	0.190	3.0	8.0	0.171	0.100	3	7.4	0.156	0.100
11/28/95	13.0	6.1	0.405	0.174	6.0	3.4	0.133	0.087	2	0.8	0.508	0.150
11/30/95	3.0	1.0	0.254	0.134	3.0	1.1	0.136	0.091	3	1.1	0.136	0.088
12/5/95	1.0	2.5	0.339	0.162	1.0	0.096	0.096	0095	3	2.7	0.095	0.093
12/7/95	1.1	13.0	0.248	0.131	1.1	1.0	0.064	0.08	1	0.2	0.081	0.101
12/11/95			0.279	0.198			0.099	0.104			0.094	0.103
12/12/95	4.0	0.6	0.249	0.131	2.0	0.4	0.075	0.093	1	0.3	0.08	0.098
12/14/95	5.0	9.1			1.0	0.8			1	0.8		
12/20/95	3.0	2.8	0.281	0.104	1.0	2.1	0.113	0.089	1	1.7	0.099	0.090
12/21/95			0.130	0.116			0.120	0.112			0.485	0.158
12/25/95			0.356	0.104			0.166	0.101			0.114	0.110
12/28/95			0.431	0.217			0.281	0.250			0.300	0.249
4/23/95	0.004	3.0			0.006	2.6			0.006	2.6		
4/25/95	0.004	3.1			0.003	3.0			0.002	2.0		
4/30/95	0.012	2.9			0.013	2.6			0.013	2.6		
5/2/96	0.004	7.9			0.063	5.1			0.003	4.2		
5/7/96	0.033	9.9			0.024	9.9			0.018	9.9		
5/9/96	0.002	9.9			0.002	9.9			0.003	9.9		

Notes: Station LEO1R is located adjacent to developed lands, Station LEO2PL is located adjacent to a plantation or *faatoaga, and* Station LEO3UND is located adjacent to undeveloped lands.

Source: ASEPA, 1996

Nearshore Waters

In terms of nearshore water quality, water samples were collected from 13 stations in the nearshore waters of Leone Bay on March 31 and April 2, 1987 (Table 30-4). These studies were made by William Brewer & Associates in conjunction with an environmental assessment of a proposed boat harbor project. Laboratory results indicated 1) an influence by fresh-water discharges from local streams and ground water; and, 2) considerable variation in water quality in the nearshore waters of Leone Bay.

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila on July 25 and August 2, 1992. The samples were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the outer waters of Leone Bay met American Samoa water quality standards in late July and early August of 1992 (Table 30-5). Laboratory results also suggest that considerable water exchange in the outer parts of Leone Bay helps maintain more desirable surface water quality. This water quality differs significantly from surface water quality near the shoreline which is influenced by significant fresh-water stream discharges and related sedimentation.

TABLE 30-4
NEARSHORE WATER QUALITY
LEONE BAY
MARCH 31 AND APRIL 2, 1987

Station No.	Time	Depth (cm)	Temperature (C)	Salinity (ppt)	D.O. (ppm)
Date: March 31, 1987					
Leafu Bridge	1555	5	28.0	1.7	5.30
		20	27.9	1.7	5.20
Date: April 2, 1987					
Leafu Bridge	1010	5	30.2	28.0	4.98
		20	29.8	27.5	4.65
1	1049	20	30.4	30.7	5.95
2	1053	20	30.4	30.2	5.80
3	1104	20	29.8 +1.0	28.4	5.20
4	1114	20	30.3	28.2	5.65
5	1124	20	29.5 +1.0	25.4	5.95
6	1136	5	28.5	27.0	5.85
		100	29.5	30.6	6.00
7	1200	20	28.9	31.8	5.80
8	1210	20	28.0	31.5	-
		5	-	28.0	-
9	1219	20	28.9	31.5	6.45
10	1226	20	28.0	31.2	6.28
11	1234	20	28.2	30.2	6.40
12	1240	20	29.4	31.5	6.05
13	1249	20	28.8	31.0	6.25

Source: Edward K. Noda & Associates, 1987

TABLE 30-5
SURFACE WATER QUALITY
OUTER LEONE BAY
JULY-AUGUST, 1992

Sample Depth	Nitrate/ Nitrite mg N/l	Total N mg N/1	Kjeldahl N mg N/l	Total P mg P/l	CHL a mg/m^3
3 feet	0.005	0.114	0.109	0.012	0.20
60 feet	0.004	0.147	0.143	0.008	0.14

Source: ASEPA, 1995

Wetlands

There are two wetlands in the Leone watershed: Leone Pala and the fresh-water swamp at Malaeloa.

Leone Pala

Leone Pala is a mangrove swamp that encompasses approximately 21 acres of land. Mangrove swamp characterizes some eight acres of the wetland. About 2.8 acres of the wetland represent open water during higher tidal conditions; however, most of the open water areas become exposed mudflats during lower tidal periods. The remaining areas of the wetland are a fresh-water wetland that is influenced by fresh-water discharges from Leafu and Aualii Stream, and three local springs. The freshwater wetland area comprises a combination of wooded swamp and wetland that has been converted to subsistence agricultural production (Biosystems Analysis, Inc., 1992).

The undisturbed mangrove area of the wetland is predominantly characterized by oriental and red mangrove, the swamp fern, and seashore paspalum. The fresh-water wetland area, which has more recently been changed to agricultural use, primarily includes spreading day flower, sour paspalum, mile-a-minute vine, as well as banana and coconut trees. Beach hibiscus is also found along inland margins of the mangroves and the uncultivated portions of the fresh-water wetland (Biosystems Analysis, Inc., 1992).

Similar to other wetlands on Tutuila, there has been continued encroachment upon Leone Pala. The most serious encroachment occurred in the late 1980's when a fill area was constructed on the south side of the mangrove swamp. A bridge was built over the open water area to provide access to this area. These developments were made to the support the construction of a new single family residence. Pedersen Planning Consultants surveyed this residential site in May, 1998. During the field investigation, PPC observed that construction of the single family was not completed. The existing residential structure appeared to be gradually deteriorating. More significantly, silt from Leafu Stream and Leone Pala appear to be building up approximately two to three feet high on the north and east sides of the concrete revetment along the perimeter of the fill. This build-up may represent Leafu's stream corrective action to regain its natural drainage course. Ultimately, increased pressure to the concrete retaining wall may gradually undermine and generate permanent damage to the retaining wall and fill area.

It is recommended that ASEPA and DOC hold informal discussions with the landowner to discuss potential resource management options. One potential option that should be considered is the removal of the residence and concrete retaining walls.

Malaeloa

The fresh-water swamp at Malaeloa encompasses about 72 acres. The wetland covers the entire low-lying area to the north of the loop road that provides access to residences in Malaeloa Aitulagi. Some areas of the swamp contain deep standing water. Fuafua Stream and eight of its 13 tributaries flow through the wetland.

"A small area of freshwater wetland is also located in the village on the south side of the road and to the east of the parking lot for Christ the King church. This wetland is a small flooded area, fed by a stream that flows along the road and eventually discharges into Fuafua Stream on the north side of the road" (Biosystems Analysis, Inc., 1992).

Predominant vegetation within the Malaeloa swamp includes falaga trees, Tahitian chestnut, and beach hibiscus. During its field survey of the swamp, Biosystems Analysis, Inc. discovered *Erythrina fusca* which has been collected in American Samoa only once, from Leone, in 1929. Other predominant plants include the herbaceous species, *Diplazium proliferum,* and red ginger (Biosystems Analysis, Inc., 1992).

Since 1977, much of the saturated, lower elevation areas in Malaeloa have gradually been filled to address past outbreaks of elephantiasis and accommodate more recent residential expansion. In addition, drainage channels along the loop road have been widened and deepened. These improvements have significantly reduced flooding and the ponding of water in Malaeloa Aitulagi. In this context, it is believed that this fresh-water swamp was once considerably larger than the wetland area delineated in 1992.

No residential development has occurred on the north and east side of the swamp at Malaeloa. However, in April, 1996, the production of subsistence crops, particularly banana, was taking place within about 30 percent of the wetland.

From the primary loop road, a vehicular trail passes through the east side of the swamp. This trail leads to a firing range near the northwest margin of the wetland. The potential expansion of this range to incorporate an indoor-outdoor and artillery has apparently been given some consideration by the U.S. Army. It is recommended that representatives of the American Samoa Coastal Management Progam coordinate with the U.S. Army representatives to keep abreast of this potential development project and provide development criteria that could be incorporated into any possible development project.

The continued function of this wetland for groundwater recharge is essential. The Malaeloa swamp represents one of the better stormwater detention opportunities on the Island of Tutuila. Any future development of adjoining lands should conserve this opportunity. It is recommended that no land uses be permitted in the swamp except those associated with subsistence crop production. Any future road improvements should enable the continued movement of stormwater flows throughout the existing swamp.

Marine Resources

Coral Communities

Between Fagatele Point and Pupualoa Point, the shoreline that fronts Vailoatai and Taputimu represents a basaltic bench approximately 50 to 100-feet wide. The nearshore waters do not have an offshore fringing reef.

No offshore reef is located between Puualoa Point and Faleapoi Point. North of Faleapoi Point, a narrow fringing reef that extends approximately 260 to 600 feet seaward of the shoreline to Logologo Point.

The width of the fringing reef increases north of Logologo Point to the west side of Leone Bay.

Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests that:

Within Leone Bay, the reef flat represents a highly stressed environment. These stresses included:

- the cumulative discharges of fresh-water, silt, sediment, and nutrients from Fuafua and Leafu streams;
- low circulation and exchange rates in the nearshore waters; and,
- subsistence harvests of marine resources.

More healthy coral communities were evident in deeper waters of the reef front near Niuaveave Rock (seaward of Auma), as well as near Sogi and Logologo Point.

1978-1979

Coral coverage was about five percent on the silty and sandy inner reef flat of Leone Bay which contained limited areas of hard bottom. On the middle reef, coral cover increased to nearly 50 percent (Aecos and Aquatic Farms, 1980).

Along the steep reef front of Leone Bay, coral coverage rose to 75 percent at depths of 20 feet. Seaward of Logologo Point, corals covered 100 percent of the reef front (Aecos and Aquatic Farms, 1980).

1987

William Brewer & Associates made a reconnaissance of coral communities and other biological characteristics of the Leone Bay in late March and early April, 1987. Coral survey results were made in the context of three nearshore areas: the moat, mid-reef flat, and outer reef flat (Figure 30-3).

The inshore moat contained no distinctive benthic fauna or flora. The bottom of the inshore moat was characterized by a frequently thick, unconsolidated layer of silt, broken bottles, and other solid waste material.

The mid-reef flat contained few corals and coral coverage averaged about 0.13 percent. In the outer reef flat, total coral coverage increased to only 0.31 percent

Biological and water quality surveys led biologists to conclude that the Leone Bay reef flat represented a highly stressed environment. These stresses included:

- the cumulative discharges of fresh-water, silt, sediment, and nutrients from Fuafua and Leafu streams;
- low circulation and exchange rates in the nearshore waters; and,
- subsistence harvests of marine resources.

These physical and biological influences produced an environment that is considerably low in biological diversity and productivity.

1992

Field investigations were also made by Maragos, Hunter, and Meier in 1992. Surveys were made in the vicinity of Avaloa, Fagalele Jr. High School (East Leone), and Niuaveve Rock (seaward of Auma).

Small apron reefs were documented between Sogi and Avaloa. Offshore areas that were observed were generally deep, flat, terraces that demonstrated signs from recent storms, especially Avaloa. Coral coverage was less than one percent at 6 meters at Avaloa Point, but increased to 10-15 percent at 18 meters.

In the vicinity of Niuaveave Rock and east Leone, coral reefs along the coast were well-developed with slopes that dropped down gradually. Live coral cover was less than one percent in shallow water (6 meters) near Niuaveave Rock; however, coral coverage increased to 15-25 percent seaward of Sogi. In deeper water (18 meters)coral coverage was about 10 percent at Niuaveave Rock and roughly 40 percent near Sogi. Marine biologists concluded, in

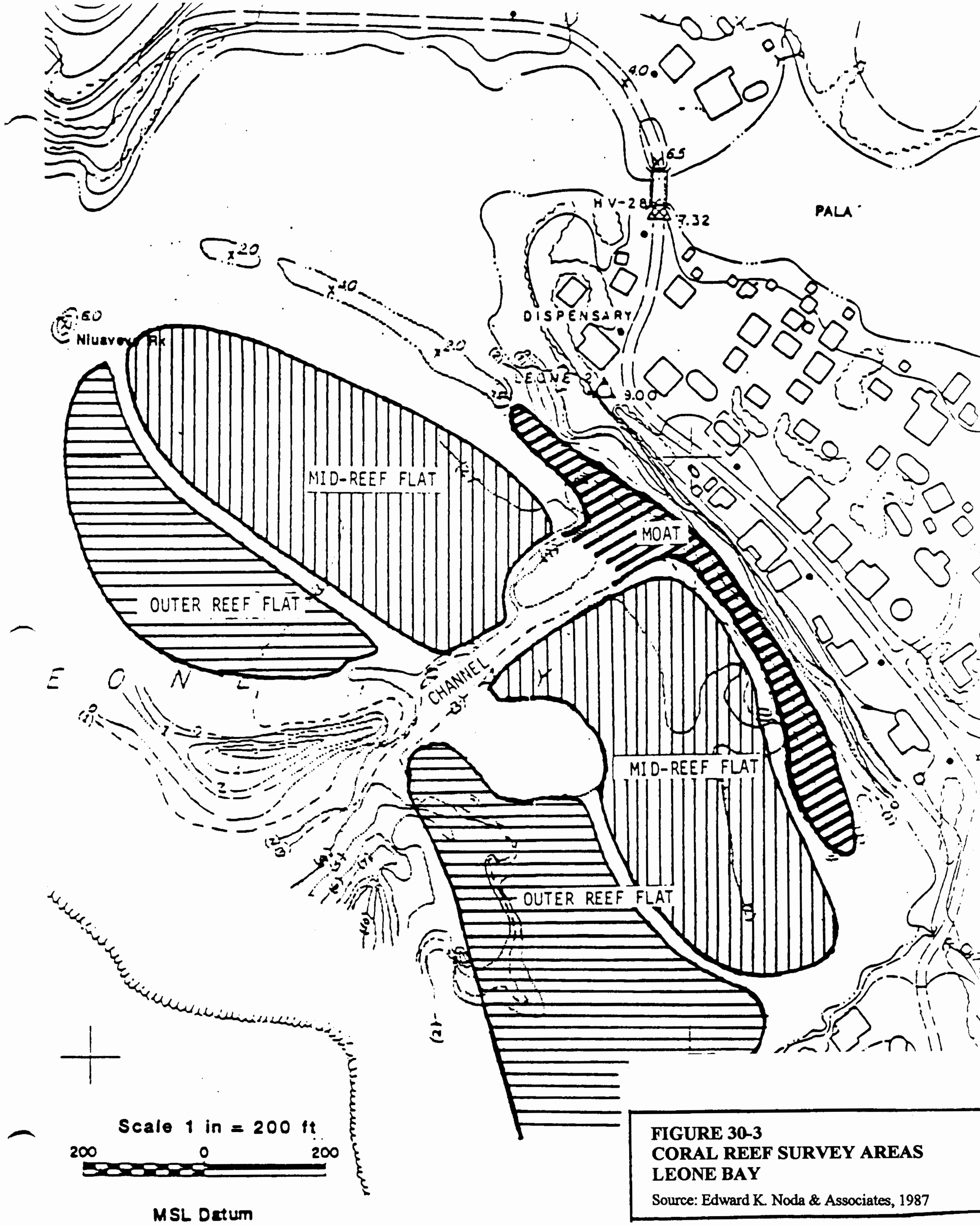


FIGURE 30-3
CORAL REEF SURVEY AREAS
LEONE BAY

Source: Edward K. Noda & Associates, 1987 part, that the reefs off Leone Bay may have been sheltered during recent storms and hurricanes. Such conditions probably allowed corals to maintain higher coral cover and species richness (Maragos, Hunter, and Meier in 1992).

1995

A 1995 survey of various coral reefs throughout the Samoan Archipelago included the reef front in Leone Bay. Marine biologists made five transects on the reef front which began seaward of Fagalele Jr. High School and continues west toward the main ava near the middle of Leone Bay. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Green documented that coral coverage was greater than 40 percent. The number of fish species observed included 150 or more different species. Fish density ranged between 5,000 and 9,999 individuals per ha. Fish biomass included between 500 and 999 kilograms per ha.

Wildlife Resources

"The sea cliff from Faasouga Point to Fagatele Point and along the northwestern side of Fagatele Bay is a nesting area for at least five species of seabirds. Major colonies of the brown booby (fua'o), grey-backed tern, blue-grey noddy (laia), brown noddy (gogo), and white tern (manu sina) are found here. White-tailed tropicbirds (tava'e), brown noddies, and white terns also nest in the coastal forest covering steep, rocky Suemalo Ridge. Fagatele Point is the main roost on Tutuila for flying foxes or fruit bats (pe'a). Thousands of bats roost in the coastal forest at the southern tip of Seumalo Ridge" (Aecos and Aquatic Farms, 1980).

Shoreline Protection

Lava sea cliffs approximately 10 to 20 feet high characterize much of the shoreline south of Leone.

North of the Fuafua Stream mouth, loose and grouted vertical rock walls provide protection to several homes built seaward of the primary shoreline roadway.

A narrow alluvial beach is located in the vicinity of the main *ava* consists of fine sand. This area contains no shore protection facilities.

A loose rock revetment stabilizes approximately 100 feet of shoreline on both sides of the Pala Lagoon bridge. In addition, a vertical concrete wall protects homes on the point south of the bridge.

Seaward of Auma, the shoreline is protected by a variety of natural resources. The shoreline is well sheltered from storm waves. The fringing reef is greater than 700 feet wide. A basalt outcropping is located 400 feet offshore. Basaltic sea cliff characterize the east and west sides of Apolima Point.

Along the Amaluia shoreline, a small alluvial beach lies between basaltic rock areas that contains no shore protection facilities. Vaipuna Stream discharges near the center of the beach.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Leone watershed that were determined to be "critical", or "potentially critical" conditions:

North of Fuafua Stream Mouth

Some of the loose and grouted vertical rock walls are undermined and failing. Homes seaward of the primary shoreline roadway are vulnerable to storm damage.

Pala Lagoon Bridge Area

There is a potential for critical erosion around the point south of the Pala Lagoon bridge.

Extending to the west and fronting Auma Village is a reach 700 feet long composed of "a narrow, dirty alluvial beach with a 3-foot high, 10 to 15-foot wide lava bench on the foreshore." An erosion scarp is stabilized in places by basalt rocks dumped on the shore. The road is located in the backshore, only 5 to 10 feet behind the erosion scarp. The shoreline is in "non-critical" condition.

Amaluia

There is significant erosion occurring east of the Vaipuna Stream mouth. A vertical, active scarp, 3 to 6 feet high, is cut into the the entire length of the backshore. East of the stream, this scarp approaches within 2 feet of the road of the primary shoreline roadway. Outcroppings of alluvial sandstone are being undercut in the scarp.

East Side of Sinamanoo Point

Along basaltic cliffs and boulders, there is a six-foot scarp that is within five feet of the primary shoreline roadway.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

Operating Groundwater Wells

The villages in the Leone watershed rely primarily upon a potable water supply that is supplied by the American Samoa Power Authority. There are, at least, six wells in the Leone watershed that are actively used by ASPA for the production of ground water (Table 30-6). These wells, which are located in Malaeloa and Leone, contribute a significant volume of groundwater to the Island of Tutuila's overall groundwater supply.

"ASPA regularly disinfects the groundwater supply at 11 wells by treatment with chlorine. The water is also chlorinated at two booster stations and at the chlorination station in Tafuna. The American Samoa Environmental Protection Agency (ASEPA), which monitors American Samoa's groundwater quality, reports that disinfection efforts are effective and chlorine residuals are maintained throughout the ASPA water system" (ASPA, 1995).

TABLE 30-6
GROUNDWATER WELLS IN THE LEONE WATERSHED
OPERATED BY ASPA

Pump Location	Well Number	Ground Elevation	Well Depth (feet)	Normal Discharge Rate (gpm)	Normal Head (psi)	Elevation Above Mean Sea Level
Leone	70	133	145	280	30	-12
Leone	80	138	162	270	30	-24
Malaeloa	91	164	177	260	90	-13
Malaeloa	92	164	160	340	90	+04
Malaeloa	93	165	205	280	90	-40
Malaeloa	119	176	210	300	40	-34

Source: ASPA Draft Utilities Master Plan, 1995

Continued Use of Individual Wastewater Disposal Systems

The future conservation of groundwater quality remains an important concern of the Territory. While a significant expansion has been made of the ASPA wastewater collection system, the continued use of individual onsite wastewater disposal systems, e.g., septic tanks and cesspools, in portions of the Leone watershed continues to contaminate Tutuila's basal aquifer. Frequent heavier rainfall periods transport a significant amount of bacteria and nutrients through a thin soil layer and the basaltic substrata. Consequently, a significant amount of the ground water used in the ASPA water system contains elevated levels of bacteria and turbidity (ASPA, 1995).

Chloride Contamination

In recent years, groundwater quality data has generally not indicated the presence of any long-term contamination of groundwater wells in the Leone watershed. On August 8, 1994, ASPA's 32 main system wells were tested for chloride concentrations. Laboratory results indicated that Well 119 in Malaeloa contained an elevated chloride content of 240 milligrams per liter. However, this level is below the National Secondary Drinking Water Regulations which require, in part, a maximum chloride concentration of 250 milligrams per liter.

"Higher chloride levels in wells has been a problem since wells were first drilled in American Samoa. During prolonged droughts, chloride levels rise and water rationing is required. Wells must be temporarily removed from service; on two occasions, the tuna canneries were shut down to conserve water. Some wells in the Tafuna-Leone area and in Aua have been permanently abandoned due to saltwater intrusion.

Elevated chloride levels are cause for concern since they indicate saltwater upconing in the wells. This condition can cause long-term damage to the aquifer. The potential impact from saltwater upconing may have already occurred in the Tafuna and Aua areas.

Two primary factors contribute to saltwater intrusion into basal lens wells which are the more common type of well in American Samoa:

- *the elevation of the bottom of the well in relation to mean sea level; and,*
- *the rate of extraction from the aquifer.*

The Ghyben-Herzberg ratio developed for basal lens aquifers states that the freshwater lens is 40 times as deep as the head of water above the sea level. To minimize upconing of saltwater, wells should not be deeper than one-third of the thickness of the freshwater lens. In the Tafuna Plains area, the lens is believed to be approximately 120 feet thick and wells drilled in a lens of this thickness should be no deeper than 40 feet. Accurate vertical control must be used to determine the static elevation of the lens surface because this will dictate the maximum depth of the well.

The rate of extraction from the aquifer is significant because higher rates are much more likely to cause upconing. At the same time, dikes and layers of the older volcanics can trap freshwater at significant depths below sea level. In Pago Pago and Aua, wells have been drilled more than 100 feet below sea level before freshwater has been encountered. However, wells of this type must be monitored often for chloride content. If levels begin to rise, the pumping rate must be reduced" (ASPA,1995).

Surface Water Supply and Quality

In 1987, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. Three systems were identified in the Leone watershed.

In Malaeloa, a stream catchment was identified along the Fuafua Stream drainage at about the 450-foot elevation in April, 1986. Two storage tanks were located at approximately 165 feet above mean sea level. It is unknown whether this system remains in use.

A second system served Auma and Leone. This system relied upon a stream catchment along Leafu Stream. The catchment was located at approximately 130 feet above mean sea level. It is unknown whether or not this system remains in use; the distribution system may have been connected to a portion of the distribution system that serves Leone.

A third system served Amaluia Village. This system obtained surface supplies from a stream catchment located along Vaipuna Stream at approximately 110-feet above mean sea level. It was noted that a piggery upslope of the surface supply generated some contamination. It is unknown whether this system remains in use.

Historical data suggests from the 1981-1986 period indicates that the Leone Village and Amaluia Village water systems contained a median of greater than 80 coliforms per 100 milliliters. Moderate coliform contamination was also documented for the Malaeloa system. Laboratory results indicated a median of 52 coliforms per 100 milliliters during the 1981-1986 period (M&E Pacific, 1987). Available data indicates that no coliforms were present in this system in 1994 because of the application of chlorine to the water supply.

Proposed Water System Improvements

The draft ASPA Utilities Master Plan points out that a desirable operational objective is for ASPA to produce water in the same area that it is consumed. The operation and maintenance of extensive water transmission systems throughout most of Tutuila are costly. In west Tutuila, the Master Plan recommends the drilling of exploratory wells in the Tafuna-Leone area.

ASPA plans to drill six-inch exploratory wells in Malaeimi, Nuuuli, Leone, Pavaiai, and Asili. Where adequate yields are found, permanent groundwater wells are recommended for subsequent use. Leone and Malaeloa are noted as two locations where there is a moderate potential for groundwater development. No specific location in the watershed is identified for this improvement. However, it is recommended that the well head of the exploratory well should not exceed 150 feet above mean sea level to accommodate drill rig limitations.

USE OF THE WATERSHED

Resident Population

Amaluia

Between 1980 and 1990, the resident population of Amaluia Village declined from 215 to 206 persons. This represents an average annual decline in population of about -0.42 percent. However development activity between 1990 and 1995 increased resident population to about 282 persons.

Population trends for Amaluia reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa more than doubled between the decade; most of that growth occurred between 1985 and 1990.

Leone

Between 1980 and 1990, the resident population of Leone Village increased from 1,652 to 3,013 residents. Such growth represented an average annual growth rate of about 8.24 percent. Development activity between 1990 and 1995 increased resident population to about 3,861 persons.

Population trends reflected in the 1990 Census for Leone suggest that considerable in-migration has gradually occurred in this community between 1980 and 1995. The proportion of 1990 residents who were born outside of American Samoa has more than doubled since 1980; however, the rate of in-migration has slowed considerably between 1985 and 1990. New residential construction clearly brought significant population growth to the community between 1990 and 1995. The proportion of new incoming residents to the community since 1990 is unknown due to the lack of available information concerning new in-migrants to American Samoa.

Malaeloa/Aitulagi

The resident population of Malaeloa/Aitulagi Village in 1990 was 585 persons. However development activity between 1990 and 1995 increased resident population to about 710 persons.

Population trends reflected in the 1990 Census for Malaeloa/Aitulagi suggest that limited in-migration has occurred in this community between 1980 and 1990. In fact, the proportion of residents who were born outside of American Samoa decreased somewhat between 1985 and 1989, but increased slightly in 1990.

Malaeloa/Ituau

The resident population of Malaeloa/Itua Village in 1990 was 523 persons. However development activity between 1990 and 1995 increased resident population to about 705 persons.

Population trends reflected in the 1990 Census for Malaeloa/Ituau suggest that some in-migration has occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa decreased somewhat between 1985 and 1990; however, the proportion doubled in 1990.

Vailoatai

Between 1980 and 1990, the resident population of Vailoatai Village increased from 677 to 805 residents. Such growth represented an average annual growth rate of about 1.89 percent. Development activity between 1990 and 1995 increased resident population to about 1,090 persons.

Population trends reflected in the 1990 Census for Vailoatai suggest that considerable in-migration has gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa more than doubled between the decade; most of that growth occurred between 1985 and 1990. One local *matai* indicated, during a November, 1994 inspection of the Village, that most in-migrants are returning American Samoans from Hawaii and the continental United States who have reached, or are nearing, retirement age.

Taputimu

Between 1980 and 1990, the resident population of Taputimu Village increased from 434 to 520 residents. Such growth represented an average annual growth rate of about 1.98 percent. Development activity between 1990 and 1995 increased resident population to about 726 persons.

Population trends reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa almost tripled between 1985 and 1990, but decreased somewhat in 1990.

Land Uses

Residential

Amaluia

The 1990 U.S. Census documented 27 homes in Amaluia. Approximately 93 percent of the homes were owner-occupied; seven percent were rental units.

The housing stock in Amaluia expanded considerably during the 1990-1995 period. Building permits were issued for 11 new housing starts. Consequently, the 1995 housing stock included approximately 38 homes.

Leone

The 1990 U.S. Census documented 443 homes in Leone. Approximately 77 percent of the homes were owner-occupied; 18 percent were rental units. The remaining five percent were vacant or used as vacation homes by absentee owners. Most all of the housing stock is single family residential except for an apartment building owned by the Kruse family and other multi-unit residential buildings at local church facility complexes.

The housing stock in Leone expanded during the 1990-1995 period. Building permits were issued for 117 new housing starts. Consequently, it is estimated that the 1995 housing stock included approximately 560 homes.

Malaeloa/Aitulagi

The 1990 U.S. Census documented 84 homes in Malaeloa/Aitulagi. Approximately 61 percent of the homes were owner-occupied; 30 percent were rental units. The remaining nine percent were vacant or used as vacation homes by absentee owners. These statistics suggest a somewhat greater proportion of rental housing compared to other villages in American Samoa.

The housing stock was expanded during the 1990-1995 period. Building permits were issued for 33 new housing starts in Malaeloa. The proportion of new housing starts in Malaeloa/Aitulagi is uncertain because of the more geographical references used with building permit applications. For this reason, it was arbitrarily assumed that 33 percent, or 11 new housing starts in Malaeloa occurred in Malaeloa/Aitulagi; the remaining 22 housing starts were assumed to have been built in Malaeloa/Ituau. Consequently, it is estimated that the 1995 housing stock in Malaeloa/Aitulagi included approximately 95 homes.

Malaeloa/Ituau

The 1990 U.S. Census documented 60 homes in Malaeloa/Ituau. Approximately 93 percent of the homes were owner-occupied; five percent were rental units. The remaining two percent were vacant or used as vacation homes by absentee owners. In contrast to Malaeloa/Aitulagi, the neighboring village Census area of Malaeloa/Ituau has a considerably higher proportion of owner-occupied housing.

The housing stock was expanded during the 1990-1995 period. Building permits were issued for 33 new housing starts in Malaeloa. The proportion of new housing starts in Malaeloa/Ituau is uncertain because of the geographical references used with building permit applications. For this reason, it was arbitrarily assumed that 67 percent, or 22 new housing starts in Malaeloa occurred in Malaeloa/Ituau; the remaining 11 housing starts were assumed to have been built in Malaeloa/Aitulagi. Consequently, it is estimated that the 1995 housing stock in Malaeloa/Ituau included approximately 82 homes.

Vailoatai

The 1990 U.S. Census documented 113 homes in Vailoatai. Approximately 87 percent of the homes were owner-occupied; 10 percent were rental units. The remaining three percent were vacant or used as vacation homes by absentee owners.

The housing stock was expanded in Vailoatai during the 1990-1995 period. Building permits were issued for 40 new housing starts. Consequently, the 1995 housing stock included approximately 153 homes.

Taputimu

The 1990 U.S. Census documented 77 homes in Taputimu. Approximately 82 percent of the homes were owner-occupied; 13 percent were rental units. The remaining five percent were vacant or used as vacation homes by absentee owners.

The housing stock was expanded during the 1990-1995 period. Building permits were issued for 28 new housing starts. Consequently, the 1995 housing stock included approximately 105 homes.

Agriculture

Piggery and Poultry Operations

A 1996 survey of piggeries by the ASG Department of Agriculture in West Tutuila indicates that there was one piggery in Amaluia that contained six pigs. During the April, 1996 survey by Pedersen Planning Consultants, three piggeries were located in Leone on the west side of the Leone Pala. One piggery was identified in Malaeloa/Aitulagi along Fuafua Stream. Two additional piggeries were documented in Vailoatai.

Traditional leaders of Leone are encouraging the establishment of new piggeries in upland areas of the watershed. They recognize the impacts of piggeries upon surface water quality and desire to move new piggeries away from local stream and within inhabited village areas (HTC Leoso, 1996).

Two commercial poultry operations were also located in Vailoatai. Both operations sell eggs and poultry to local stores.

Crop Production

Subsistence and commercial crop production take place in the Leone watershed. In April, 1996, the following agricultural land areas were observed:

- north of Amaluia, a large plantation along the middle reaches of Vaipuna Stream;
- a banana and taro plantation in Vailoatai;
- a banana and breadfruit plantation west of Auma; and,
- a small truck farm for vegetable crops in Malaeloa/Ituau.

There are numerous other *faatoaga* that are situated throughout the watershed.

Commercial

Amaluia

There are approximately three commercial enterprises that are based in Amaluia. No new businesses were established during the 1990-1995 period. Existing commercial enterprises include a village grocery store, a wholesale/retail distributor, and a landscaping/tree trimming contractor.

Leone

There are approximately 47 commercial enterprises that operate in Leone. These enterprises include eight grocery stores, seven retail shops, seven bus and taxi operations, five wholesaler operations, three professional services, two landscaping services, one auto repair shop, a laundromat, a janitorial service, two bakeries, gas station, a fast-food operation, a cable service company, a pool hall, a silk screen printing operation, a distributor of amusement machines, and a commercial diving contractor. Four new commercial operations were established during the 1990-1995 period.

Malaeloa/Aitulagi and Malaeloa/Ituau

There are approximately 18 commercial enterprises that are based in Malaeloa. About six of these enterprises are bus and taxi operations. There are five grocery and retail stores. Other enterprises include two auto repair shops, a security service, an aquaculture operation, a gas plumbing service, and a wholesaler.

Existing business license data does not differentiate between Malaeloa/Aitulagi and Malaeloa/Ituau. It is believed that about 75 percent of the commercial enterprises are located in Malaeloa/Ituau; the remaining 25 percent are located in Malaeloa/Aitulagi. Only one new commercial operation was established during the 1990-1995 period.

Vailoatai

There are approximately 28 commercial enterprises that are based in Vailoatai. At least two of the enterprises wee established during the 1990-1995 period. Existing commercial enterprises include seven village grocery and retail stores, a pool hall, one auto body shop, transportation companies, a refrigeration repair service, and other technical services.

Taputimu

There are approximately five commercial enterprises that are based in Taputimu. These enterprises include four grocery store operations and one laundromat. No new commercial operations were established during the 1990-1995 period.

Industrial

Amaluia, Leone, and Vailoatai

No light industrial operations were based in Amaluia or Leone in 1995.

Malaeloa and Taputimu

A sharkfin processing business is located in Malaeloa. The only industrial operation in Taputimu includes one earthmoving contractor.

Public Facilities

Amaluia

The ASG Department of Education does not offer an early childhood education program in Amaluia. Elementary school students are bussed to Alataua-Lua Elementary School in Nua and Leone High School in Leone.

Leone

Public facilities in Leone include the ASG Department of Medical Services dispensary near the center of the Village, as well as ASG school facilities.

The ASG Department of Education's early childhood education program offers educational opportunities to younger children, between three and four years of age, at different locations in the Leone area. In September, 1994, a total of 95 students were enrolled in this program.

Leone Midkiff Elementary School is attended by K-8 students who are bussed from Malaeloa/Aitulagi, Malaeloa/Ituau, and Taputimu. Leone Midkiff had a September, 1994 enrollment of 1,088 students. High school students attend Leone High School.

Malaeloa

The ASG Department of Education offers an early childhood education program which was providing educational opportunities for 38 children in September, 1994. It is believed, however, that this facility is located in Malaeloa/Ituau, but is, in part, attended by younger children from Malaeloa/Aitulagi. Elementary school and high school students are bussed to Leone Midkiff Elementary and Leone High School.

The ASG Department of Education offers an early childhood education program which was providing educational opportunities for 38 children in September, 1994. It is believed that this facility is located in Malaeloa/Ituau, but is, in part, attended by younger children from Malaeloa/Aitulagi. Elementary school students attend Leone Midkiff Elementary; high school students are bussed to Leone High School.

Vailoatai

The ASG Department of Education offers an early childhood education program in Vailoatai which was providing educational opportunities for 41 children in September, 1994. Elementary school students are bussed to Lupelele Elementary in Iliili and Leone High School for the ASG Department of Education's secondary education.

Taputimu

The ASG Department of Education offers an early childhood education program which was providing educational opportunities for 26 children in September, 1994. Elementary school and high school students are bussed to Leone Midkiff Elementary and Leone High School.

Use of the Nearshore Waters

The high sea cliffs along the south part of the watershed limit the type of recreational activities that occur along portions of the shoreline. For the most part, use of the nearshore waters revolves around fishing. General water recreation also takes place in various parts of the reef flat of Leone Bay.

An American Samoa Subsistence Fishing Survey was conducted by the University of Hawaii Sea Grant Program in the summer of 1992. This survey involved onsite interviews with shoreline users who were participating in fishing activities on selected days during that period. The results of the survey revealed, in part, that there is some use of the nearshore waters in the vicinity of Taputimu and Vailoa, Leone, and Amaluia.

Some 8 to 12 persons were documented fishing on the reef in the vicinity of Vailoa and Taputimu. Fishing methods that were observed included rod and reel, throw net, diving, gleaning, and poles.

On the reef flat in Leone Bay, 12 to 17 persons were involved in fishing. These residents used throw nets, rod and reel, fishing poles, gleaning, and diving.

Along the shoreline of Amaluia, eight to 12 persons participated in fishing activities. Fishing methods included the use of rod and reels, throw nets, gleaning, fishing poles, and diving.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Amaluia

Some future residential expansion will occur in Amaluia, but future growth will slow considerably from increased residential growth that occurred between 1990 and 1995. Future residential expansion is expected to represent the infilling of undeveloped housesites within existing village where about six additional housesites are possible. An additional five potential housesites are located on steeper slopes that are immediately upland of the community.

Future residential growth during the 20-year planning period will likely include the replacement of some existing one-story, single family units to accommodate more than one family. Residential construction in Amaluia will be hampered by the lack of developable lands within the village. Steeper slopes and the presence of two drainage areas within the small valley will clearly limit the extent of residential construction in Amaluia.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Amaluia.

1996-2000	Five new single family homes on slopes upland of the existing residential area. Six new single family units within the existing village area.
2001-2005	Five existing single family homes in the village will be replaced with two-story units that will accommodate two families.
2006-2010	No new residential construction is anticipated except for home extensions, repairs, and renovations.
2011-2015	Five existing single family homes in the village will be replaced with two-story units that will accommodate two families.

The cumulative effect of this prospective residential growth on Amaluia is that the village housing stock will increase to roughly 59 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.33 persons per household, the future village population will include about 373 persons.

Leone

Future residential expansion in Leone Village is expected to gradually increase because of a number of factors that will continue to influence future growth.

- Much of the vacant land is suitable for residential development.
- Public and private schools are available in the community.
- A variety of commercial retail opportunities are convenient to the resident population.

Despite its attractiveness to perspective residents, such growth will be slower in Leone than the more recent growth of about five percent per year between 1990 and 1995. Diminished growth will stem from the lack of developable housesites and the continued demand for lower residential densities between three and four units per acre.

More affluent American Samoans from Hawaii and the continental United States can be expected to represent the majority of future in-migrants to Leone. These new arrivals will be seeking basic shelter and a more relaxed lifestyle. A part of their relaxed lifestyle will also incorporate more household conveniences and amenities into their households. Household financial needs will be met through the use of professional and technical skills in the local economy, or their establishment of a new commercial enterprise. Many may attempt to operate commercial enterprises from their homes.

New housesites in the area are generally being built along existing paved roadways and dirt trails within Leone. Future residential growth will generally occur within existing residential areas or extensions of existing residential areas. Residential densities will generally be comparable to existing residential areas; only slight increases in density will occur in selected areas.

An onsite inspection of the Village in November, 1994 and a review of 1990 topographic conditions suggest that residential expansion will occur in six areas within Leone.

- Seaward of Leone Midkiff School and the nearby ASG housing complex, it is estimated that there are about 40 potential sites for single family housing.
- Between Leone Midkiff and Tutuila's primary roadway, the development of 38 single family housesites is feasible.
- 18 single family housesites are potentially available between Tutuila's primary roadway, Holy Cross Church, and Logologo Point.
- The area east of Pala Lagoon and the adjoining residential area surrounding Holy Cross Church and St. Theresa's Girls School complex could accommodate about 21 single family homes.
- 33 single family homes could be constructed in the Aualii-Leafu Stream watershed despite the presence of saturated soils and a floodplain.
- The Vaiala area, which is immediately west of Malaeloa, could easily accommodate 29 additional single family homes along existing dirt trails.

Future residential expansion of Leone in these areas will be concurrent. Residential construction will bring additional moderate to expensive homes. The housing stock is expected to remain primarily as a single family residential community. Leone will continue to be a prominent, residential bedroom community where many of American Samoa's government and business leaders and their families.

During the next 20 years, Pedersen Planning Consultants believes that such development will more specifically generate the following volume of residential construction within Leone.

1996-2000 15 single family homes will be constructed seaward of Leone Midkiff School and the nearby ASG housing complex.

15 single family homes will be built between Leone Midkiff and Tutuila's primary roadway.

10 single family housesites will be developed between Tutuila's primary roadway, Holy Cross Church, and Logologo Point.

10 single family houses will be constructed within the residential area east of Pala Lagoon and adjacent to Holy Cross Church and St. Theresa's Girls School complex.

10 single family homes will be built in the Aualii-Leafu Stream watershed.

10 single family homes will be constructed in the Vaiala area.

2001-2005	15 single family homes will be constructed seaward of Leone Midkiff School and the nearby ASG housing complex.
	15 single family homes will be built between Leone Midkiff and Tutuila's primary roadway.
	Eight single family housesites will be developed between Tutuila's primary roadway, Holy Cross Church, and Logologo Point.
	11 single family houses will be constructed within the residential area east of Pala Lagoon and adjacent to Holy Cross Church and St. Theresa's Girls School complex.
	10 single family homes will be built in the Aualii-Leafu Stream watershed.
	10 single family homes will be constructed in the Vaiala area.
2006-2010	Five single family homes will be constructed seaward of Leone Midkiff School and the nearby ASG housing complex.
	Five single family homes will be built in the Aualii-Leafu Stream watershed.
	Five single family homes will be constructed in the Vaiala area.
2011-2015	Five single family homes will be constructed seaward of Leone Midkiff School and the nearby ASG housing complex.
	Eight single family homes will be built between Leone Midkiff and Tutuila's primary roadway.
	Eight single family homes will be built in the Aualii-Leafu Stream watershed.
	Four single family homes will be constructed in the Vaiala area.

The cumulative effect of this prospective residential growth on Leone is that the housing stock will increase to roughly 739 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.89 persons per household, the future village population will include about 4,350 persons.

Malaeloa/Aitulagi

Some future residential expansion will occur in Malaeloa/Aitulagi, but future growth will continue to be modest and gradual. There is an ample supply of vacant lands north of the existing residential area. ASPA has already installed power lines through a portion of this area, but electrical power service was not provided since appropriate sewer systems were not installed by the existing landowner. It is believed that existing sewage disposal requirements will eventually be met by the landowner.

While a significant amount of vacant land is present in this area of Malaeloa/Aitulagi, future residential expansion is expected to occur only along existing dirt trails. The presence of low-lying areas in portions of this area will likely discourage any extensive *faatoaga* activities, as well as any significant residential development. It is believed that vacant lands north of the existing residential area could easily provide about 51 housesites along existing dirt trails.

Another potential residential growth area is located below steeper slopes on the east side of Malaeloa/Aitulagi. The potential construction of six additional homes in this area is anticipated along an existing dirt trail.

Infilling within the existing residential area of Malaeloa/Aitulagi along the north and south side of the village loop road is expected to provide about seven additional home locations. The presence of intermittent lowlands and drainage areas will limit growth in this area. The community's past experience with elephantiasis and other waterborne diseases will encourage a more careful selection of building sites.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and the potential infilling of the existing residential community will generate the following volume of residential construction within Malaeloa/Aitulagi:

1996-2000	15 new single family homes north of the existing residential area along existing dirt trails.
	Three new single family homes on the east of the existing residential along an existing dirt trail.
	Infilling of existing residential area via the construction of two new single family homes.
2001-2005	15 new single family homes north of the existing residential area along existing dirt trails.
	Three new single family homes on the east of the existing residential along an existing dirt trail.
	Infilling of existing residential area via the construction of three new single family homes.
2006-2010	Six new single family homes north of the existing residential area along existing dirt trails.
	Some home extensions, repairs, and renovations will also occur.
2011-2015	15 new single family homes north of the existing residential area along existing dirt trails.
	Infilling of existing residential area via the construction of two new single family homes.

The cumulative effect on Malaeloa/Aitulagi of this prospective residential growth is that the housing stock will increase to roughly 159 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.38 persons per household, the future village population will include about 1,015 persons.

Malaeloa/Itua

Considerable residential expansion will occur in Malaeloa/Ituau during the next 20 years. Significant growth is anticipated in this community because of the availability and accessibility to vacant lands that are suitable for residential development.

While a significant amount of vacant land is present in this area of Malaeloa/Ituau, various parts of this village Census area are characterized by small wetlands and low lands that contain saturated soils. In addition, the southeast part of Malaeloa also has two small drainages and related flood plain area that somewhat constrain future residential development.

Similar to other parts of Tutuila, future residential expansion in Malaeloa/Ituau is expected along existing dirt trails which presently provide access to one or two homes and adjoining faatoaga area. Such growth will ultimately be most prominent in the southwest part of the village. However, future residential growth can be expected throughout the community.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities within Malaeloa/Ituau will generate the following sequence and volume of residential construction:

1996-2000	Seven new single family homes in the area north of Tutuila's primary roadway and west of the Malaeloa loop access road.

Seven new single family homes in the area north of Tutuila's primary roadway and east of the Malaeloa loop access road.

Four single family homes south of Tutuila's primary access road and east of the road to Taputimu.

Fourteen single family homes south of Tutuila's primary access road and west of the road to Taputimu.

2001-2005 Seven new single family homes in the area north of Tutuila's primary roadway and west of the Malaeloa loop access road.

Seven new single family homes in the area north of Tutuila's primary roadway and east of the Malaeloa loop access road.

Three single family homes south of Tutuila's primary access road and east of the road to Taputimu.

Thirteen single family homes south of Tutuila's primary access road and west of the road to Taputimu.

2006-2010 Five new single family homes in the area north of Tutuila's primary roadway and west of the Malaeloa loop access road.

Three single family homes south of Tutuila's primary access road and east of the road to Taputimu.

Thirteen single family homes south of Tutuila's primary access road and west of the road to Taputimu.

2011-2015 Seven new single family homes in the area north of Tutuila's primary roadway and west of the Malaeloa loop access road.

Seven new single family homes in the area north of Tutuila's primary roadway and east of the Malaeloa loop access road.

Three single family homes south of Tutuila's primary access road and east of the road to Taputimu.

Thirteen single family homes south of Tutuila's primary access road and west of the road to Taputimu.

The cumulative effect on Malaeloa/Ituau of this prospective residential growth is that the housing stock will increase to roughly 195 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 7.34 persons per household, the future village population will include about 1,432 persons.

Vailoatai

Some future residential expansion is expected to occur in Vailoatai, but future growth will slow considerably from increased residential growth that occurred between 1990 and 1995. Future residential expansion will represent the infilling of undeveloped housesites within existing residential areas northeast and southwest of the access road to Leone High School and radio station WVUV. Pedersen Planning Consultants believes that an additional 66 homes will be built within these areas. The potential number of housesites is expected to be distributed almost equally on both sides of the Leone High School access road. Such development is expected to be along existing dirt trails.

There is a considerable amount of vacant, undeveloped land in Vailoatai Village. However, a significant number of small wetland areas and other areas containing saturated soils will discourage residential construction for many areas.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and the potential infilling of the existing residential community will generate the following volume of residential construction within Vailoatai:

1996-2000 17 new single family homes northeast of Leone High School access road;

16 new single family homes southeast of Leone High School access road;

2001-2005 17 new single family homes northeast of Leone High School access road;

16 new single family homes southeast of Leone High School access road;

2006-2010 no new residential construction is anticipated except for home extensions, repairs, and renovations; and,

2011-2015 conversion of about 22 one-story single family units to two story duplex units.

The cumulative effect of this prospective residential growth on Vailoatai is that the village housing stock will increase to roughly 241 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.13 persons per household, the future village population will include about 1,476 persons.

<u>Taputimu</u>

Some future residential expansion is anticipated in Taputimu, but future growth will probably continue to be slow and gradual. There is an ample supply of vacant lands east and upland of the existing residential areas between the 100 and 175-foot elevation. However, future expansion is expected to occur initially along existing dirt trails where vacant lands are present. Other potential expansion areas include vacant lands where a short extension of an existing trail can be developed without a significant cost. In addition, some limited infilling will also take place within the existing residential area.

The focus of future expansion is anticipated on the southeast side of Taputimu. An existing dirt trail provides access to about 27 potential housesites. This area is situated between 85 and 130 feet above mean sea level.

Adjoining lands to the east provide additional developable lands that could, in part, be converted to residential use during the next 20 years. The development of some 25 homesites would leave a considerable amount of land for *faatoaga* purposes.

Infilling within existing residential areas is expected to provide about seven additional home locations. The consistent, low density nature of the existing residential nature indicates a strong desire by the family *sao* to maintain lower densities within the community.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and the potential infilling of the existing residential community will generate the following volume of residential construction:

1996-2000 four new single family homes inside the main village area;

15 new single family homes southeast of the existing residential area;

2001-2005 three new single family homes inside the main village area;

12 new single family homes southeast of the existing residential area;

2006-2010 no new residential construction is anticipated except for home extensions, repairs, and renovations;

2011-2015 extension of existing trail on southeast side of village and the construction of 25 single family homes between the 100 and 150 foot elevation.

The cumulative effect of this prospective residential growth is that the housing stock will increase to roughly 164 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.90 persons per household, the future village population will include about 968 persons.

Commercial

Amaluia

Future commercial facility expansion in Amaluia is not anticipated. The lack of developable lands and the proximity of competing commercial services in Leone will strongly discourage the construction of additional commercial retail facilities. At the same time, the anticipated increase in resident population will encourage the formation of various home-based occupations that will likely include professional and technical services.

Leone

Leone is expected to remain as an important commercial support center for the west end of Tutuila. It will continue to provide some limited retail opportunities. Future commercial expansion is anticipated along Tutuila's primary roadway where five commercial building sites are possible near Alamai Samoa Corporation facilities. In Vaiala, the development of two additional commercial buildings is feasible along the north side of the road into Malaeloa Aitulagi. Nevertheless, the diversity and number of commercial enterprises in Leone will continue to be secondary to Pavaiai and Nuuuli where the majority of consumer purchases will be made west Tutuila residents.

A significant growth in professional and technical services is also anticipated in Leone. Most of these services will represent home-based occupations. It is believed that several professional and technical services will become more successful and outgrow available floor space at local homes. For this reason, the future renovation, expansion, or replacement of three or four one-story commercial buildings can be expected during the next 20 years. Such development will involve the replacement of smaller one-story commercial buildings with two or three-story structures that will provide ground floor retail and professional/technical services on the second floor.

During the next 20 years, the path of future commercial expansion is expected to include the following development within Leone.

1996-2000 Three new retail stores will be constructed along Tutuila's primary road in the vicinity of Alamai Samoa Corporation complex.

One new grocery or retail store will be built in Vaiala on the road to Malaeloa/Aitulagi.

2001-2005 Two new retail stores will be constructed along Tutuila's primary road in the vicinity of Alamai Samoa Corporation complex.

One new grocery or retail store will be built in Vaiala on the road to Malaeloa/Aitulagi.

2006-2010 No new commercial facility construction will occur. However, the replacement of two smaller commercial buildings is anticipated along the primary roadway between Holy Cross Church and Pala Lagoon. Both buildings will include three ground floor retail stores and three second floor office spaces.

2011-2015 The replacement of two additional commercial buildings is expected along the primary roadway between Holy Cross Church complex and Pala Lagoon.

Both buildings will be story structures that will include three ground floor retail stores and six professional services on the upper two floors.

Consequently, the community will have about 20 new commercial operations by the year 2015.

Malaeloa/Aitulagi

Expanded commercial facility expansion in Malaeloa/Aitulagi is expected to be limited. Such expansion will likely include the establishment of two new retail stores between 2001 and 2005. Otherwise, local residents will depend heavily upon the growing services that will be available in Leone and Pavaiai.

Expanded commercial facility expansion in Malaeloa/Aitulagi is expected to include the development of six new retail stores. Two feasible commercial locations are situated west of Faasao High School. Two additional retail store sites are believed to be feasible along the west side of the Malaeloa loop access road. Another two potential locations are situated on the south side of Tutuila's primary access road, between its intersections with the Taputimu access road and the Malaeloa loop access road.

Malaeloa/Ituau

Future commercial expansion in Malaeloa/Ituau will probably include the construction of two new retail stores during the 1996-2000 period. Two additional stores will be built between 2001 and 2005. No stores will be developed between 2006 and 2010 during an anticipated slowdown in the American Samoa economy. Two additional retail outlets will be constructed during the 2011-2015 period. Otherwise, local residents will depend heavily upon the growing services that will be available in Leone and Pavaiai.

Vailoatai

Expanded commercial facility expansion in Vailoatai is expected to be limited. Such expansion will include the establishment of two new retail stores between 1996 and the year 2000 and three additional retail stores by the year 2005. Two additional retail operations will begin between 2011 and 2015 to support the growing population. Consequently, the community will have seven new commercial operations by the year 2015. Otherwise, local residents will depend heavily upon the growing services that will be available in Leone and Pavaiai.

Taputimu

Future commercial facility expansion in Taputimu is expected to be limited. Such expansion will include the establishment of two new retail stores between 2001 and 2005. Two additional retail operations will likely begin between 2011 and 2015 to support the growing population. Consequently, the community will have four new commercial operations by the year 2015.

Otherwise, local residents will depend heavily upon the growing services that will be available in Leone and Pavaiai.

Industrial

Amaluia

The construction of new industrial facilities in Amaluia is not anticipated in light of more desirable locations in the Tafuna Plains.

Leone

The gradual increase in resident population in Leone will likely attract other small, home-based activities of an industrial nature. Two new home-based enterprises are expected in the 2001-2005 period; three additional enterprises are anticipated between 2011 and 2015. However, the construction of new industrial facilities is not anticipated.

Malaeloa/Aitulagi

The gradual increase in resident population within Malaeloa/Aitulagi will likely attract other small, home-based activities of an industrial nature. Two new home-based industrial operations are expected to establish during the 2001-2005 period. However, the construction of new industrial facilities within the community is not anticipated.

Malaeloa/Ituau

The gradual increase in resident population within Malaeloa/Ituau will likely attract other small, home-based activities of an industrial nature. However, the construction of new industrial facilities is not anticipated.

Vailoatai

The gradual increase in resident population within Vailoatai will likely attract other small, home-based activities of an industrial nature. However, the construction of new industrial facilities is not anticipated.

Taputimu

The gradual increase in resident population will likely attract other small, home-based activities of an industrial nature. However, the construction of new industrial facilities is not anticipated.

Public Facilities

Through the application of 1990 age characteristics to anticipated village populations in the year 2015, the general demand for future early childhood programs, elementary education, and high school education was quantified (Table 30-7). In some cases, these demands may generate the future development of expanded public school facilities within or outside the Leone watershed.

TABLE 30-7
POTENTIAL DEMAND FOR PUBLIC SCHOOL FACILITIES
YEAR 2015
LEONE WATERSHED
(NUMBER OF STUDENTS)

Village	Early Childhood	Elementary	Secondary
Amaluia	19	79	19
Leone	261	914	435
Malaeloa/Aitulagi	71	233	101
Malaeloa/Ituau	72	329	143
Vailoatai	74	325	177
Taputimu	58	252	87

Source: Pedersen Planning Consultants, 1995

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Leone watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 30-8 and 30-9).

TABLE 30-8
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
LEONE WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Amaluia	1,307	29,925
Leone	229,225	536,380
Malaeloa/Aitulagi	33,556	89,254
Malaeloa/Ituau	52,102	156,064
Vailoatai	95,898	131,810
Taputimu	62,526	114,948

Source: Pedersen Planning Consultants, 1995

TABLE 30-9
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
LEONE WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Amaluia	915	20,948
Leone	160,458	375,466
Malaeloa/Aitulagi	23,489	62,478
Malaeloa/Ituau	36,471	109,245
Vailoatai	67,129	92,267
Taputimu	43,768	80,464

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of three streams, the nearshore waters and adjoining shoreline.

100-Year Peak Discharge Areas and Drainage Area Descriptions

The Federal Emergency Management Agency (FEMA) determined the drainage area and 100-year peak discharges for three streams in the Leone watershed (Table 30-10). These estimates suggest the occurrence of significant stormwater flows during a 100-year storm event.

TABLE 30-10
ESTIMATED 100-YEAR PEAK DISCHARGES
LEONE WATERSHED

Flooding Source and Location	Drainage Area (Square Miles)	Potential 100-Year Peak Discharge (cfs)
Leafu Stream (Leone)		
At mouth	1.45	3,210
Above confluence with Aualii Stream	1.25	2,880
Below confluence with Unnamed Tributary	1.13	2,680
Upstream limit	1.00	2,430
Fuafua Stream		
At mouth	1.87	3,790
At highway crossing	1.73	3,610
Above confluence with Unnamed Tributary 1	1.64	3,480
Above confluence with Unnamed Tributary 2	1.31	2,980
Above confluence with Vaitai Stream	0.67	1,760
Upstream limit	0.58	1,570
Vaitai Stream		
Above confluence with Sigaloa Stream	0.19	570
Above confluence with Unnamed Tributary	0.10	320
Upstream limit	0.07	230

Source: Federal Emergency Management Agency, 1991

Flood profiles developed by the U.S. Army Corps of Engineers for the lower reaches of Fuafua and Vaitai streams indicate that 100-year flood elevations that would range between 10 and 155 feet above mean sea level. The 155-foot elevation is anticipated to occur on the northeastern reaches of Fuafua Stream. The anticipated flood elevations suggest potential flooding along the north and south sides of loop roadway to Malaeloa/Aitulagi.

Flood profiles developed for the lower reaches of Auali and Leafu streams indicate that a 100-year flood would generate produce elevations of between 7 and 10 feet above mean sea level. These potential flood levels could impact residential and commercial facilities that are located along the Leafu Stream drainage.

The upland areas of the Leone watershed, as well as lands south and east of the Fuafua Stream drainage, have been designated by the Federal Emergency Management Agency as "zone x." This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Leone watershed indicates that there is a coastal flood hazard through much of the nearshore waters and adjoining shoreline. From Pupualoa Point to Fagatele Point, a potential 100-year flood is estimated to generate flood levels in this area of between two and three feet above mean sea level (MSL).

North and west of Pupualoa Point, potential coastal flood elevations between four and six feet above MSL are accompanied with a warning for potential velocity hazards associated with nearshore wave action.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

The review of available information concerning coral communities indicate that the reef flat of Leone Bay represents a stressed environment. These conditions are, in part, a result of continued discharges of stormwater runoff and sediments to the nearshore waters. Significant surface discharges are received from both Fuafua Stream and Leafu Stream.

In order to conserve coral communities in the nearshore waters, it is important that practical efforts are made to detain stormwater runoff. The environment of the watershed contains two wetlands, i.e., Leone Pala and Malaeloa wetland, that provides two excellent opportunities for the detention of stormwater runoff. Future residential and commercial construction within or along the margins of these wetlands should be prohibited to enable the continued, long-term use of these detention areas. As stated earlier, discussions with the owner(s) of the man-made fill and residential structure within Leone Pala should be initiated by ASCZM and ASEPA to investigate options that might lead to some restoration of the Leone Pala.

At the time of this report, a feasibility study is being made of potential stormwater management opportunities along Leafu Stream. This study should consider potential opportunities for stream restoration and stormwater detention.

Other coastal areas of the watershed, e.g., between Avaloa Point and Puualoa Point, also receive turbid, stormwater runoff from Faalogo Stream and an unnamed stream to the west in Taputimu. To reduce the impact of these discharges, it is recommended that several natural depressions in Taputimu and Vailoatai are conserved. Future residential and commercial expansion in the vicinity of these features should be setback from the depressions and the drainage courses that drain into the depressions. The issuance of building permits in these areas should include:

- a site plan review and onsite inspection to ensure residents' understanding of the setback requirements;
- technical assistance that would help residents integrate the conservation of the natural depressions into residential and commercial development plans; and,
- a variable setback requirement of 50 to 100 feet radius around the perimeter of the depression.

The use of drywells with new residential and commercial structures also represent another opportunity to reduce localized flooding, and, at the same time, permit the recharge of stormwater runoff. Where surface drainage from new residential and commercial construction is expected to generate undesirable stormwater discharges, ASDOC should incorporate a requirement for the onsite construction of drywells along with building permits.

Nearshore Water Quality and the Marine Environment

The concern for continued turbidity and sedimentation in the nearshore waters the Leone watershed is important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the Leone watershed. They provide shelter to fish, invertebrates, and other marine organisms.

Some of these resources represent a supplemental food source for residents of the Leone watershed and other areas in West Tutuila.

The future monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of Leone Bay. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters of the Bay.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef flat and reef front east of Leone Bay at least once every three years. Long-term monitoring of this site should also include an evaluation of the impact of sedimentation and turbidity that may also be influencing the nearshore marine environment.

Groundwater and Surface Water Supplies

Enforcement of Regulations Associated With Connection to the ASPA Wastewater Collection System

While regular chlorination of the groundwater supplies remains effective, many homes and commercial facilities in the Leone watershed are not connected to ASPA's wastewater system. Some soils in the Leone watershed are generally ineffective to treat wastewater from septic tanks because of the limited depth to bedrock and other soil characteristics. Consequently, ASPA must remain committed to the enforcement of its regulations that require the connection of any residential and commercial facility that is within 300 feet of any ASPA wastewater collection system.

Conservation of Leone Pala and Malaeloa Wetland for Future Groundwater Recharge

The conservation of some land areas in the Leone must be conserved to ensure the long-term recharge of rainfall into Tutuila's basal aquifer. It is recommended that no new land uses be permitted within or along the margins of Leone Pala and the Malaeloa wetland. Existing land uses should be permitted to remain. Agricultural uses should also remain a permitted use in the Malaeloa wetland.

Salt Water Intrusion

Groundwater levels are approximately three to six feet above mean sea level through most of the Tafuna-Leone Plain. *"Because saltwater underlies freshwater everywhere, saltwater upconing can occur where well depths and pumping rates are not matched to the aquifer hydraulic conductivity, rates of ground-water flow, and freshwater lens thickness"* (U.S. Geological Survey, 1989). The draft Utilities Master Plan recommends that future ASPA groundwater wells should be drilled no deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered. It is recommended that this policy be adopted by the ASPA Water Division.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Leone watershed will be to:

- Continue enforcement of ASPA regulations associated with connections to the ASPA wastewater collection system.
- Restrict the establishment of new land uses in Leone Pala and the Malaeloa wetland.
- Establish groundwater development policies that minimize the potential for saltwater intrusion into future groundwater supplies.
- Conserve and enhance inland stormwater detention areas, e.g., natural depressions in Taputimu, for stormwater detention and groundwater recharge.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with designated residents of Amaluia, Leone, Malaeloa, Vailoatai, and Taputimu to encourage village participation in the implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 30-11. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 30-11
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
LEONE WATERSHED

Participating Public agency	Resource Management Objective	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated residents from each village in the watershed. 4. Make annual assessment of resource management program.
ASCZM/DOC	Conserve and enhance potential inland stormwater detention and groundwater recharge opportunities	1. Establish setbacks for natural depressions in the Taputimu area and other parts of the Leone watershed. 2. Provide technical assistance to residents that help residents integrate the conservation of natural depressions with residential and commercial development plans.
ASCZM/DOC	Detain stormwater runoff in future residential and commercial areas.	Where undesirable stormwater discharges are anticipated, require the use of onsite drywells for new residential and commercial facilities.
ASDOC	Conserve wetland for stormwater detention and groundwater recharge opportunities.	1. Prepare resolution for the Territorial Planning Commission that enables ASDOC to restrict the establishment of new land uses in Leone Pala and the Malaeloa wetland for its approval. 2. Submit approved resolution to Governor and Fono for their approval.
ASDOC	Monitor changes in population and land use	Annually map the type and location of land uses in each village of the watershed and estimate resident populations.
ASPA	Reduce potential saltwater intrusion into groundwater wells of the watershed.	ASPA Board of Directors and Water Division should adopt a policy that no groundwater wells will be drilled any deeper than the upper one-third of the basal lens except when unusual geologic conditions are encountered.
ASDPW	Maintain stormwater culverts along the primary shoreline roadway.	1. Establish a periodic maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Maintain all culverts along the primary shoreline roadway.
ASDMWR	Conserve marine communities of Leone Bay.	1. Monitor and quantify changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) along the fringing reef flat and reef front of Leone Bay approximately every three years. 2. Identify stresses upon coral communities and marine life and evaluate potential impacts from sedimentation.

Source: Pedersen Planning Consultants, 1998

AFAO-ASILI
Watershed 31

GEOGRAPHY

The Afao-Asili watershed is located along the southwest coast of Tutuila. The watershed comprises about 1.07 square miles of land area (Figure 31-1).

The east and west boundaries of the inland watershed include Masinaoleafiafi Ridge and Vaiala Ridge, respectively. The north boundary of the watershed represents the west portion of West Tutuila's central plateau, which is located about the 1,268 elevation. Two smaller ridges, Sepu Ridge and Malagatiga Ridge, define the watershed planning area into two separate drainages.

The Afao-Asili watershed is situated between Sinamanoo Point and Mu Point. Vaisigano Point and Asili Point are the shoreline boundaries that define the villages of Afao and Asili. Small, unnamed embayments front each of these villages.

Three stream courses are situated in this watershed. These include Asili Stream, Malagateine Stream, and Atauloma Stream.

RESOURCES OF THE WATERSHED

Soils

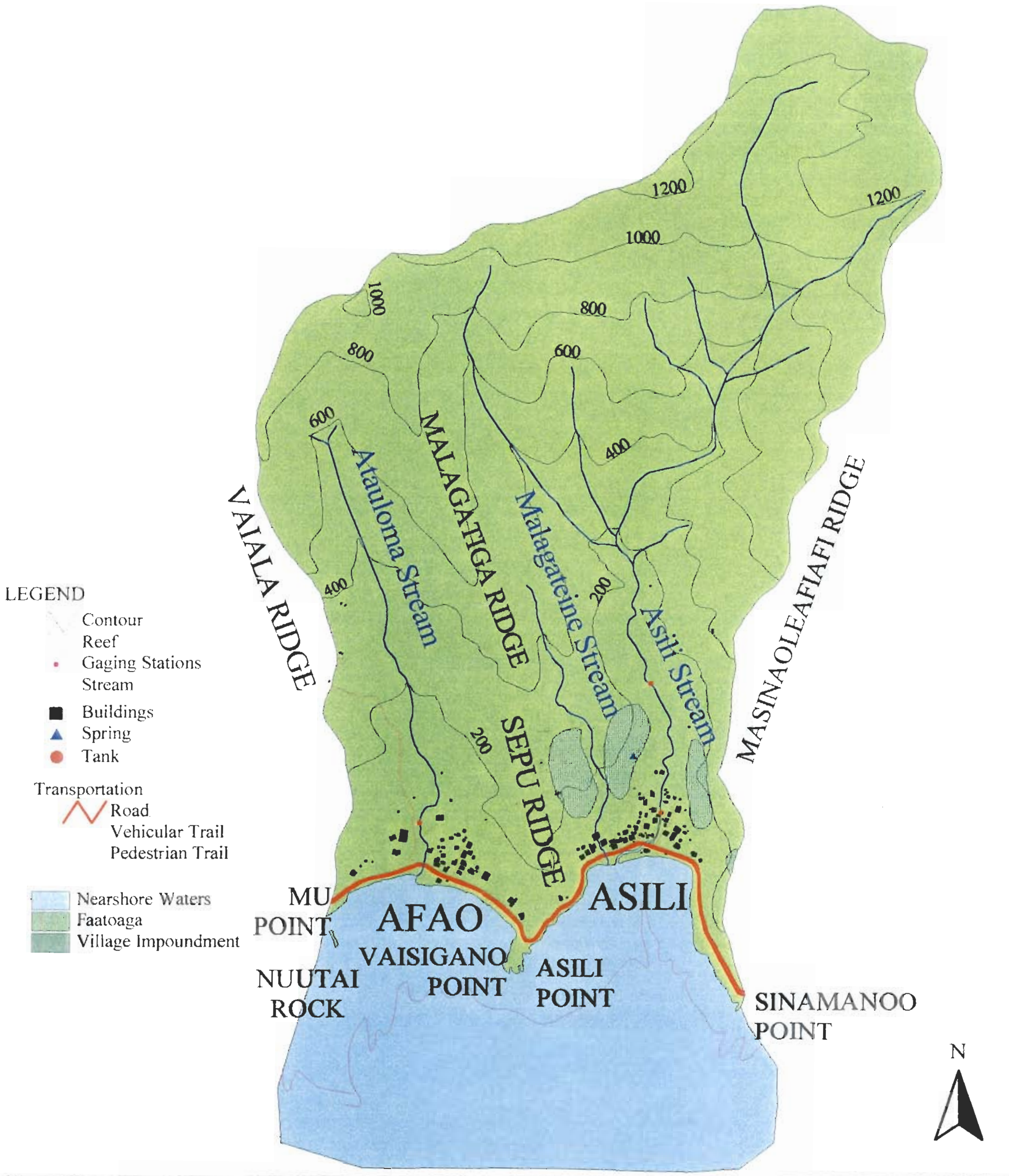
The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 31-2). Seven soil classifications were identified by the U.S. Soil Conservation Service for lands within the Afao-Asili watershed (Table 31-1).

TABLE 31-1
SELECTED SOIL CHARACTERISTICS
AFAO-ASILI WATERSHED

SCS Soil Unit	Name	Typical Slope (Percent)	Flood	*Runoff*	Erosion	Soil Depth To: High Water (Feet)	Soil Depth To: Bed Rock (Inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
1	Aua very stony silty clay loam	15-30	None	Med	Med	>6	<60	Severe Slope	Moderate
2	Aua very stony silty clay loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
3	Fagasa-Ofu silty clays	30-60	None	Med to Rapid	Med to Severe	>6	20-40	Severe Slope Depth	Moderate
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-40	Severe Slope Depth	Limited
9	Leafu Stony Silty Clay	0-3	Occ.	Slow	Slight	3-5	>60	Severe Flood Wet	Moderate
19	Oloava Silty Clay Loam	6-12	None	Slow	Slight	>6	>60	Severe Filter	Good
34	Urban Land-Aua-Leafu Complex	0-30	A. None L. Occ	A.Slow to Med L. Slow	A.Slight to Mod L. Slight	A. >6 L. 3-5	>60	Severe A. Slope L. Flood Wet	Limited

Notes:
1. A.= Aua soils found on mountain foot slopes 6-30 percent
2. L.= Leafu soils found on coastal plains & valley floors 0-6 percent

Source: U.S. Soil Conservation Service, 1984



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75

Miles

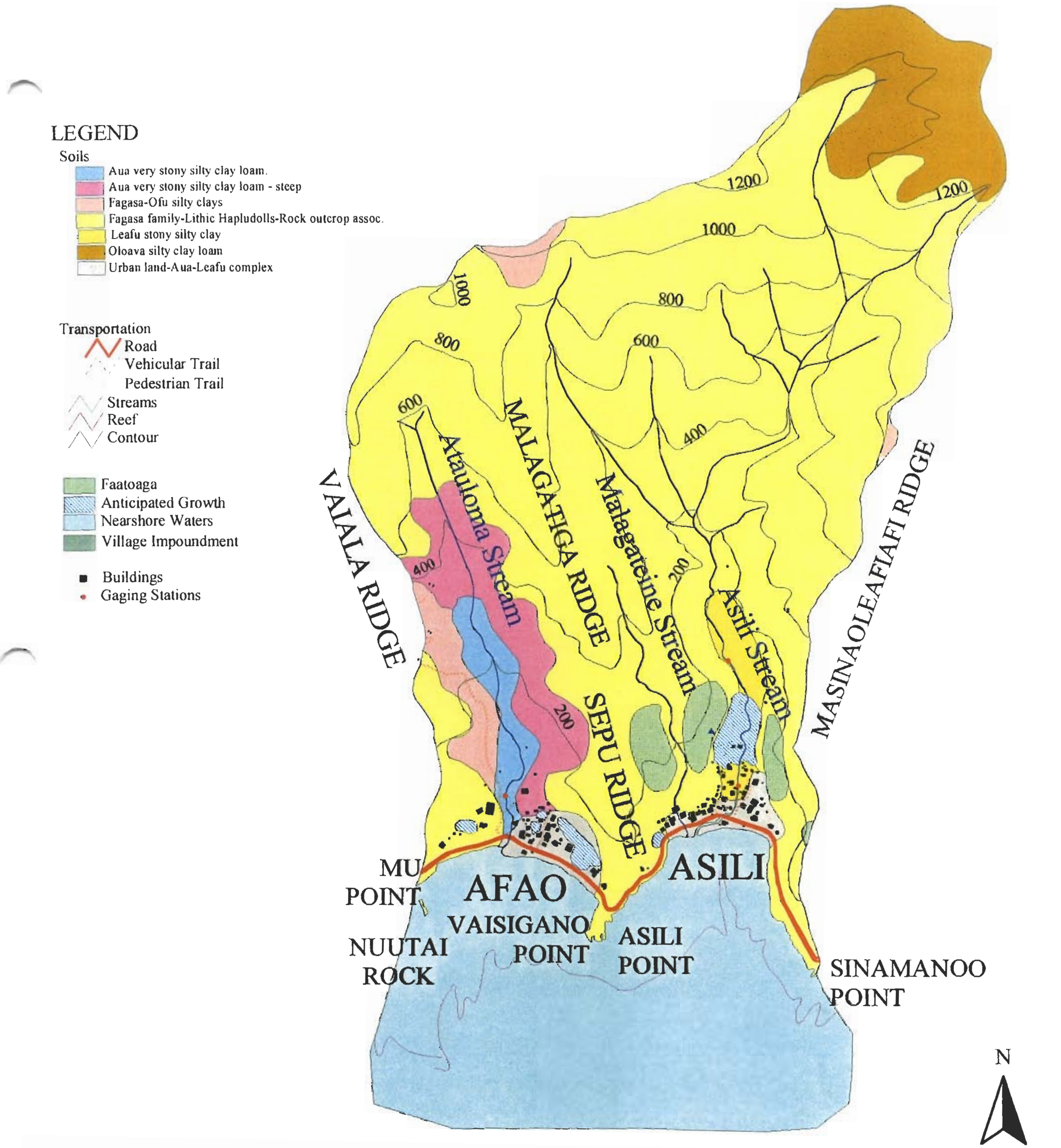
Scale: 1:15,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Afao-Asili Watershed **31**

Existing Conditions

Figure 31-1



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75

Miles

Scale: 1:15,000

Prepared by: Pedersen Planning Consultants

Tel: 307-327-5434

Afao-Asili Watershed **31**

Management Issues

Figure 31-2

Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

The inhabited village areas of Afao and Asili are characterized by the Urban Land-Aua-Leafu complex (SCS mapping unit 34).

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. The soil has limited to moderate potential for runoff. The erosion potential is slight to moderate.

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, does not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and cesspools in areas that contain these soils may be making a contribution of nutrients and bacteria into the nearshore waters of Vatia Bay.

Aua Very Stony Silty Clay Loam (15 to 30 percent slopes)

Aua very stony silty clay loam soils (SCS mapping unit 1) are soils found along lower elevations of the Atauloma Stream drainage.

These soils typically occur up to about 60 inches in depth. The permeability of these soils ranges between 2 and 6 inches per hour. The potential for runoff or erosion from the Aua soils is believed to be moderate (U.S. Soil Conservation Service, 1984).

While moderately suited for agricultural production, the U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). However, the U.S. Soil Conservation Service also advises that the stony and erosive characteristics of these soils may limit production. While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that typically hamper installation and provide inadequate soil treatment.

Fagasa-Ofu Silty Clays

A portion of the slopes on the East Side of Vaiala Ridge contains soils that are identified by the U.S. Soil Conservation Service as Fagasa-Ofu Silty Clays (SCS mapping unit 3).

The soil ranges between 20 to 40-inches in depth. The permeability of this silty clay loam is moderately rapid (2 to 6 inches per hour). The potential for surface runoff from these soils is considered moderate to rapid. However, the potential for erosion is moderate to severe.

The U.S. Soil Conservation Service indicates that this soil type is somewhat suitable for the production of subsistence crops. The soil can annually sustain from one to 5 tons per acre of erosion without impacting crop productivity. However, the Soil Conservation Service recommends the use of mulch, crop residues, and cross-slope farming to reduce the potential for soil erosion.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

Steeper slopes along the central and lower sections of the Atauloma Stream drainage are characterized by Aua very stony silty clay loam soils (SCS mapping unit 2).

The Aua soils range between seven to 60 inches in depth. The permeability of these soils (between 2 and 6 inches per hour) is moderately rapid. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that hamper installation and provide inadequate soil treatment.

Leafu Stony Silty Clay (0 to 3 percent slopes)

Leafu stony silty clay soils (SCS mapping unit 9) are found in the upper part of Asili Village, as well as the central and lower sections of Asili Stream.

This soil is a deep soil that typically extends up to 60 inches in depth. Its permeability ranges between 2 and 6 inches per hour. Runoff from these soils is generally slow and the potential for soil erosion is limited. However, these soils are typically subject to brief periods of flooding after heavier rainfall periods.

These soils are somewhat suitable for subsistence agriculture. However, this land use is constrained by occasional periods of flooding and general soil wetness. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these Leafu soils for residential land uses is not recommended by the U.S. Soil Conservation Service because of the inherent flood potential associated with this soil. The same characteristics also hamper the use of these soils for septic tank systems and related soil-based treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Oloava Silty Clay Loam (6 to 12 Percent Slopes)

The steeper upland slopes in the northeast part of the watershed contain Oloava Silty Clay Loam (SCS mapping unit 19). In a typical cross section, this soil is very deep, well-drained, and extends up to 60 inches in depth. The surface is a silty clay loam. However, a mid-layer between 12 to 40 inches in depth is often characterized by soft, weathered cinders. Greater depths contain more gravel mixed with the sandy loam.

The permeability of the Oloava soil is moderately rapid above the mid-layer (2 to 6 inches per hour). However, permeability becomes very rapid (6 to 20 inches per hour) through the cinder material between about 12 to 40 inches in depth.

This soil is well-suited to the production of subsistence crops. The U. S. Soil Conservation Service estimates that this soil can annually sustain up to two tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). The limited erosion potential exhibited by these soils can be minimized through the use of mulches, hedgerow planting, crop residues, and other ground covers.

Residential development is not desirable on these soils. Site development can expose the highly permeable cinder layer and contaminate local groundwater supplies. The use of onsite wastewater disposal systems can also contaminate ground water because soil-based treatment would typically be too rapid for adequate treatment.

Streams

Stream Locations

There are three streams in the Afao-Asili watershed that are situated within two separate drainages. East of Malagatiga Ridge and Sepa Ridge, surface runoff from steeper slopes upland of Asili Village are carried into either Asili Stream or Malagateine Stream. West of Malagatiga Ridge, surface runoff from upland slopes is transported by only Atauloma Stream.

Asili Stream originates about 1,190 feet above mean sea level. Runoff that drains into Asili Stream and its seven tributaries discharge near the center of the embayment that fronts Asili Village.

The main branch of Malagateine Stream begins near the 520-foot contour along the East Side of Malagatiga Ridge. This stream discharges into the northwest side of the embayment in front of Asili Village.

Atauloma Stream begins about 760 feet above mean sea level. Ridge. This stream course passes east of the old Atauloma School building (now ASG housing) before discharging into the northwest side of the embayment in front of Afao Village.

Stream Flows Within the Watershed

Asili Stream

Several water-flow gages have historically been established along Asili Stream. Between 1977 and 1986, a continuous-record stream gage (No. 16931500) was maintained at an elevation of 330 feet approximately 0.8 mile upstream from the stream mouth. These measurements enabled the U.S. Geological Survey to estimate a median flow of 1.60 cubic feet per second (cfs).

The same gage was operated as a partial-record site between 1987 and 1990. Extreme flows during this period of record included a maximum discharge of 653 cfs on October 28, 1960 and a minimum of 0.20 cfs on August 6, 1983 (Wong, 1996).

A low-flow, partial record station (No. 16932000) was located 0.5 mi. upstream from the Asili Stream mouth between 1959 and 1984. Twenty-four measurements of stream flow led the U.S. Geological Survey to estimate a median flow of 1.85 cfs for this period (Wong, 1996).

Between 1959 and 1990, another low-flow, partial record station (No. 16932500) was operated 100 feet upstream from the primary shoreline roadway bridge that crosses Asili Stream. Data generated from 34 measurements of stream flow were used to estimate a median flow of 2.85 cfs (Wong, 1996).

Various one to two-day measurements of stream flow were made at various points along Asili Stream. These records are available from the U.S. Geological Survey. However, this data is not presented in this report since more reliable long-term data is available from other long-term stream gages.

Atauloma Stream

A continuous-record stream gage (No. 16931000) was maintained about 200 feet upstream of the Atauloma Stream mouth between 1958 and 1990. These streamflow records enabled the U.S. Geological Survey to calculate a median flow of 1.60 cfs for that period.

This gage was also operated as a partial-record site between 1987 and 1990. Extreme stream flows for the period of record included a maximum discharge of 653 cfs on October 28, 1960 and a minimum of 0.20 cfs on August 6, 1983.

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Atauloma Stream in Afao Village and Asili Stream in Asili Village were two of 37 streams in American Samoa that were inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

Atauloma Stream was surveyed in a rocky riffle that was located underneath the primary shoreline bridge (station 3a). Asili Stream was surveyed in two locations. Station 12a was established immediately upstream of the primary shoreline roadway bridge. Station 12b was situated just upslope of Asili Village near the 60-foot elevation.

Two species of gobie fish and one species of eel were observed along Atauloma Stream. Six species of shrimp were also identified at station 3a; one of the shrimp species was abundant. One species of mollusks was also observed.

Along Asili Stream, two species of gobie fish, one species of mountain bass, and one abundant species of eel were documented downstream (station 12a). Five species of shrimp and one species of mollusk were also recorded.

Further upstream, four species of gobie fish were documented; three of these fish were abundant. One specie of mountain bass was also present. One abundant species of eel was also identified. Three species of shrimp were present at station 12b; one species was abundant. Two species of mollusks were also observed.

Surface Water Quality

Streams

Two miscellaneous water quality samples were collected along Asili Stream in May 1984 and May 1985 (Table 31-2). This data demonstrates that water quality did not exceed the ASEPA criteria for total nitrogen in the May 1985 sample or total phosphorus in both samples. However, based upon the total Kjeldahl nitrogen level in the 1984 sample, it is likely that the total nitrogen criterion would have been exceeded on this date.

In addition, turbidity and total suspended solids levels were elevated in the 1984 samples. However, turbidity was measured in formazin units on that date and is not strictly comparable with the current ASEPA turbidity standard which is based on ntu.

More recently, ASEPA is making a more detailed evaluation of selected streams in Asili, Leone and Afono to better ascertain the source of sedimentation that impacts surface water quality and the nearshore marine environment. Monitoring includes the weekly collection of water quality samples from stream locations adjacent to developed lands, a *faatoaga*, and undeveloped lands. Subsequent laboratory analyses are made for total suspended solids, turbidity, total nitrogen, and total phosphorus. Selected monitoring locations were chosen, in part, because of the availability of long-term stream flow data for these streams (Wiegman, 1996).

TABLE 31-2
MISCELLANEOUS WATER QUALITY SAMPLES
MAY 1984 AND MAY 1985

	Water Quality Parameter							
Stream ***Asili***	TN (μg/l)	TKN (μg/l)	NO_3+NO_2 (μg/l)	TP (μg/l)	Turbidity (ftu)**	TSS (mg/l)	pH	Total Coliform (#/100 ml)
5-18-84		240		62	62	14		
5-02-85	200	51	150	62	--	--	--	--

Source: ASEPA, 1995

In terms of Asili Stream, data collected between October and December, 1995, as well as in April and May, 1996, indicate that surface waters occasionally exceed the Territory's water quality standards for fresh surface waters (Table 31-3). However, available data suggests that there is no significant difference in the water quality at the three stream locations. Somewhat greater turbidity and total suspended solid levels were documented at the stations adjacent to developed and agricultural lands in April-May, 1996.

TABLE 31-3
WATER QUALITY MONITORING
ASILI STREAM
OCTOBER, 1995-MAY, 1996

Stations	ASO1R[1]				AS02PL[2]				AS03UND[3]			
Date	*TSS (mg/L)*	*Turb-idity (NTU)*	*TN (mg/L*	*TP (mg/L*	*TSS (mg/L*	*Turb-idity (NTU)*	*TN (mg/L*	*TP (mg/L*	*TSS (mg/L*	*Turb-idity (NTU)*	*TN (mg/L*	*TP (mg/L*
10/31/95	4.0	1.4			2	2.8			2	4.0		
11/2/95	5.0	1.3			4	1.4			2	3.8		
11/7/95	5.0	1.3			3	3.7			3	3.8		
11/9/95	5.0	7.9			5	7.4			4	7.2		
11/14/95	8.0	6.1			8	3.6			6	3.2		
11/21/95	3.0	2.0	0.069	0.050	3	2.0	0.062	0.050	2	1.0	0.076	0.048
11/24/95	3.0	9.9	0.106	0.068	5	8.9	0.107	0.066	5	7.9	0.107	0.066
11/28/95	3.2	1.4	0.089	0.043	3	1.4	0.082	0.042	2	0.6	0.072	0.045
11/30/95	3.0	1.2	0.049	0.044	3	1.2	0.049	0.043	2	0.9	0.046	0.041
12/5/95	3.0	2.9	0.052	0.050	2	2.8	0.051	0.075	3	2.6	0.054	0.066
12/7/95	1.0	1.0	0.069	0.056	1	4.0	0.181	0.063	1	0.1	0.142	0.067
12/11/95			0.070	0.061			0.196	0.078			0.125	0.061
12/12/95	1.0	0.9	0.075	0.056	2	10.0	0.172	0.058	2	9.0	0.137	0.087
12/14/95	1.0	0.6			2	2.1			2	2.1		
12/20/95	0.0	2.3	0.084	0.049	0	1.7	0.087	0.057	1	2.1	0.096	0.050
12/21/95			0.120	0.065			0.213	0.096			0.232	0.098
12/25/95			0.141	0.065			0.123	0.057			0.180	0.071
12/28/95			0.410	0.218			0.250	0.209			0.276	0.249
4/23/95	0.004	7.0			0.003	5.5			0.002	4.3		
4/25/95	0.005	2.3			0.007	2.1			0.010	2.0		
4/30/95	0.002	3.7			0.008	3.0			0.003	2.9		
5/2/96	0.015	8.0			0.013	8.0			0.003	6.4		
5/7/96	0.042	9.9			0.024	9.9			0.018	9.9		
5/9/96	0.003	9.9			0.003	9.9			0.003	9.9		

Notes:
1) Station ASO1R is located adjacent to developed lands.
2) Station ASO2PL is located adjacent to a plantation or *faatoaga.*
3) Station ASO3UND is located adjacent to undeveloped lands.

Source: ASEPA, 1996

Wetlands

There are no significant wetlands in the Afao-Asili watershed. In April, 1996, a small area of saturated soils was observed in the vicinity of the Asili Stream mouth.

Marine Resources

Coral Communities

Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests that:

- In 1979, the fringing reef flats seaward of Asili and Afao were characterized by coral coverages that ranged between 10 and 15 percent.

- In 1992, the reef fronts seaward of Asili and Afao contained lower coral coverage at depths of six meters. Coral coverage increased at 18 meters. Considerably greater coral coverage was evident in the nearshore waters seaward of Afao.

  <u>1978-1979</u>

  In the embayment fronting Asili, coral cover was slightly less than 10 percent on the middle reef flat that was located about 80 to 165 feet offshore. Between 165 and 245 feet offshore, live coral cover was approximately 15 percent. Similar coverage extended to about 330 feet from the shoreline. On the outer reef flat (245 to 330 feet offshore), coral coverage reached 35 percent near the *ava* that provides boat access to the deeper waters of the embayment (Aecos and Aquatic Farms, 1980).

  Seaward of Afao, smaller coral microatolls and encrusting corals comprised about 10 percent cover in mid-reef depressions on the fringing reef flat. Coral coverage on the consolidated limestone platform further offshore increased to 10 to 15 percent (Aecos and Aquatic Farms, 1980).

  <u>1992</u>

  Field investigations were also made by Maragos, Hunter, and Meier in 1992. Surveys were made at sites seaward of Afao and Asili.

  Coral coverage was documented to be less than one percent on the reef front seaward of Asili at a depth of six meters. Seaward of Afao, coral coverage increased to 10-20 percent coverage at the six meter depth.

  At a depth of 18 meters, live stony coral coverage was reported to range between 5 to 10 percent seward of Asili. Coral coverage of 20 to 40 percent was documented on the reef front at Afao.

Shoreline Protection

Basaltic cliffs and boulders characterize much of the shoreline in the embayments that front Asili and Afao. In addition, some limited shore protection facilities are present along the pocket beaches that are present in both embayments.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Afao-Asili watershed that were determined to be “critical”, or “potentially critical” conditions.

Asili

Fronting Asili Village, Malagateine Stream and Asili Stream both discharge over a 1,000-foot long pocket beach. East of the Asili Stream mouth, one house is located seaward of the primary shoreline roadway. An active 2-foot scarp is present along the seaward side of the primary shoreline roadway that approaches within five feet of the road. The presence of undermined coconut trees and a former World War II bunker provide evidence of past shoreline erosion.

Afao

West of the Atauloma Stream mouth, one home and a public bus stop are located on the seaward side of the primary shoreline roadway. A scarp that extends up to 6 feet high is cut into the backshore east of the shoreline residence. Despite the placement of basaltic boulders along some 200 feet of this shoreline, the scarp is with two to five feet of the shoreline roadway in some areas.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

There are no groundwater wells in the watershed that are operated by the American Samoa Power Authority. However, both Asili and Afao are served by the ASPA water system that relies upon groundwater supplies from the Tafuna-Leone Plain.

Surface Water Supply and Quality

In April, 1986, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. Two village water systems were identified in the Afao-Asili watershed.

In Asili, a spring source between Malagateine Stream and Asili Stream was identified upslope of the inhabited village area at about the 100-foot elevation. One storage tank was located on the northwest of the inhabited village area at approximately 45 feet above mean sea level. In April 1996, Chief Leota of Asili reported that this system is no longer used by village residents.

A second system continues to serve Afao Village. This system includes a stream catchment along Atauloma Stream. The catchment is located at approximately 200 feet above mean sea level. HC Tagaloa reported in April, 1996 that the intake box of the stream catchment is cleaned on a monthly basis.

Historical data from the 1981-1986 period indicates that the Asili Village water systems contained a median coliform bacteria level of greater than 80 coliforms per 100 milliliters. The Afao system contained a median bacterial level of 35 coliforms per 100 milliliters during the same period.

USE OF THE WATERSHED

Resident Population

Afao

Between 1980 and 1990, the resident population of Afao Village increased from 80 to 145 residents. Such growth represented an average annual growth rate of about 8.13 percent. Development activity between 1990 and 1995 increased the resident population to about 194 persons.

Population trends for Afao reflected in the 1990 Census suggest that considerable in-migration has gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa increased from 31 to 55 percent between 1980 and 1984. However, the number of persons born outside of American Samoa diminished to 45 in 1990.

Asili

Between 1980 and 1990, the resident population of Asili Village increased from 145 to 203 residents. Such growth represented an average annual growth rate of about 4.0 percent. Development activity between 1990 and 1995 increased resident population to about 268 persons.

Population trends reflected in the 1990 Census suggest that some in-migration has occurred in Asili between 1980 and 1990. The proportion of residents who were born outside of American Samoa has increased almost 50 percent during the 1980-1990 period. However, the increase in migration apparently did not occur until 1990. Between 1985 and 1990, the proportion of residents who were born outside American Samoa actually declined from 29 (1980-1984) to 25 percent. In contrast, this migration statistic increased to 43 percent during the 1990 Census.

Land Uses

Residential

The 1990 U.S. Census documented 25 homes in Afao. Approximately 60 percent of the homes were owner-occupied; 36 percent were rental units. The remaining four percent were vacant or used as vacation homes by absentee owners. The housing stock expanded considerably during the 1990-1995 period. Building permits were issued for eight new housing starts. Consequently, the 1995 housing stock included approximately 33 homes.

The 1990 U.S. Census documented 25 homes in Asili. Approximately 92 percent of the homes were owner-occupied; eight percent were rental units. The housing stock expanded considerably during the 1990-1995 period. Building permits were issued for nine new housing starts. Consequently, the 1995 housing stock included approximately 34 homes.

Agriculture

<u>Piggeries</u>

Discussions with Chief Leota in April, 1996 suggest that one small piggery is located in the Asili Village. However, an inventory of piggeries by the ASG Department of Agriculture indicate that there were six piggeries in Asili which contained 85 pigs; two piggeries in Afao housed 22 pigs.

<u>Faatoaga</u>

In April, 1996, three larger *faatoaga* were located north of Asili Village. These agricultural areas included the production of subsistence crops.

Commercial

There are approximately two commercial enterprises that are based in Afao. No new businesses were established during the 1990-1995 period. In 995, commercial enterprises included two village grocery stores.

There are approximately two commercial enterprises that in Asili. No new businesses were established during the 1990-1995 period. Commercial enterprises in 1995 included an auto towing service and a bus company.

Industrial

In 1995, no light industrial operations were based in Afao or Asili.

Public Facilities

The ASG Department of Education does not offer an early childhood education program in Afao. Elementary school students are bussed to Alataua-Lua Elementary School in Nua and Leone High School in Leone.

The ASG Department of Education offers an early childhood education program in Asili that provided educational opportunities to approximately 32 children in September, 1994. Elementary school students are bussed to Siliaga Elementary School in Aoloau and Leone High School in Leone.

Use of the Nearshore Waters

The high sea cliffs along the south part of the watershed limit the type of recreational activities that occur along portions of the shoreline. For the most part, use of the nearshore waters revolves around fishing. General water recreation also takes place in various parts of the reef flats that front Asili and Afao.

An American Samoa Subsistence Fishing Survey was conducted by the University of Hawaii Sea Grant Program in the summer of 1992. This survey involved onsite interviews with shoreline users who were participating in fishing activities on selected days during that period. The results of the survey revealed, in part, that there is some use of the nearshore waters in the vicinity of Afao and Asili.

Some 15 to 17 persons were documented fishing on the reef seaward of Asili Village. Fishing methods that were observed included the use of rod and reels, gleaning, throw nets, gill nets, as well as diving.

On the reef flat fronting Afao, seven to 20 persons were involved in fishing. These residents used fishing poles, gleaning, throw nets, diving, as well as rods and reels.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Some future residential expansion is expected to occur in Afao, but future growth will likely slow considerably from increased residential growth that occurred between 1990 and 1995. Future residential expansion will represent the infilling of undeveloped housesites within existing village where about eleven additional housesites are possible.

It is anticipated that future residential growth in Afao during the 1996-2015 period will also include the replacement of some existing one-story, single family units to accommodate more than one family. Residential construction in Afao will be hampered by the lack of developable lands within the village. Steeper slopes that are immediately upland of the existing village residential area will limit the extent of residential construction in Afao.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Afao.

1996-2000	Six new single family homes within the existing residential area.
2001-2005	Five new single family homes within the existing residential area.
2006-2010	No new residential construction is anticipated except for home extensions, repairs, and renovations.
2011-2015	Four existing single family homes in the village will be replaced with two-story units that will accommodate two families.

The cumulative effect on Afao of this prospective residential growth is that the village housing stock will increase to roughly 48 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 5.01 persons per household, the future village population will include about 240 persons.

Some future residential expansion is expected in Asili, but future growth will slow considerably from increased residential growth that occurred between 1990 and 1995. Future residential expansion will represent the infilling of one undeveloped housesites within existing village. Most all of the expansion is anticipated on steeper slopes that are immediately upland of the community.

Future residential growth for Asili during the 20-year planning period will also include the replacement of some existing one-story, single family units to accommodate more than one family.

Residential construction in Asili will be hampered by the lack of developable lands within the village. Steeper slopes behind the existing village limit the number of potential developable housesites. During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Asili.

1996-2000	Five new single family homes on slopes upland of the existing residential area.
2001-2005	Five new single family homes on slopes upland of the existing residential area.
2006-2010	Five new single family homes on slopes upland of the existing residential area.
2011-2015	Four new single family homes on slopes upland of the existing residential area.
	Five existing single family homes in the village will be replaced with two-story units that will accommodate two families.

The cumulative effect on Asili of this prospective residential growth is that the village housing stock will increase to roughly 58 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.73 persons per household, the future village population will include about 390 persons.

Commercial

Future commercial facility expansion in Afao is not anticipated. The lack of developable lands and the proximity of competing commercial services in Leone will strongly discourage the construction of additional commercial retail facilities. At the same time, the anticipated increase in resident population will probably encourage the formation of three home-based occupations between 2001 and 2005 that will likely include professional and technical services.

Future commercial facility expansion in Asili is not anticipated. The lack of developable lands and the proximity of competing commercial services in Leone will strongly discourage the construction of additional commercial retail facilities. At the same time, the anticipated increase in resident population is expected to encourage the formation of various home-based occupations that will likely include professional and technical services.

Industrial

The gradual increase in resident population in Afao and Asili will likely attract two small, home-based activities of an industrial nature in both villages. However, the construction of new industrial facilities is not anticipated.

Public Facilities

<u>Afao</u>

Population characteristics for Afao in 1990 suggest that approximately ten percent of the village population is three and four years of age. Elementary school-aged children (5 and 13 years old) include about 20 percent of village population; high school students represented only eight percent of the population.

The application of population characteristics to the anticipated 2015 village population suggest increased student enrollments in future early childhood education programs, as well as elementary and high school facilities outside Afao. Anticipated student enrollments from the village population are expected to be as follows in the year 2015:

- early childhood education 24 students
- elementary school 46 students
- high school 19 students

Another public facility in Afao includes ASG housing at the former Atauloma Girls' School Building and two adjacent single family residences. The former Girls' School facility is a two-story structure that contains two three-bedroom units, three two-bedroom units, and one one-bedroom unit. This structure is gradually deteriorating and receiving little or no facility maintenance. It is anticipated that this facility will become vacated during the year 2000.

The remaining two single family residences within Afao are in fair condition. It is assumed that these structures will remain in the ASG housing inventory through the year 2015. It is anticipated that these units will be renovated by the year 2000 to increase the facility life of these housing units.

Asili

Population characteristics for Asili in 1990 suggest that approximately three percent of the village population is three and four years of age. Elementary school-aged children (5 and 13 years old) include about 20 percent of village population; high school students represented 12 percent of the population.

The application of these population characteristics to the anticipated 2015 village population suggest increased student enrollments in the local early childhood education program, as well as the elementary and high school facilities outside Asili. Anticipated student enrollments from the future village population are expected to be as follows in the year 2015:

- early childhood education 12 students
- elementary school 78 students
- high school 47 students

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Afao-Asili watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 31-4 and 31-5).

TABLE 31-4
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
AFAO-ASILI WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Asili	5,817	34,426
Afao	3,174	19,457

Source: Pedersen Planning Consultants, 1995

TABLE 31-5
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
AFAO-ASILI WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Asili	4,072	24,098
Afao	2,222	13,620

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of Asili, Malagateine, and Atauloma Streams, the nearshore waters and adjoining shoreline.

Inland Flood Potential

The flood insurance rate maps that encompass the Afao-Asili watershed indicate that potential flooding along Asili, Malagateine, and Atauloma Streams could be generated via a 100-year storm event. The lower reaches of these streams have been designated by FEMA as "zone A" where no potential base flood elevations were determined. Downstream storm culverts that pass underneath the primary shoreline roadway are also identified as adequate to accommodate 100-year storm flows along the lower reaches of Asili, Malagateine, and Atauloma Streams.

The remaining inland areas of the Leone watershed have been designated by the Federal Emergency Management Agency as "zone x." This designation refers to areas that are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Afao-Asili watershed indicates that there is a coastal flood hazard along the shoreline of the watershed and the adjacent nearshore waters. A potential 100-year flood is anticipated to generate flood levels of six feet above mean sea level (MSL) in these areas. FEMA has also designated the coastal area between Mu Point and Sinamanoo Point as an area where there is a potential hazard associated with the velocity of nearshore wave action.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Heavier rainfall, steeper inland slopes, and more erosive soils in the upland watershed regularly contribute to the periodic transport of turbid waters into the downstream embayments of the Afao-Asili watershed. The primary source is natural sedimentation from more erosive soils on steeper upland slopes of the watershed. Some sedimentation is also believed to be generated somewhat from *faatoaga* areas that are situated in steeper slopes above Asili Village. The perennial flows of Asili, Malagateine, and Atauloma Stream carry turbid water and sediments to the nearshore waters that adjoin the watershed.

Impermeable building roofs and paved surfaces also generate sheet flow within the inhabited village area. Frequent runoff from these sources regularly discharges sediments, solid waste materials, and other domestic garbage into the streams of the watershed.

Increased detention of stormwater flows is necessary to reduce the volume of turbid water and sediment discharges into the embayments of the watershed. Unfortunately, the limited amount of undeveloped land area in Asili and Afao preclude any significant opportunities. Saturated soils near the mouth of Asili Stream may provide some limited detention to lower stream flows, but do not slow medium and higher stream flows.

The use of drywells in paved parking areas that are associated with any future commercial facilities and residences would also help provide some detention and infiltration of stormwater flows. This application should be required in conjunction with the construction of paved vehicular parking area for any new structures in Asili or Afao.

Nearshore Water Quality and the Marine Environment

Turbidity and Sedimentation

The concern for continued turbidity and sedimentation in the nearshore waters the Afao-Asili watershed is important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the watershed. They provide shelter to fish, invertebrates, and other marine organisms. Some of these resources represent a supplemental food source for residents of the Afao-Asili watershed and other areas in West Tutuila.

Nutrient Inputs

A nutrient contribution is also occurring through the continued use of septic tanks, cesspools, or other soil-based, wastewater treatment systems in the watershed. Some bacterial contamination from these discharges may also be occurring in the nearshore waters. While the total volume of wastewater generation from the watershed is limited, the discharges are concentrated in the two village residential areas where housing densities are higher. Local soils are generally inadequate to provide effective treatment. Consequently, the exposure of bacteria to saline, marine waters probably provides the best treatment for wastewater effluent that reaches the nearshore waters.

The long-term input of turbid and nutrient-enriched waters into the nearshore waters represents an important concern. These inputs are potential detrimental to the quality and composition of the nearshore marine environment. However, the degree of impact upon water quality is also highly dependent upon currents and water exchange within the nearshore water environment.

As the population of the watershed and West Tutuila grows, sediment, nutrient, and bacterial inputs will only increase. Aside from these resource management considerations, the future use of the nearshore waters for fishing, swimming and general recreation will also represent a more significant public health concern.

It is most desirable for Asili and Afao to be incorporated into the ASPA wastewater collection system. However, the limited population of the west end of Tutuila will likely continue to make this system expansion unfeasible. In the absence of this reality, village areas that are unsuitable for soil-based, wastewater treatment should be more specifically identified. As recommended in the ASPA Utilities Master Plan, this identification process should be based upon a more detailed sanitation survey of inhabited residential areas in Asili and Afao. This survey would evaluate existing wastewater treatment practices, soil characteristics, the location and density of land uses, the distance to surface water supplies and the nearshore waters, topography, and other related factors. Using the conclusions and recommendations associated with this evaluation, ASPA and other participating Project Notification and Review System (PNRS) agencies will be better able to:

- require the use of septic tanks and leachfields that provide a sufficient amount of additional soil-based treatment;
- provide greater technical assistance to building permit applicants; and/or,
- deny building applications in land areas that are unsuitable for soil-based treatment systems.

Long-Term Monitoring

The future monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of the embayments that front Asili and Afao. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters of these embayments.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef flats and reef fronts seaward of Asili and Afao at least once every three years. Long-term monitoring of this site should also include an evaluation of the impact of sedimentation and turbidity that may also be influencing the nearshore marine environment.

Groundwater and Surface Water Supplies

As stated earlier, Asili and Afao are already connected to the ASPA water system. While the use of surface water supplies is not recommended for potable use, it is desirable for existing surface catchments and storage tanks to be maintained by villages for non-potable uses and emergency consumption. In the event of a hurricane or other unanticipated event that disables ASPA water delivery for an extended period of time, it is desirable to have an emergency water supply that could be chemically disinfected for potable use, as well as used for non-potable purposes. Traditional leaders should be encouraged to continue or undertake this responsibility if adequate resources are available from the communities.

To facilitate the long-term conservation of these resources, it is also recommended that a 100-foot buffer or setback should be established around each surface supply, i.e., stream or spring catchment, in the watershed. In essence, the establishment of piggeries, new structural development, or other land uses would not be permitted within the 100-foot radius to prevent potential contamination of the surface supplies.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Afao-Asili watershed will be to:

- detain urban runoff through the use of drywells in conjunction with the development of new building structures in Afao and Asili;
- conserve stream catchments;
- maintain culverts underneath the primary shoreline roadway;
- perform detailed sanitation survey of Asili and Afao; and,
- conserve coral communities.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting potential hazards or undesirable conditions, share potential solutions with designated residents of Asili and Afao, and encourage participation of traditional leaders and village residents in the implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 31-6. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 31-6
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
AFAO-ASILI WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASEPA	Monitor water quality of Asili, Malagateine, and Atauloma Streams, as well as the nearshore waters.	Measure changes in and total/fecal bacteria, total suspended solids, turbidity, and nutrients on a quarterly basis.
ASPA/ASEPA	Perform a detailed evaluation of community sanitation problems associated with the use of soil-based treatment systems.	1. Survey existing residential and commercial areas. 2. Evaluate existing treatment practices, soil characteristics, location and density of land uses, the distance to water supplies and nearshore waters, topography, and other factors. 3. Require use of septic tanks and leachfields that provide sufficient amounts of additional soil-based treatment; or, deny building applications in areas unsuitable for soil-based treatment.
ASEPA	Conserve surface water supplies	1. Identify village surface water supplies that are actively used. 2. Revise American Samoa GIS to delineate 100-foot buffers around each surface supply. 3. Restrict land uses within designated buffers.
ASCZM/DOC	Detain stormwater runoff in future residential and commercial areas.	Where undesirable stormwater discharges are anticipated, require the use of onsite drywells for new residential and commercial facilities.
DPW	Maintain culverts along the primary shoreline roadway	1. Establish a periodic storm culvert maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Clean debris and other material blocking culverts.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASCC Land Grant Program	Reduce sedimentation from agricultural activities	1. Determine locations where upslope agricultural activities may be generating some sedimentation. 2. Encourage soil conservation methods with resident growers of subsistence crops.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) approximately every three years.

Source: Pedersen Planning Consultants, 1998

NUA-SEETAGA
Watershed 32

GEOGRAPHY

The Nua-Seetaga watershed is located along the southwest coast of Tutuila. The watershed comprises about 1.2 square miles of land area (Figure 32-1).

The inland boundaries of the watershed include Vaiala Ridge, the peak of Leaiafaalava Mountain, Leileia Mountain and Niuasele Ridge. Within these boundaries, there is an additional geographic feature known as Niualuau Ridge that defines the east boundary of Failolo Village.

Along the shoreline, the Nua-Seetaga watershed lies between Mu Point on East Side of Nua Village and Maugasaa Ridge and Siulepa Ridge along the West Side of Failolo Village. Nua-Seetaga Bay is a prominent embayment along the nearshore waters that adjoin the watershed.

The are five primary stream courses in the Nua-Seetaga watershed. These streams include an unnamed stream (Stream 32A) on the East Side of the watershed, Soonapule Stream, Vaialae Stream, Afutele Stream, and Leaute Stream.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 32-2). Five soil classifications were identified by the U.S. Soil Conservation Service for lands within the Nua-Seetaga watershed (Table 32-1).

TABLE 32-1
SELECTED SOIL CHARACTERISTICS
NUA-SEETAGA WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence. Ag. Potential
2	Aua very stony silty clay loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
3	Fagasa-Ofu silty clays	30-60	None	Med To Rapid	Med to Severe	>6	20-40	Severe Slope Depth	Moderate
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
34	Urban land-Aua-Leafu complex	0-30	A. None L. Occ	A.Slow to Med L. Slow	A.Slight to Mod L. Slight	A.>6 L.3-5	>60	Severe A.Slope L.Flood Wet	Limited
35	Urban land-Ngedebus complex	0-5	Occ. brief	Slow	Slight	>3.5	>60	SevereFlood Wet Poor Filter	Poor

Notes:
1. A.= Aua- found on mountain foot slopes 6-30 percent
2. L.= Leafu- found on coastal plains & valley floors 0-6 percent
3. N/A = Not Available

Source: U.S. Soil Conservation Service, 1984

American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1

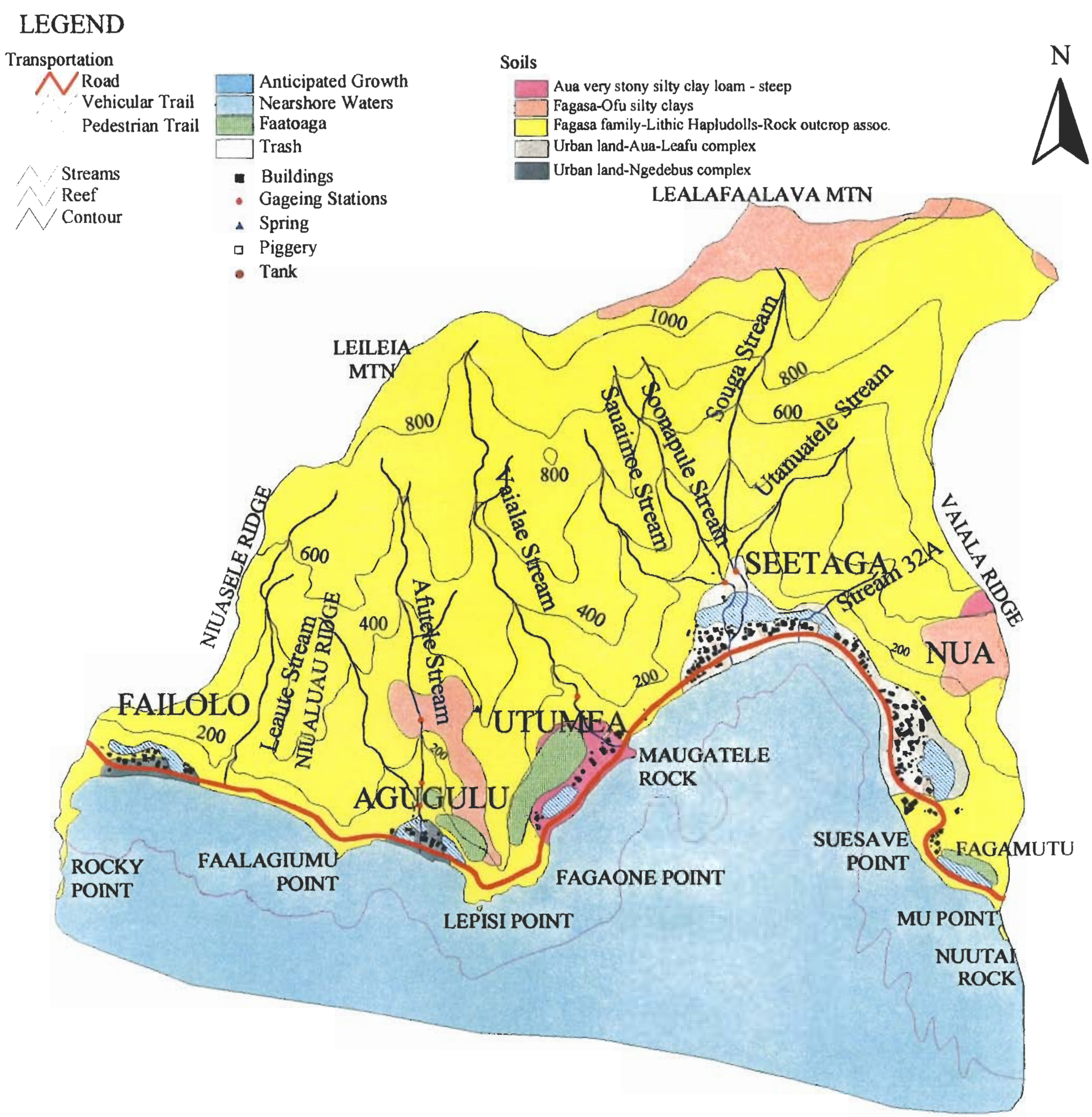
Miles

Scale: 1:18,000

Nua-Seetaga Watershed 32

Existing Conditions

Figure 32-1



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1

Miles

Scale: 1:18,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Nua-Seetaga Watershed Management Issues

32

Figure 32-2

Urban Land-Aua-Leafu Complex (0 to 30 percent slopes)

Urban Land-Aua-Leafu complex (SCS mapping unit 34) soils are found within most of the inhabited village areas of Nua and Seetaga.

This soil type represents a combination of Aua and Leafu soils. These soils typically are found at depths of 60 inches or more. The permeability of this soil is moderately rapid and ranges between 2 and six inches per hour. Urban Land-Aua-Leafu complex has limited to moderate potential for runoff. The erosion potential is slight to moderate.

This soil has limited potential for subsistence agriculture. The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). Consequently, the use of these lands for subsistence agriculture is not likely to generate significant downslope erosion.

The use of these soils for septic tank systems and related soil-based wastewater treatment is not desirable. A higher composition of larger rock fragments, combined with moderately rapid permeability, does not promote effective wastewater treatment. Consequently, the cumulative use of septic tanks and cesspools in areas that contain these soils may be making a contribution of nutrients and bacteria into the nearshore waters of Nua-Seetaga Bay.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

The Utumea area and some adjoining steeper slopes of the Vaialae Stream drainage are characterized by Aua very stony silty clay loam soils (SCS mapping unit 2).

The Aua soils range between seven to 60 inches in depth. The permeability of these soils (between 2 and 6 inches per hour) is moderately rapid. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). The soils contain a significant amount of larger stones that hamper installation and provide inadequate soil treatment.

Urban Land-Ngedebus Complex

Urban land-Ngedebus complex soils (SCS mapping unit 35) is situated along the shoreline within the village areas known as Agugulu and Failolo.

These soils generally comprise coral fragments, sand, cinders and other material that have been graded or filled to support residential, commercial and public facilities in the village areas.

The Ngedebus soil extends to a depth of 60 inches or more. The surface layer, which extends about 4 inches below ground elevation, typically contains light, brownish-gray and brown sand. The underlying material is characterized by pale brown and light yellow, brown sand. The permeability of Ngedebus soil ranges between six and 20 inches per hour.

Surface drainage on this soil is generally slow, and the hazard of potential soil erosion is slight. In some places, the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide (U.S. Soil Conservation Service, 1984).

These soils are generally suitable to support residential and commercial development in areas that are protected from flooding. However, this soil is poorly suited in unprotected areas.

Where moderate to higher housing densities occur, the U. S. Natural Resources Conservation Service recommends the use of community sewage systems to prevent the potential contamination of groundwater and surface water supplies. Lower housing densities are present in both Agugulu and Failolo.

Fagasa-Ofu Silty Clays

Soils that are identified by the U.S. Soil Conservation Service as Fagasa-Ofu Silty Clays (SCS mapping unit 3) are found in the vicinity of Lealafaalava Mountain, along the lower slopes of the Afutele Stream drainage, and a small area upland of Nua Village on the west side of Vaiala Ridge.

The soil ranges between 20 to 40-inches in depth. The permeability of this silty clay loam is moderately rapid (2 to 6 inches per hour). The potential for surface runoff from these soils is considered moderate to rapid. However, the potential for erosion is moderate to severe.

The U.S. Soil Conservation Service indicates that this soil type is somewhat suitable for the production of subsistence crops. The soil can annually sustain from one to 5 tons per acre of erosion without impacting crop productivity. However, the Soil Conservation Service recommends the use of mulch, crop residues, and cross-slope farming to reduce the potential for soil erosion.

Fagasa-Ofu Silty Clay soils are also poorly suited when applied to septic tank and related effluent drainfield installations. Steeper slopes and limited depth to bedrock constrain potential opportunities for soil-based wastewater treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Steeper upland land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. Since the Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur, significant erosion of these soils can be expected from undeveloped upslope areas of the watershed. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and streams. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

There are five surface water drainages in the watershed.

There are no defined stream courses in the vicinity of Nua Village. However, there are three to four man-made channels in Nua that expedite the transport surface runoff from the slopes of Vaiala Ridge through the village into the nearshore waters of Nua-Seetaga Bay. In addition, Stream 32A drains a portion of the slopes on the West Side of Vaiala Ridge and discharges into the nearshore waters from the East Side of Seetaga.

Most of Seetaga is situated within the Soonapule Stream drainage, which receives surface runoff from the south slopes of Lealafaalava Mountain. The primary stream originates near the 825-foot contour. Tributaries to Soonapule Stream include Utanuatele Stream, Souga Stream, and Sauaimoe Stream.

Vaialae Stream, which originates about the 780-foot contour, drains the northeast side of Leileia Mountain and the lower residential area of Utumea.

Afutele Stream and two tributaries transport surface runoff from the south side of Leleia Mountain. This stream course begins at about 650-feet above mean sea level and passes through Agugulu before its shoreline discharge into Nua-Seetaga Bay.

Runoff from the southwest slopes of Leileia Mountain is drained by Leaute Stream. This stream course originates at about the 690-foot elevation between Niualuau Ridge and Niuasele Ridge. The stream discharges east of Failolo Village into the nearshore waters. Logoua Falls is located just upstream of the stream mouth at about the 60-foot elevation.

Stream Flows Within the Watershed

<u>Soonapule Stream</u>

Two low-flow, partial record stations have historically measured stream flow along Soonapule Stream and its tributary, Utanuatele Stream. A gage was established on Soonapule Stream (No. 16930000) between 1959 and 1976. This gage was located approximately 50 feet upstream from the confluence with Utanuatele Stream. Some 18 measurements of stream flow enabled the U.S. Geological Survey to estimate a median flow of 0.44 cubic feet per second (cfs).

Between 1960 and 1976, a second gage was operated on Utanuatele Stream (No. 16930200), approximately 200 feet upstream from the confluence with Soonapule Stream. Fifteen streamflow measurements were used by the U.S. Geological Survey to estimate a median stream flow of 0.36 cfs (Wong, 1996).

<u>Vaialae Stream</u>

A low-flow, partial record station (No. 16929000) was installed on Vaialae Stream between 1959 and 1976. This station, which was situated about 0.1 mile upstream from the stream mouth, provided 19 measurements of stream flow. This data enabled the U.S. Geological Survey to calculate a median flow of 0.41 cfs (Wong, 1996). Chief Faiai of Utumea reported in April, 1996 that Vaialae Stream generally flows throughout the year (Faiai, 1996).

Afutele Stream

Between 1959 and 1976, a low-flow, partial record station (No. 16928000) was located on Afutele Stream approximately 0.1 mi. upstream from the stream mouth. Nineteen recorded measurements of stream flow were used by the U.S. Geological Survey to estimate a median flow of 0.38 cfs (Wong, 1996).

Aquatic Fishes and Invertebrates

Field surveys of fishes and invertebrates were made by the U.S. Fish and Wildlife Service, Division of Ecological Services, in March-April, 1978 and the U.S. Army Corps of Engineers in August, 1980. Afutele Stream in Agugulu Village and Soonapule Stream in Seetaga Village were two of 37 streams in American Samoa that were inventoried by representatives of these federal agencies. Results from both field surveys were summarized in an American Samoa Stream Inventory that was published by the U.S. Army Corps of Engineers, Honolulu District, in July, 1981.

Afutele Stream was surveyed in a rocky riffle in one location that was situated about 50 feet upstream of the primary shoreline bridge (station 5a). Soonapule Stream was surveyed in one streambed location just upstream from the primary shoreline bridge (station 31a).

Two abundant species of gobie fish and two common species of mountain bass were observed along Afutele Stream. Five species of shrimp were also identified at station 5a; three of these shrimp species were abundant.

Two abundant species of gobie fish were identified along the lower reach of Soonapule Stream (station 31a). One abundant and one common species of mountain bass were also documented. One abundant species of eel was also present. Eight species of shrimp were also reported; one species was abundant.

Surface Water Quality

No surface water quality is available for the streams and nearshore waters of the Nua-Seetaga watershed. One exception is bacterial data associated with existing stream catchments (see groundwater and surface water supplies.

Wetlands

No significant wetlands are located in the Nua-Seetaga watershed.

Marine Resources

Coral Communities

A fringing reef extends throughout Nua-Seetaga. Available aerial photography suggests that the width of the fringing reef ranges between 100 and 1,700 seaward of the shoreline.

Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests that:

- Limited coral coverage was observed on the inner reef flat of Nua-Seetaga Bay. However, on the east side of the Bay, coral coverage increased to about 15 percent between 245 and 330 feet from shore.

1978-1979

On the east side of Nua-Seetaga Bay, lower-growing coral colonies cover about 5 percent of the bottom beyond 80 feet from shore. Coral coverage increased to about 15 percent from 245 to 330 feet offshore.

Seaward of Seetaga Village, only a few, smaller colonies of four different species of coral were present on the inner reef flat. Coral cover was also low along the margins of the ava at the head of Nua-Seetaga Bay. Coral abundance and diversity increased further from shore.

Marine biologists from Aecos and Aquatic Farms also observed that underwater visibility was only about 6 feet on the inner reef flat seaward of Seetaga Village and the mouth of Soonapule Stream.

1992

Field investigations were also made by Maragos, Hunter, and Meier in 1992. A survey was made seaward of Utumea. However, coral coverage data for this survey site were not included in the coastal resources inventory report.

Shoreline Protection

Basaltic lava boulders and outcrops, as well as five coral sand beaches, characterize the shoreline of the watershed. Several homes are located seaward of the primary shoreline roadway in Seetaga. Otherwise, all homes are located inland of the shoreline roadway.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Nua-Seetaga watershed that were determined to be “critical”, or “potentially critical” conditions:

Nua

The sandy beach between Mu Point and Suesave Point contains a 4 to 6-foot scarp into the backshore. The scarp reaches the primary shoreline roadway in some places even though gravel and boulders have been dumped along 400 feet of this shoreline to stabilize the scarp.

North of Suesave Point is the home of the village *faifeau* in Nua. A portion of a concrete wall seaward of his home and related church facilities has failed and caused a paved area in front of the *faifeau’s* house to collapse.

Seetaga

Much of the shoreline between the villages of Nua and Seetaga contains exposed beach rock near the high tide line. Rock outcroppings are being undermined. The primary shoreline roadway is within only a few feet of the scarps. Boulders have been placed along the shoreline to stabilize the scarp. In front of Nua Village, unprotected dirt fill was also observed to be place 15 feet onto the foreshore to apparently reclaim eroded land.

On the west side of the Soonapule Stream mouth, several homes seaward of the primary shoreline roadway are threatened. Inadequate shore protection was present on the seaward side of these homes.

Utumea

Immediately northeast of Maugatele Rock, basalt boulders have been piled on the shore in front of Utumea to stabilize an erosion scarp. The scarp is eroding behind the rocks to within 2 feet of the primary shoreline roadway.

Southwest of Maugatele Rock, an erosion scarp is also within only a few feet of the primary shoreline roadway. In some cases, the scarp has reached the edge of pavement.

Agugulu

Just east of Agugulu Village, a 10-foot high scarp is within 3 feet of the primary shoreline roadway. Basaltic boulders and rocks have been placed along the shoreline to stabilize the scarp and protect the shoreline roadway. Some road repairs have been made along portions of this segment of the primary shoreline roadway.

Immediately seaward of Agugulu Village, another scarp was located along the backshore. The scarp was within five feet of the primary shoreline roadway. The east end of this shoreline contained some basaltic boulders that were dumped to stabilize this erosion

Failolo

Seaward of the east side of Failolo, significant erosion was observed. A scarp was cut into the shoreline road shoulder. Coconut trees were toppled on the adjoining beach, approximately 15 feet seaward of the scarp. A bus stop seaward of the road was destroyed. In one area of the road, half of the road width was damaged.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

There are no groundwater wells in the watershed that are operated by the American Samoa Power Authority. However, all villages in the watershed are served by the ASPA water system that relies upon groundwater supplies from the Tafuna-Leone Plain.

Surface Water Supply and Quality

In April, 1986, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. Three village water systems were identified in the Nua-Seetaga watershed.

The village of Nua is served by surface supplies from both Atauloma Stream in Afao and another surface system in Seetaga. The Atauloma Stream catchment is located at about the 400-foot contour in the Afao watershed. This system contained no storage facility.

The Seetaga system served the west part of Nua, Seetaga, and Utumea. This system included the use of a stream catchment along Utanuatele Stream. The catchment was located at about the 180-foot elevation. Three storage tanks were situated along the lower elevation of Souga, Soonapule, and Sauaimoe Streams .

Agugulu and Failolo were served by a spring supply that was situated upslope of Agugulu and east of Afutele Stream. The spring was located at about the 380-foot contour. No storage facilities supported this system.

Historical data suggests from the 1981-1986 period indicates that the Nua Village water systems contained a median coliform bacteria level of only 10 coliforms per 100 milliliters which suggests relatively good drinking water quality. In contrast, the Seetaga and Agugulu systems contained a median bacterial level of greater than 80 coliforms per 100 milliliters during the same period.

USE OF THE WATERSHED

Resident Population

Nua

Between 1980 and 1990, the resident population of Nua Village increased from 182 to 267 residents. Such growth represented an average annual growth rate of about 4.67 percent. Development activity between 1990 and 1995 increased resident population to about 300 persons.

Population trends for Nua reflected in the 1990 Census suggest that considerable in-migration gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa doubled between the 1980-1984 period and 1990. In 1990, 52 percent of Nua's residents were persons born outside of American Samoa.

Seetaga

Between 1980 and 1990, the resident population of Seetaga Village increased from 207 to 228 residents. Such growth represented an average annual growth rate of about 1.01 percent. Development activity between 1990 and 1995 increased resident population to about 253 persons.

Population trends for Seetaga reflected in the 1990 Census suggest that considerable in-migration gradually occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa doubled between the 1980-1984 period and 1990. In 1990, 42 percent of Seetaga's residents were persons who were born outside of American Samoa.

Utumea

Between 1980 and 1990, the resident population of Utumea Village increased from 46 to 53 residents. Such growth represented an average annual growth rate of about 1.52 percent. Between 1990 and 1995, the resident population declined to about 51 persons.

Population trends for Utumea reflected in the 1990 Census statistics suggest that considerable in-migration gradually occurred in this community between 1985 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about six percent. Between 1985 and 1990, this proportion jumped to 69 percent. During 1990, however, this proportion declined sharply to 30 percent. The significant increase in-migration can be attributed to the return of American Samoans in one or more extended families who previously resided in the continental United States and have returned with younger children born in America.

Agugulu

Between 1980 and 1990, the resident population of Agugulu Village increased from 38 to 42 residents. Such growth represented an average annual growth rate of about 1.05 percent. Development activity between 1990 and 1995 increased resident population to about 71 persons.

Population trends for Agugulu reflected in the 1990 Census statistics suggest that limited in-migration has occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 31 percent. Between 1985 and 1990, this dropped to 19 percent, but increased to 38 percent in 1990. The departure of only five persons, who originally were born outside of American Samoa, could easily account for the 12 percent drop in in-migration between 1985 and 1990.

Failolo

Between 1980 and 1990, the resident population of Failolo Village increased from 76 to 81 residents. Such growth represented an average annual growth rate of about 0.66 percent. Development activity between 1990 and 1995 increased resident population to about 138 persons.

Population trends for Failolo reflected in the 1990 Census statistics suggest that significant in-migration occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 12 percent. Between 1985 and 1990, the proportion increased to 24 percent. However, in 1990, the proportion increased to 52 percent.

Land Uses

Residential

The 1990 U.S. Census documented 34 homes in Nua. Approximately 94 percent of the homes were owner-occupied; none were rental units. The remaining six percent were vacant or used as vacation homes by absentee owners. The housing stock expanded slightly during the 1990-1995 period. ASG Building Division records indicate that three residential building permits were issued for three homes in Nua and two houses in Nua-Seetaga. It was assumed that building permits were issued for three new houses in Nua and two new homes in Seetaga. Consequently, the 1995 housing stock in Nua includes approximately 37 homes.

The 1990 U.S. Census documented 30 homes in Seetaga. Approximately 93 percent of the homes were owner-occupied; none were rental units. The remaining seven percent were vacant or used as vacation homes by absentee owners. The housing stock expanded only slightly during the 1990-1995 period. ASG Building Division records indicate that three residential building permits were issued for three homes in Nua and two houses in Nua-Seetaga. It was assumed that building permits were issued for three new houses in Nua and two new homes in Seetaga. Consequently, the 1995 housing stock in Seetaga includes approximately 32 homes.

The 1990 U.S. Census documented six homes in Utumea. All of the homes were owner-occupied; none were rental units. The housing stock did not expand during the 1990-1995 period. ASG Building Division records indicate that no new residential building permits were issued during this period. A local resident indicates that only building repairs or improvements were made to existing homes (Faiai, 1994). Consequently, the 1995 housing stock in Utumea remained at six houses.

The 1990 U.S. Census documented four homes in Agugulu. All of the homes were owner-occupied; none were rental units. The housing stock expanded considerably during the 1990-1995 period. ASG Building Division records indicate that three new residential building permits were issued during this period. Consequently, the 1995 housing stock in Agugulu included seven houses.

The 1990 U.S. Census documented 12 homes in Failolo. Seventy-five percent of the homes were owner-occupied; none were rental units. . The remaining 25 percent were vacant or used as vacation homes by absentee owners. The housing stock expanded considerably during the 1990-1995 period. ASG Building Division records indicate that five new residential building permits were issued during this period. Consequently, the 1995 housing stock in Failolo included 17 houses.

Agriculture

Piggeries

In April, 1996, several piggeries were located in the watershed. However, a somewhat earlier inventory by the ASG Department of Agriculture in early 1996 is believed to be more representative of the number of piggeries and related pig population (Table 32-2). This inventory suggests that roughly 530 pigs were being raised in 24 piggeries in early, 1996.

TABLE 32-2
PIGGERIES IN THE NUA-SEETAGA WATERSHED
1996

Village	Number of Piggeries	Total Number of Pigs
Nua-Seetaga	17	318
Utumea	2	85
Agugulu	2	22
Failolo	3	105
Total	24	530

Subsistence Crop Production

In April 1996, several faatoaga were documented in the following general locations:

- Two plantations upland of Agugulu Village and east of Afutele Stream;
- One larger plantation southwest of Vaialae Stream and upslope of Utumea that contained breadfruit, banana, and coconut production;
- Coconut, banana, and breadfruit production near the confluence of Soonapule, Sauaimoe, and Souga Stream;
- Coconut production on the southeast side of Utanuatele Stream between the 150 and 400-foot contour.
- One small coconut plantation on the east side of Souga Stream between the 575 and 600-foot elevation.

Commercial

There are approximately six commercial enterprises that are based in Nua. No new businesses were established during the 1990-1995 period. Existing commercial enterprises include two bus companies, one village grocery store, one pool hall, one retail store, and one ice block/*lumpia* distributor.

There are approximately nine commercial enterprises that are based in Seetaga. No new businesses were established during the 1990-1995 period. Existing commercial enterprises include three village grocery stores, one bus company, one pool hall, two retail stores, one video store, and one landscaping and carpentry service.

There are two commercial enterprises that are based in Utumea. No new businesses were established during the 1990-1995 period. In 1995, commercial enterprises included a bus transportation company, as well as one cleaning and chemical products company. Both companies were home-based commercial enterprises.

ASG business license records indicate that there are two commercial enterprises based in Agugulu. No new businesses were established during the 1990-1995 period. The two registered businesses included a store and one laundromat. During a November, 1994 village inspection, it appeared that the laundromat and store operation had closed their operations.

ASG business license records indicate that there are no commercial enterprises based in Failolo. No building permits were issued for new commercial facilities during the 1990-1995 period. A November, 1994 survey of the village confirmed that no commercial facilities are present in the village. It is suspected that local residents make consumer purchases in Amanave and Seetaga where village stores are located. Grocery shopping and other retail shopping probably is made in Leone, Nuuuli, or Fagatogo.

Industrial

There are no light industrial operations in this watershed.

Public Facilities

The ASG Department of Education does not offer an early childhood education program in Nua. Elementary school-aged children from Nua, Seetaga, Afao, Agugulu, Amaluia, and Amanave attend Alataua-Lua Elementary School in Nua. This public school had a student enrollment of 309 students in September, 1994. High school students are bussed to Leone High School in Leone.

The ASG Department of Education does not offer an early childhood education program in Seetaga. Elementary school-aged children attend Alataua-Lua Elementary School in Nua and high school students are bussed to Leone High School.

The ASG Department of Education does not offer an early childhood education program in Utumea. Elementary school-aged children attend Leone Midkiff Elementary School and Leone High school.

The ASG Department of Education does not offer an early childhood education program in Agugulu. Elementary school-aged children attend Alataua-Lua Elementary School in Nua and Leone High School in Leone.

The ASG Department of Education does not offer an early childhood education program in Failolo. Elementary school-aged children attend Alataua-Lua Elementary School in Nua and Leone High School in Leone.

Use of the Nearshore Waters

Fishing

An American Samoa Subsistence Fishing Survey was conducted by the University of Hawaii Sea Grant Program in the summer of 1992. This survey involved onsite interviews with shoreline users who were participating in fishing activities on selected days during that period. The results of the survey revealed, in part, that there is some use of the nearshore waters seaward of Failolo, Agugulu, Utumea, Nua, and Seetaga.

The survey documented 13 to 20 persons using the reef areas seaward of Nua and Seetaga. Rods and reels and diving were the fishing methods observed in this area.

In Utumea, use of the shoreline by 7 to 11 fishermen were documented. Fishermen employed the use of gleaning, diving, fishing poles, as well as rods and reels to fish the reef area.

In Agugulu, 9 to 11 persons were documented using the reef for fishing purposes. Fishermen were observed fishing via rods and reels, gleaning, fishing poles, throw nets, and spears.

Some 11 to 15 persons were reported fishing on the reef in Failolo. Fishing methods that were observed included the use of rods and reels, throw nets, gill nets, diving, gleaning, spears and fishing poles.

General Water Recreation

Local residents of the communities of the watershed frequently use the nearshore waters for swimming and general water recreation. Use areas are primarily in the vicinity of sandy beaches, which afford convenient public access. A growing use of some shoreline areas, e.g., Agugulu, are made by other Tutuila residents who enjoy coming to a less crowded shoreline location on some weekends and holidays.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Nua

Modest residential expansion is expected to occur in Nua. Such growth will exceed the limited residential growth that occurred between 1990 and 1995. Future residential expansion will represent the infilling of undeveloped housesites and *faatoaga* areas within existing village where 11 additional housesites are possible. In addition, five additional housesites could potentially be developed on the southeast side of the former Fagamutu village near Mu Point.

Future residential construction in Nua will be constrained by the lack of developable lands within the village. Steeper slopes that are immediately upland of the existing village residential area; this condition will limit the extent of residential construction upland of Nua.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Nua.

1996-2000	Three new single family homes within the existing residential and *faatoaga* areas.
2001-2005	Three new single family homes within the existing residential and *faatoaga* areas.
2006-2010	Two new single family homes within the existing residential and *faatoaga* areas. Two new single family homes east of former Fagamutu village.
2011-2015	Three new single family homes within the existing residential and *faatoaga* areas. Three new single family homes east of former Fagamutu village.

The cumulative effect of this prospective residential growth on Nua is that the village housing stock will increase to roughly 53 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.91 persons per household. As a result, the future village population is expected to include about 366 persons.

Seetaga

Nominal residential expansion is expected to occur in Seetaga. However, growth will exceed the limited residential growth that occurred between 1990 and 1995. Future residential expansion will represent the infilling of undeveloped housesites and *faatoaga* areas within the existing village where 17 additional housesites are possible.

Future residential construction in Seetaga will likely be constrained by the lack of developable lands within the village. Steeper slopes are immediately upland of the existing village residential area; this condition will limit the extent of residential construction upland of Seetaga.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Seetaga.

1996-2000 Five new single family homes within the existing residential and *faatoaga* areas.

2001-2005 Five new single family homes within the existing residential and *faatoaga* areas.

2006-2010 Two new single family homes within the existing residential and *faatoaga* areas.

2011-2015 Five new single family homes within the existing residential and *faatoaga* areas.

The cumulative effect on Seetaga of this prospective residential growth is that the village housing stock will increase to roughly 49 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.75 persons per household. Consequently, the future village population is expected to include about 331 persons.

Utumea

Nominal residential expansion is expected to occur in Utumea. However, growth will exceed the limited residential growth that occurred between 1990 and 1995, as well as the previous decade. It is anticipated that future residential expansion will represent the infilling of four potential housesites that are presently undeveloped within the inhabited village area.

Future residential construction in Utumea will primarily be constrained by the lack of developable lands within the village. Steeper slopes are immediately upland of the existing village residential area; this condition will limit the extent of residential construction upland of Utumea.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Utumea.

1996-2000 One new single family home within the existing residential area.

2001-2005 One new single family home within the existing residential area.

2006-2010 One new single family home within the existing residential area.

2011-2015 One new single family home within the existing residential area.

The cumulative effect on Utumea of this prospective residential growth is that the village housing stock will increase to roughly 10 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 7.32 persons per household. Using these assumptions, it is anticipated that the future village population will include about 73 persons.

Agugulu

Gradual residential expansion is expected to occur in Agugulu during the next 20 years. However, growth will be less than the rate of residential growth (15 percent per year) that occurred between 1990 and 1995, but slightly greater than the previous decade (1.1 percent per year). Future residential expansion will represent the infilling of seven potential housesites that are presently undeveloped within the inhabited village area.

Future residential construction in Agugulu will primarily be constrained by the lack of developable lands within the village. Steeper slopes that are immediately upland of the existing village residential area; this condition will limit the extent of residential construction upland of the Village.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Agugulu.

1996-2000 Two new single family homes within or upland of the existing residential area.

2001-2005 Two new single family homes within or upland of the existing residential area.

2006-2010 One new single family home within or upland of the existing residential area.

2011-2015 Two new single family homes within the existing residential area.

The cumulative effect on Agugulu of this prospective residential growth is that the village housing stock will increase to roughly 14 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 8.70 persons per household. Consequently, the future village population is expected to include about 122 persons.

Failolo

Some residential expansion is expected to occur in Failolo during the next 20 years. However, growth will be considerably less than the rate of residential growth (eight percent per year) that occurred between 1990 and 1995. Future residential expansion will represent the infilling of six potential housesites that are presently undeveloped within the inhabited village area.

Future residential construction in Failolo will primarily be constrained by the lack of developable lands within the village. Steeper slopes that are immediately upland of the existing village residential area; this condition will limit the extent of residential construction upland of the Village.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction within Failolo.

1996-2000 Two new single family homes within or upland of the existing residential area.

2001-2005 Two new single family homes within or upland of the existing residential area.

2006-2010 Only improvements and extensions of existing homes will occur during this period.

2011-2015 Two new single family homes within or upland of the existing residential area.

The cumulative effect on Failolo of this prospective residential growth is that the village housing stock will increase to roughly 23 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.91 persons per household. Consequently, the future village population will include about 159 persons.

Commercial

Nua

Future commercial facility expansion in Nua is not anticipated. The lack of developable lands and the proximity of competing commercial services in Leone will strongly discourage the construction of additional commercial retail facilities. At the same time, the anticipated increase in resident population will encourage the formation of various home-based occupations that will likely include professional and technical services.

Seetaga

Future commercial facility expansion in Seetaga is not anticipated due to the lack of developable lands and the anticipated growth of competing commercial services in Leone. At the same time, the anticipated increase in resident population will encourage the establishment of various home-based occupations that will likely include professional and technical services.

Utumea

Future commercial facility expansion in Utumea is not anticipated due to the lack of developable lands, the limited consumer population, the availability of commercial facilities in the adjoining village of Seetaga, and expanding commercial facilities in nearby Leone. At the same time, the anticipated increase in resident population will encourage the establishment of various home-based occupations that will likely include professional and technical services and/or the sale and distribution of various commercial products on a wholesale and retail basis.

Agugulu

Future commercial facility expansion in Agugulu is not anticipated even though two potential commercial sites are available. It is believed, however, that the store and laundromat operations will be re-established. A growing population will increase the feasibility of these operations. Other consumer shopping will probably occur in Leone where commercial facility expansion is anticipated.

At the same time, the anticipated increase in resident population in Agugulu will encourage the establishment of various home-based occupations. These enterprises will likely include two technical service operations and/or a home-based company that sells and distributes various commercial products on a wholesale and retail basis.

Failolo

Future commercial facility expansion in Failolo is not anticipated even though one potential commercial site is available. Other consumer shopping will continue to occur outside of the village where greater commercial facilities and services are available.

At the same time, the anticipated increase in resident population in Failolo will encourage the establishment of various home-based occupations. These enterprises will likely include one technical service operations and/or a home-based company that sells and distributes various commercial products on a wholesale and retail basis.

Industrial

The gradual increase in resident population in Nua, Seetaga, Utumea, Agugulu, and Failolo will likely attract other small, home-based activities of an industrial nature, e.g., sheet metal fabrication business. However, the construction of new industrial facilities is not anticipated.

Public Facilities

Through the application of 1990 age characteristics to anticipated village populations in the year 2015, the general demand for future early childhood programs, elementary education, and high school education was quantified (Table 32-3). In some cases, these demands may generate the future development of expanded public school facilities within or outside the Nua-Seetaga watershed.

TABLE 32-3
POTENTIAL DEMAND FOR PUBLIC SCHOOL FACILITIES
YEAR 2015
NUA-SEETAGA WATERSHED
(NUMBER OF STUDENTS)

Village	Early Childhood	Elementary	Secondary
Nua	22	77	33
Seetaga	23	76	40
Utumea	6	10	6
Agugulu	6	23	17
Failolo	10	30	14

Source: Pedersen Planning Consultants, 1995

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Future population growth and changes in land use in the Nua-Seetaga watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. The consumption of potable water will also increase with a growing population (Tables 32-4 and 32-5).

TABLE 32-4
ANTICIPATED AVERAGE DAY DEMAND
DRINKING AND OTHER POTABLE WATER
NUA-SEETAGA WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Nua	25,219	38,821
Seetaga	8,977	28,387
Utumea	3,590	7,903
Agugulu	1,113	10,819
Failolo	2,531	12,726

Source: Pedersen Planning Consultants, 1995

TABLE 32-5
ANTICIPATED AVERAGE DAILY WASTEWATER GENERATION
NUA-SEETAGA WATERSHED AREA
(IN GALLONS PER DAY)

Village	1995	2015
Nua	17,653	27,175
Seetaga	6,284	19,871
Utumea	2,513	5,532
Agugulu	793	7,573
Failolo	1,772	8,908

Source: Pedersen Planning Consultants, 1995

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of the lower elevations of the Soonapule Stream and Sauaimoe Stream, as well as the nearshore waters and adjoining shoreline.

Inland Flood Potential

The flood insurance rate maps that encompass the Nua-Seetaga watershed indicate that potential flooding along the lower reaches of Soonapule and Sauaimoe Streams could be generated via a 100-year storm event. The lower reaches of these streams have been designated by FEMA as “zone A” where no potential base flood elevations were determined. The downstream storm culvert that passes underneath the primary shoreline roadway in Seetaga is also identified as adequate to accommodate 100-year storm flows.

The remaining inland areas of the Nua-Seetaga watershed have been designated by the Federal Emergency Management Agency as “zone x.” This designation refers to areas that are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Nua-Seetaga watershed indicates that there is a coastal flood hazard along the shoreline of the watershed and the adjacent nearshore waters. A potential 100-year flood is anticipated to generate flood levels between five and seven feet above mean sea level (MSL) in these areas. FEMA has also designated the entire the coastal area of the watershed as an area where there is a potential hazard associated with the velocity of nearshore wave action.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Heavier rainfall, steeper inland slopes, and more erosive soils in the upland watershed regularly contribute to the periodic transport of turbid waters into the downstream embayments of the Nua-Seetaga watershed. The primary source is natural sedimentation from more erosive soils on steeper upland slopes of the watershed. Some sedimentation is also believed to be generated somewhat from *faatoaga* areas that are situated in steeper slopes above Agugulu and Seetaga. The perennial flows of the five primary streams in the watershed frequently carry turbid water and sediments to the nearshore waters that adjoin the watershed.

Impermeable building roofs and paved surfaces also generate sheet flow within the inhabited village area. Frequent runoff from these sources regularly discharges sediments, solid waste materials, and other domestic garbage into the streams of the watershed.

Increased detention of stormwater flows is necessary to reduce the volume of turbid water and sediment discharges into the embayments of the watershed. Unfortunately, the limited amount of undeveloped land area in the watershed communities preclude any significant opportunities.

The use of drywells in paved parking areas that are associated with any future commercial facilities and residences would help provide some detention and infiltration of stormwater flows. This application should be required in conjunction with the construction of paved vehicular parking area for any new structures in Nua, Seetaga, Utumea, Agugulu, and Failolo.

Nearshore Water Quality and the Marine Environment

Turbidity and Sedimentation

The concern for continued turbidity and sedimentation in the nearshore waters the Nua-Seetaga watershed is important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the Nua-Seetaga watershed. They provide shelter to fish, invertebrates, and other marine organisms. Some of these resources represent a supplemental food source for residents of the watershed and other areas in West Tutuila.

Nutrient Inputs

A nutrient contribution is also occurring through the continued use of septic tanks, cesspools, or other soil-based, wastewater treatment systems in the watershed. Some bacterial contamination from these discharges may also be occurring in the nearshore waters. While the total volume of wastewater generation from the watershed is limited, the discharges are concentrated in the two village residential areas where housing densities are higher. Local soils are generally inadequate to provide effective treatment. Consequently, the exposure of bacteria to saline, marine waters probably provides the best treatment for wastewater effluent that reaches the nearshore waters.

Some piggery wastes are also located along streams of the watershed. Nutrient-enriched waters are typically discharged into the nearshore waters. One significant exception is a larger piggery in Utumea along Vaialae Stream. Chief Faiai reported in April, 1996 that wastewater from his piggery drained to a nearby septic tank, which is periodically pumped out by the American Samoa Power Authority. The collection and pumpage of these wastes is commendable since local soils are inadequate to treat wastewater.

The long-term input of turbid and nutrient-enriched waters into the nearshore waters represents an important concern. These inputs are potentially detrimental to the quality because they can adversely change the composition of the nearshore marine environment. However, the degree of impact upon water quality is also highly dependent upon currents and water exchange within the nearshore environment.

As the population of the watershed and West Tutuila grows, sediment, nutrient, and bacterial inputs will only increase. Aside from these resource management considerations, the future use of the nearshore waters for fishing, swimming and general recreation will also represent a more significant public health concern.

It is most desirable for villages in the Nua-Seetaga watershed to be incorporated into the ASPA wastewater collection system. However, the limited population of the west end of Tutuila will likely continue to make this system expansion unfeasible. In the absence of this reality, village areas that are unsuitable for soil-based, wastewater treatment should be more specifically identified. As recommended in the ASPA Utilities Master Plan, this identification process should be based upon a more detailed sanitation survey of more densely inhabited areas such as Nua and Seetaga. This survey would evaluate existing wastewater treatment practices, soil characteristics, the location and density of land uses, the distance to surface water supplies and the nearshore waters, topography, and other related factors. Using the conclusions and recommendations associated with this evaluation, ASPA and other participating Project Notification and Review System (PNRS) agencies will be better able to:

- require the use of septic tanks and leachfields that provide a sufficient amount of additional soil-based treatment;
- provide greater technical assistance to building permit applicants; and, if necessary,
- deny building applications in land areas that are unsuitable for soil-based treatment systems.

Long-Term Monitoring

The future monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of Nua-Seetaga Bay. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters of these embayments. However, future levels bacterial contamination and nutrient inputs should also be documented to help ensure future public safety and evaluate potential stresses to the fringing coral reef communities.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef flats and reef fronts seaward of Nua, Seetaga, and Utumea at least once every three years. Long-term monitoring of this site should also include an evaluation of the impact of sedimentation and turbidity that already influences the nearshore marine environment.

Groundwater and Surface Water Supplies

As stated earlier, Nua, Seetaga, Utumea, Agugulu, and Failolo are already connected to the ASPA water system. While the use of surface water supplies is not recommended for potable use, it is desirable for existing surface catchments and storage tanks to be maintained by villages for non-potable uses and emergency consumption. In the event of a hurricane or other unanticipated event that disables ASPA water delivery for an extended period of time, it is desirable to have an emergency water supply that could be chemically disinfected for potable use, as well as used for non-potable purposes. Traditional leaders should be encouraged to continue or undertake this responsibility if adequate resources are available from the communities.

To facilitate the long-term conservation of these resources, it is also recommended that a 100-foot buffer or setback should be established around each surface supply, i.e., stream or spring catchment, in the watershed. In essence, the establishment of piggeries, new structural development, or other land uses would not be permitted within the 100-foot radius to prevent potential contamination of the surface supplies.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Nua-Seetaga watershed will be to:

- detain urban runoff through the use of drywells in conjunction with the development of new building structures in Nua and Seetaga;
- conserve stream catchments;
- maintain culverts underneath the primary shoreline roadway;
- perform detailed sanitation survey of Nua and Seetaga; and,
- conserve coral communities.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting potential hazards or undesirable conditions, share potential solutions with designated residents of Nua, Seetaga, Utumea, Agugulu, and Failolo, and encourage the participation of traditional leaders and village residents in the implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 32-6. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 32-6
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
NUA-SEETAGA WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASEPA	Monitor water quality of Stream 32A, Soonapule, Vaialae, Afutele, and Leaute Streams, as well as the nearshore waters.	Measure changes in and total/fecal bacteria, total suspended solids, turbidity, and nutrients on a quarterly basis.
ASPA/ASEPA	Perform a detailed evaluation of community sanitation problems associated with the use of soil-based treatment systems.	1. Survey existing residential and commercial areas in Nua and Seetaga. 2. Evaluate existing treatment practices, soil characteristics, location and density of land uses, the distance to water supplies and nearshore waters, topography, and other factors. 3. Require use of septic tanks and leachfields that provide sufficient amounts of additional soil-based treatment; or, deny building applications in areas unsuitable for soil-based treatment.
ASEPA	Conserve surface water supplies	1. Identify village surface water supplies that are actively used. 2. Revise American Samoa GIS to delineate 100-foot buffers around each surface supply. 3. Restrict land uses within designated buffers.
ASCZM/DOC	Detain stormwater runoff in future residential and commercial areas.	Where undesirable stormwater discharges are anticipated, require the use of onsite drywells for new residential and commercial facilities in Nua and Seetaga.
DPW	Maintain culverts along the primary shoreline roadway	1. Establish a periodic storm culvert maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Clean debris and other material blocking culverts.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASCC Land Grant Program	Reduce sedimentation from agricultural activities	1. Determine locations where upslope agricultural activities may be generating some sedimentation. 2. Encourage soil conservation methods with resident growers of subsistence crops.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) approximately every three years.

Source: Pedersen Planning Consultants, 1998

AMANAVE
Watershed 33

GEOGRAPHY

The Amanave watershed is situated along the southwest tip of the Island of Tutuila. The watershed contains approximately 0.4 square miles of land area.

The inland boundaries of the watershed include Tiatele Ridge, Olotafatafa Ridge, Leileia Mountain, and Niuasele Ridge (Figure 33-1).

Along the shoreline, Cape Taputapu defines the northwest shoreline boundary. Maugasaa Hill and Siulepa Hill represent the southeast boundary. Amanave Bay is the prominent embayment that adjoins the watershed. Two smaller coves, Vava Cove and Loa Cove, are situated southeast of Cape Taputapu.

There are three primary stream drainages in the watershed. These drainages include Puna-Maululu, Laloafu-Leafu, and an unnamed stream on the northwest side of Amanave Bay.

RESOURCES OF THE WATERSHED

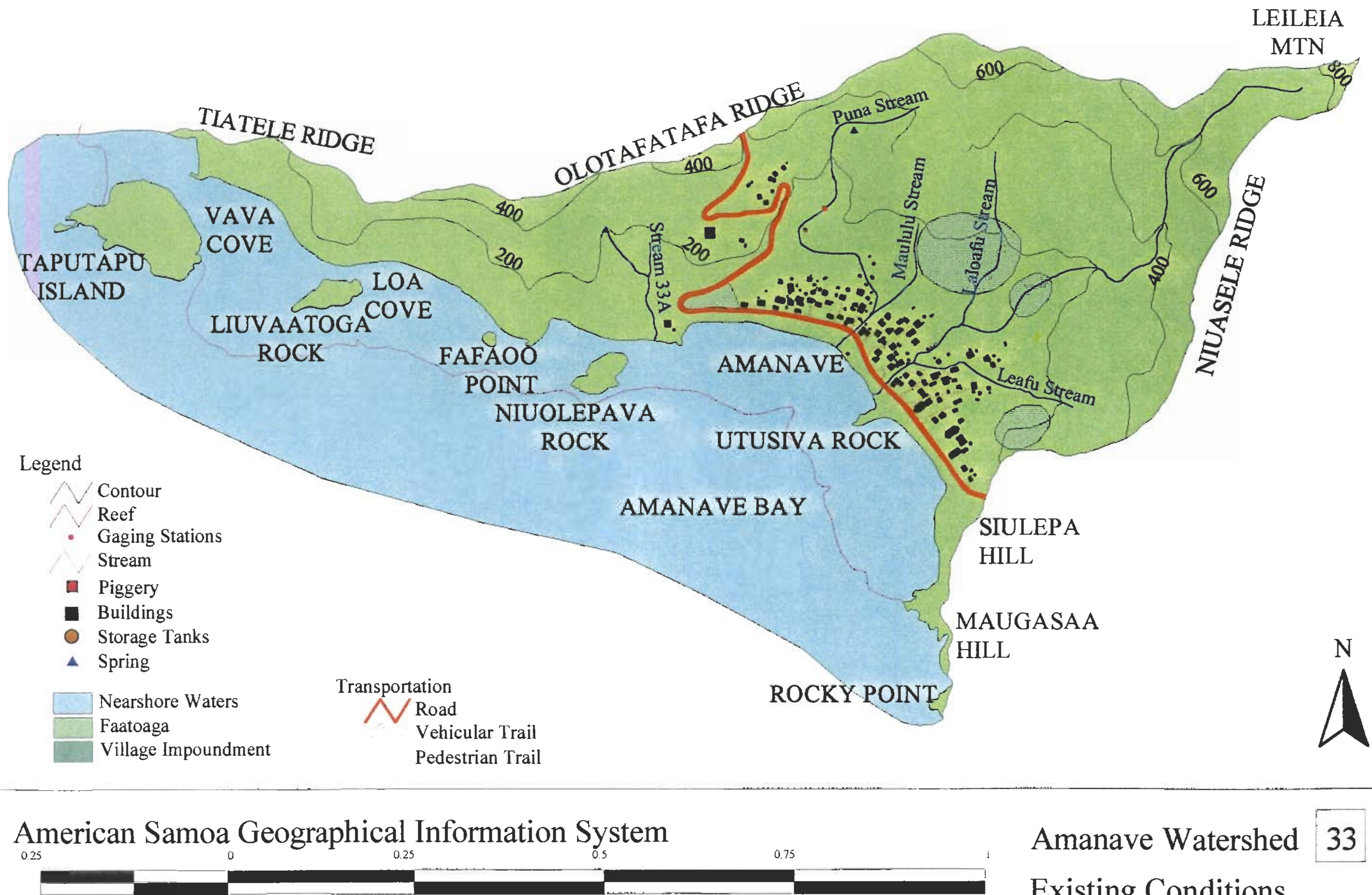
Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 33-2). Five soil classifications were identified by the U.S. Soil Conservation Service for lands within the Amanave watershed (Table 33-1).

TABLE 33-1
SELECTED SOIL CHARACTERISTICS
AMANAVE WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To:		Land Use Suitability	
						High Water (feet)	Bed Rock (inches)	Soil Based WW Treatment	Subsistence Ag. Potential
1	Aua very stony silty clay loam	15-30	None	Med	Med	>6	<60	Severe Slope	Moderate
2	Aua very stony silty clay loam	30-60	None	Rapid	Severe	>6	>60	Severe Slope	Poor
3	Fagasa-Ofu silty clays	30-60	None	Med to Rapid	Mod to Severe	>6	20-40	Severe Slope Depth	Moderate
4	Fagasa family-Lithic Hapludolls-Rock outcrop assoc.	70-130	None	Very Rapid	Very Severe	>6	20-60	Severe Slope Depth	Limited
35	Urban land-Ngedebus complex	0-5	Occ. brief	Slow	Slight	>3.5	>60	SevereFlood Wet Poor Filter	Poor

Source: U.S. Soil Conservation Service, 1984



American Samoa Geographical Information System

Scale: 1:12,000

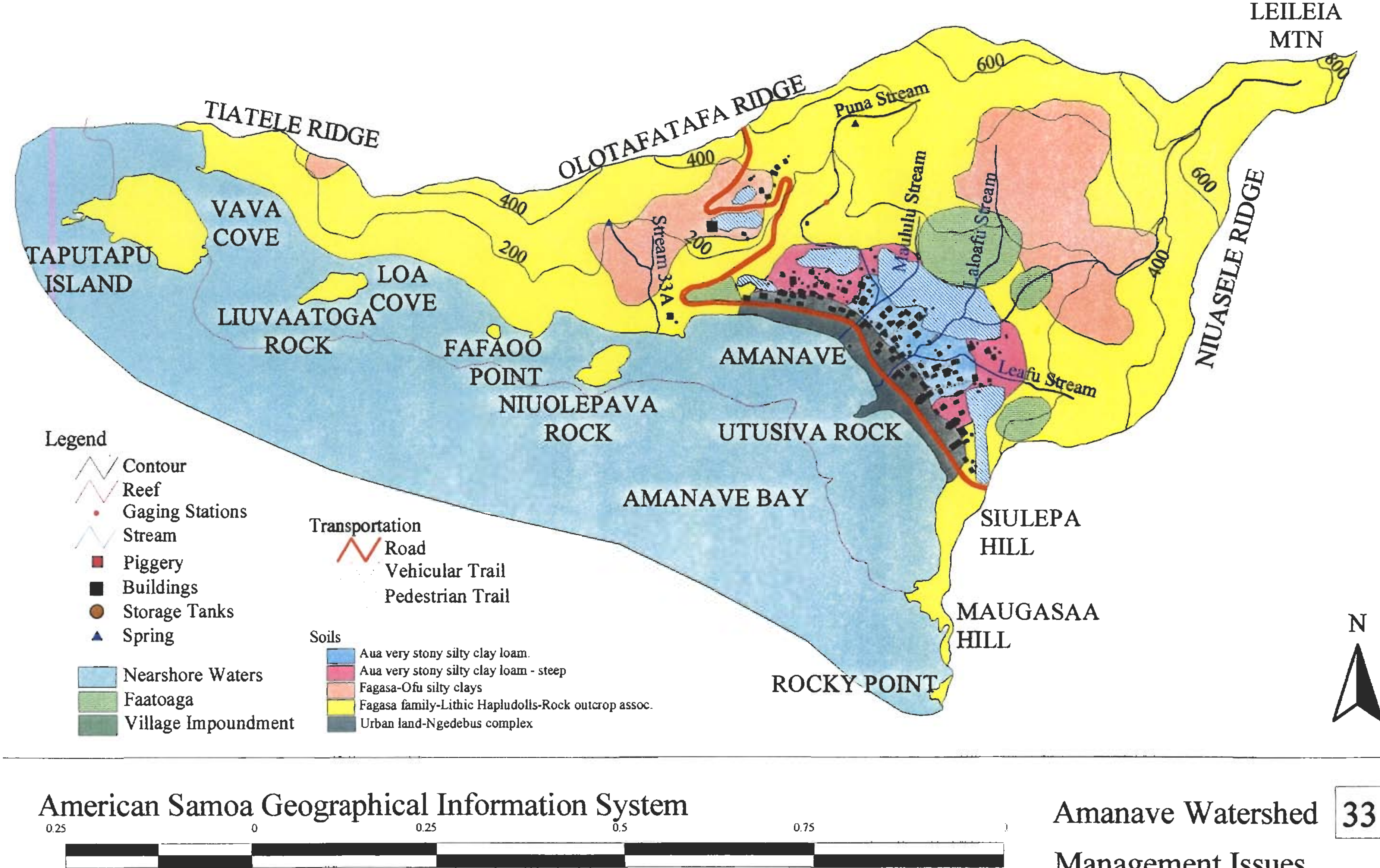
Prepared by: Pedersen Planning Consultants

Tel: 307-327-5434

Amanave Watershed 33

Existing Conditions

Figure 33-1



American Samoa Geographical Information System

Scale: 1:12,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Amanave Watershed 33

Management Issues

Figure 33-2

Urban Land-Ngedebus Complex

Urban land-Ngedebus complex soils (SCS mapping unit #35) characterizes most of the lands in the front of Amanave Village. This soil extends approximately 100 to 150 inland of the primary shoreline roadway.

These soils generally comprise coral fragments, sand, cinders and other material that have been graded or filled to support residential, commercial and public facilities in the village area.

The Ngedebus soil extends to a depth of 60 inches or more. The surface layer, which extends about 4 inches below ground elevation, typically contains light, brownish-gray and brown sand. The underlying material is characterized by pale brown and light yellow, brown sand.

The permeability of Ngedebus soil ranges between six and 20 inches per hour. Surface drainage on this soil is generally slow, and the hazard of potential soil erosion is slight. In some places the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide (U.S. Soil Conservation Service, 1984).

These soils are generally suitable to support residential and commercial development in areas that are protected from flooding. However, this soil is poorly suited in unprotected areas (U.S. Soil Conservation Service, 1984).

Where moderate to higher housing densities occur, the U. S. Natural Resources Conservation Service recommends the use of community sewage systems prevent the potential contamination of groundwater and surface water supplies. In Amanave, housing densities average between four and five units per acre.

Aua Very Stony Silty Clay Loam (15 to 30 percent slopes)

A portion of the inhabited village area (Figure 33-2) is characterized by Aua very stony silty clay loam (SCS mapping unit 1).

These soils typically occur up to about 60 inches in depth. The permeability of these soils ranges between 2 and 6 inches per hour. The potential for runoff or erosion from the Aua soils is believed to be moderate (U.S. Soil Conservation Service, 1984).

While moderately suited for agricultural production, the Soil Conservation advises that the stony and erosive characteristics of these soils may limit production. However, the U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that typically hamper installation and adequate soil-based treatment. Poorly treated wastewater effluent from the septic tanks or cesspools may generate subsurface discharges of bacteria and nutrients to the nearshore waters.

Aua Very Stony Silty Clay Loam (30 to 60 percent slopes)

Soils on steeper slopes in the upland areas of the inhabited village area are identified by the U.S. Soil Conservation Service as Aua very stony Silty Clay Loam on 30 to 60 percent slopes (SCS mapping unit 2).

The Aua soils range between seven to 60 inches in depth. The permeability of these soils (between 2 and 6 inches per hour) is moderately rapid. For watershed management purposes, it is important to note that these Aua soils have a high potential for runoff and erosion.

This Aua soil is not recommended for agricultural production because of the stoniness of the soil, the high erosion potential, and hazards associated with subsistence crop cultivation on steeper slopes. However, when cultivation in these soils is necessary, the use of a mulch or ground cover is recommended to reduce soil erosion in cultivated areas.

The U.S. Soil Conservation Service estimates that this soil can annually sustain up to 5 tons per acre of erosion without impacting crop productivity (U.S. Soil Conservation Service, 1984). While the erosive characteristics of this soil generally may not significantly impact subsistence crop productivity, the erosive quality of the soil can be a significant contributor to sedimentation in downslope streams and the nearshore waters.

The general characteristics of these Aua soils are also undesirable for individual wastewater disposal systems (U.S. Soil Conservation Service, 1984). These soils contain a significant amount of larger stones that hamper installation and adequate soil-based treatment.

Fagasa-Ofu Silty Clays

Two areas of Fagasa-Ofu silty clays are found in the Amanave watershed (SCS mapping unit 3). One area is located on the southeast slopes of Olotafatafa Ridge between Stream 33A and the upland housing area. A second area is the upper slopes of the Laloafu-Leafu Stream drainage.

The soil ranges between 20 to 40-inches in depth. The permeability of this silty clay loam is moderately rapid (2 to 6 inches per hour). The potential for surface runoff from these soils is considered moderate to rapid. However, the potential for erosion is moderate to severe.

The U.S. Soil Conservation Service indicates that this soil type is somewhat suitable for the production of subsistence crops. The soil can annually sustain from one to 5 tons per acre of erosion without impacting crop productivity. However, the Soil Conservation Service recommends the use of mulch, crop residues, and cross-slope farming to reduce the potential for soil erosion.

Fagasa-Ofu Silty Clay soils are also poorly suited when applied to septic tank and related effluent drainfield installations. Steeper slopes and limited depth to bedrock constrain potential opportunities for soil-based wastewater treatment.

Fagasa Family-Lithic Hapludolls-Rock Outcrop Association

Adjoining land areas throughout most of the remaining watershed contain deep, well-drained soils on steep mountain ridges and slopes. The U.S. Soil Conservation Service identifies these soils as part of the Fagasa family-Lithic Hapludolls-Rock outcrop association (SCS mapping unit 4).

Since this soil type is a combination of two general soil classifications, soil depths can vary between 20 and 60 inches. The soil represents a combination of silty clay and loam. The Fagasa Family-Lithic Hapludolls soil typically occurs on very steep slopes; consequently, the potential for surface runoff and erosion are high.

The cultivation of subsistence crops on these soils is not considered desirable. However, when cultivation in these soils is necessary, care should be exercised to minimize the amount of exposed soil in cultivated areas.

When heavier rainfall events occur in this watershed, a significant contribution of soil erosion can be expected from undeveloped upslope areas of the watershed that contain this soil type. Natural runoff from steeper slopes in the watershed carries water, sediments, and organic debris to downslope drainage courses and Vaitele Stream. Such erosion can readily influence downstream water quality.

Streams

Stream Locations

The Laloafu-Leafu Stream drainage consists of the main stem of Laloafu Stream, a long unnamed tributary that begins at the 760-foot contour along the southwest slopes of Leileia Mountain, and Leafu Stream. The main stem of Laloafu Stream begins near the 325-foot elevation. After its confluence with its tributaries at the rear and central part of Amanave Village, Laloafu Stream discharges along the shoreline of Amanave Bay.

Puna Stream, originates at about 420 feet above mean sea level on the southeast slopes of Olotafatafa Ridge. This stream course meanders along steeper slopes of the west part of the watershed before joining with its tributary, Maululu Stream, near the center of the inhabited village area. Puna Stream ultimately discharges near the center of the Amanave Bay shoreline.

An unnamed stream, Stream 33A, and one tributary begin upslope from the west side of the inhabited village area near the 200-foot contour. Malama Spring may be the source of surface water for a portion of this drainage that ultimately discharges near Malama Point.

Stream Flows Within the Watershed

A low-flow, partial record station (No. 16927000) was established on Puna Stream, approximately 0.2 mile upstream from the Maululu Stream confluence between 1959 and 1975. Fifteen measurements of stream flow enabled the U.S. Geological Survey to estimate a median flow of 0.16 cubic feet per second (Wong, 1996).

During an April, 1996 survey of the watershed, one Amanave resident reported that none of the streams in the watershed are perennial (Taifane, 1996).

Surface Water Quality

Streams

No surface water quality is available for streams in the Amanave watershed.

Nearshore Waters

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila on July 25 and August 2, 1992 (Table 33-2). The samples were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the outer waters of Amanave Bay met American Samoa water quality standards in late July and early August of 1992. Laboratory results also suggest that stormwater runoff from undeveloped lands upland of Amanave Bay may not generate any significant discharge of nutrients.

TABLE 33-2
SURFACE WATER QUALITY
OUTER AMANAVE BAY
JULY-AUGUST, 1992

Sample Depth	Nitrate/ Nitrite mg N/l	Total N mg N/1	Kjeldahl N mg N/l	Total P mg P/l	CHL a mg/m^3
3 feet	0.005	0.114	0.109	0.012	0.20
60 feet	0.004	0.147	0.143	0.008	0.14

Source: ASEPA, 1992

Wetlands

No wetlands are believed to be located in the Amanave watershed.

Marine Resources

Coral Communities

The fringing reef seaward of Amanave Village is between 300 to 800 feet wide. Various private consultants have made various field investigations of the fringing reef in these areas since the late 1970's. In a cumulative sense, the available survey information suggests:

- coral coverage was less than five percent along the reef flat in the late 1970's; the inner reef flat was almost devoid of coral.
- Coral coverage along the reef front may have declined between 1992 and 1995.

1978-1979

The inner reef flat that fronts Amanave Village was almost devoid of live coral. On the middle reef flat, coral coverage was about two percent. Coral coverage increased to about five percent on the outer reef near the margin (Aecos and Aquatic Farms, 1980).

1992

Field investigations were also made in Amanave Bay by Maragos, Hunter, and Meier in 1992. Along the reef front, live coral was about five percent at about six meters. However, coral coverage increased considerably in deeper waters (18 meters) where coverage ranged between 40 and 50 percent.

1995

A 1996 study of various coral reefs throughout the Samoan Archipelago included the performance of five transects along the reef front between Utusiva Rock and Maugasaa Hill. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Coral coverage was documented to be less than 20 percent. Most coral colonies were small; however, medium-sized colonies were relatively abundant (Green, 1996).

Field observations indicate that fish species richness ranged between 100 and 149 species. Fish density was considered moderate, or between 5,000 and 9,999 individuals per ha. Fish biomass was observed to be less than 500 kilograms per ha.

Shoreline Protection

Almost half of the shoreline of the Amanave watershed includes basaltic cliffs and boulders. Roughly 2,100 feet of beach fronts the inhabited village area. Small pocket beaches are located in Loa Cove and Vava Cove.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Amanave watershed that were determined to be “critical”, or “potentially critical” conditions.

East Amanave

Between Utusiva Rock and Siulepa Hill, a grassed roadway shoulder with coconut trees separated the primary shoreline roadway from the beach. A scarp was cut along the entire length of the grassy shoulder; coconut trees were leaning and had fallen on the foreshore. The scarp was within two feet of the road along the southern part of the shoreline reach. Village residents placed dirt from a recent landslide on the shore to stabilize the scarp.

West Amanave

On the west side of the sandy beach fronting Amanave Village, basalt boulders have been dumped on the shoreline to stabilize a scarp and provide protection to the primary shoreline roadway. The rocks were unstable and slumping onto the beach. High tide reached the base of the rocks. An active scarp was eroding behind the rocks and is within 3 feet of the road. Some portions of the shoreline road had been damaged.

Groundwater and Surface Water Supplies

There are no groundwater wells in the watershed that are operated by the American Samoa Power Authority. However, Amanave Village is served by the ASPA water system that relies upon groundwater supplies from the Tafuna-Leone Plain.

Surface Water Supply and Quality

In April, 1986, M&E Pacific made a survey of existing village water systems on the Island of Tutuila. One village water system was identified in the Amanave watershed.

The village of Amanave was served by surface supplies from:

- a stream catchment along Puna Stream at about the 140-foot contour;
- a fresh-water Spring southwest of Puna Stream at the 350-foot elevation;

- a non-potable stream catchment along Laloafu Stream at approximately 50-feet above mean sea level; and,
- the village water system in Agugulu (Nua-Seetaga Watershed 32).

One 6,000-gallon, concrete tank provided storage for potable water supplies. It is uncertain whether any of these supplies are maintained and/or used by Amanave Village for potable and non-potable uses.

Historical data suggests from the 1981-1986 period indicates that the Amanave Village water systems contained a median coliform bacteria level of greater than 80 coliforms per 100 milliliters. Available data from FY 1994 indicated that the village system was being chlorinated and contained no bacterial contamination.

Proposed Water System Improvements

The ASPA water system contained no water storage reservoirs west of Leone in 1998. However, ASPA plans to build a 0.5 million gallon storage tank in Amanave Village. "*This tank will provide better service during peak demand periods since water supply to any point can come from two directions"* (ASPA, 1995).

USE OF THE WATERSHED

Resident Population

Between 1980 and 1990, the resident population of Amanave Village increased from 269 to 378 residents. Such growth represented an average annual growth rate of about 4.05 percent. Development activity between 1990 and 1995 increased resident population to about 536 persons.

Population trends reflected in the 1990 Census statistics suggest that significant in-migration occurred in this community between 1980 and 1990. The proportion of residents who were born outside of American Samoa during the 1980-1984 period was about 17 percent. Between 1985 and 1990, the proportion increased to 29 percent. However, in 1990, the proportion increased to 43 percent.

Land Uses

Residential

The 1990 U.S. Census documented 53 homes in Amanave. Seventy-seven percent of the homes were owner-occupied; 17 percent were rental units. The remaining six percent were vacant or used as vacation homes by absentee owners.

The housing stock expanded considerably during the 1990-1995 period. ASG Building Division records indicate that 20 new residential building permits were issued during this period. Consequently, the 1995 housing stock in Amanave included 73 houses.

Agriculture

Piggeries

In April, 1996, one resident reported that there were eight piggeries in the watershed. However, a somewhat earlier inventory by the ASG Department of Agriculture in early 1996 is believed to be more representative of the number of piggeries and related pig population. This inventory documented 10 piggeries that housed a total of 201 pigs in early, 1996.

Subsistence Crop Production

Four areas of agriculture production were located in the watershed in April, 1996. These areas generally included:

- banana production on the west side of Amanave Village (upslope of the primary shoreline roadway) near Malama Point;
- coconut production northeast of the village along the unnamed tributary to Laloafu Stream;
- coconut production on the east side of Maululu Stream; and,
- coconut production east of Amanave Village on the south side of Leafu Stream.

Commercial

ASG business license records indicate that there are 11 commercial enterprises based in Amanave. One building permit was issued for a new commercial facilities during the 1990-1995 period. Consequently, the village had 12 commercial enterprises in 1995. Commercial enterprises in 1995 included five grocery stores, four bus companies, one gas service station, and one retail store.

Industrial

No light industrial operations were based in Amanave in 1995.

Public Facilities

The ASG Department of Education offers an early childhood education program. This program provided educational opportunities for 20 younger children in September, 1994.

Elementary school-aged children attend Alataua-Lua Elementary School in Nua. High school students attend Leone High School in Leone.

Use of the Nearshore Waters

Fishing

An American Samoa Subsistence Fishing Survey was conducted by the University of Hawaii Sea Grant Program in the summer of 1992. This survey involved onsite interviews with shoreline users who were participating in fishing activities on selected days during that period. The results of the survey revealed, in part, that there is some use of the nearshore waters that adjoin the Amanave watershed.

Some 12 to 20 persons were documented fishing on the reef in Amanave. Documented fishing methods included the use of rods and reels, throw nets, gill nets, diving, gleaning, and fishing poles.

In April, 1996, three fishermen were observed fishing on the reef.

General Water Recreation

Six children were participating in general water recreation on the inner reef flat in April, 1996. One resident commented that about six persons per day use the nearshore water on weekdays. On weekends, the nearshore waters are typically used by about 10 persons per day (Taifane, 1996).

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Some residential expansion is expected to occur in Amanave during the next 20 years. However, growth will be considerably less than the annual rate of residential growth (almost eight percent per year) that occurred between 1990 and 1995. Future residential expansion is expected to include three areas: 1) the infilling of seven potential housesites that are presently undeveloped within the inhabited village area; 2) the construction of 25 homes immediately upslope of the village between the 25 and 50-foot elevation; and 3) the development of four additional homesites between the 225-325 elevation on the south side of Olotafatafa Ridge.

Future residential construction in Amanave will primarily be constrained by the lack of developable lands within the village. Steeper slopes that are immediately upslope of the primary residential area and upland *faatoaga* will limit the extent of residential construction upslope of the Village. However, the attractiveness of this community will continue to attract greater in-migration from the continental United States, Hawaii, and Western Samoa until the supply of developable land is depleted.

During the next 20 years, Pedersen Planning Consultants believes that these potential development opportunities and constraints will generate the following sequence and volume of residential construction.

1996-2000 Two new single family homes on the south side of Olotafatafa Ridge between 225 and 325 feet above mean sea level.

Three new homes will be built within the primary village area between the shoreline and the 25-foot elevation.

Seven new single family homes will be constructed upslope of the primary village area between the 25 and 50-foot elevation.

2001-2005 Two new single family homes on the south side of Olotafatafa Ridge between 225 and 325 feet above mean sea level.

Two new homes will be built within the primary village area between the shoreline and the 25-foot elevation.

Seven new single family homes will be constructed upslope of the primary village area between the 25 and 50-foot elevation.

2006-2010 Two new homes will be built within the primary village area between the shoreline and the 25-foot elevation.

Four new single family homes will be constructed upslope of the primary village area between the 25 and 50-foot elevation.

2011-2015 Seven new single family homes will be constructed upslope of the primary village area between the 25 and 50-foot elevation.

The cumulative effect of this prospective residential growth is that the village housing stock will probably increase to roughly 109 housing units in the year 2015. During the same period, it is believed that the average household size will have gradually decreased to approximately 6.27 persons per household. Consequently, the future village population is anticipated to include about 683 persons.

Commercial

Future commercial facility expansion in Amanave is anticipated even though only one feasible commercial site is available within the primary village area. It is expected that another retail store will be built in the primary village area by the year 2000.

Industrial

The gradual increase in resident population is expected to attract one small, home-based enterprise of an industrial nature. However, the construction of new industrial facilities is not anticipated.

Public Facilities

Population characteristics for Amanave in 1990 suggest that approximately eight percent of the village population is three and four years of age. Elementary school-aged children (5 and 13 years old) include about 20 percent of the village population; high school students represented about ten percent of the population.

The application of 1990 population characteristics to the anticipated 2015 village population suggest increased student enrollments in future early childhood, elementary education, and high school programs within and outside of Amanave. Anticipated student enrollments from the village population are expected to be as follows in the year 2015:

- early childhood education 55 students
- elementary school 137 students
- high school 68 students

Impact of Future Population Growth Upon Water Consumption and Waste Generation

Residential and population growth in the Amanave watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. Wastewater generation, for example, is expected to rise from about 11,075 gallons per day (gpd) to 39,499 gpd (American Samoa Power Authority, 1996).

The consumption of potable water will also increase with a growing population. The American Samoa Power Authority (ASPA) estimates that the average day demand for water in Amanave was about 15,821 gallons in 1995. By the year 2015, ASPA anticipates that the average demand will increase to roughly 56,427 gpd.

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. In the Amanave watershed, a detailed analysis of Puna and Maululu Streams.

The flood insurance rate maps that encompass the Amanave watershed indicate that potential flooding along the lower reaches of Puna and Maululu Streams could be generated via a 100-year storm event. The lower reaches of these streams have been designated by FEMA as “zone A” where no potential base flood elevations were determined.

The remaining inland areas of the Amanave watershed have been designated by the Federal Emergency Management Agency as "zone x." This designation refers to areas that are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Amanave watershed indicates that there is a coastal flood hazard along the shoreline of the watershed and the adjacent nearshore waters. A potential 100-year flood is anticipated to generate flood levels between four and five feet above mean sea level (MSL) in these areas. FEMA has also designated the entire the coastal area of the watershed as an area where there is a potential hazard associated with the velocity of nearshore wave action.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Heavier rainfall, steeper inland slopes, and more erosive soils in the upland watershed regularly contribute to the periodic transport of turbid waters into the downstream embayments of the Nua-Seetaga watershed. The primary source is natural sedimentation from more erosive soils on steeper upland slopes of the watershed. Some sedimentation is also believed to be generated somewhat from *faatoaga* areas that are situated in steeper slopes above Amanave Village. The intermittent flows of the three primary drainages in the watershed frequently carry turbid water and sediments to the nearshore waters that adjoin the watershed.

Impermeable building roofs and paved surfaces also generate sheet flow within the inhabited village area. Frequent runoff from these sources regularly discharges sediments, solid waste materials, and other domestic garbage into the streams of the watershed.

Increased detention of stormwater flows is necessary to reduce the volume of turbid water and sediment discharges into the embayments of the watershed. Unfortunately, there is a limited amount of undeveloped land area in the watershed that is suitable for the construction of stormwater detention facilities.

The use of drywells in paved parking areas that are associated with any future commercial facilities and residences would help provide some detention and infiltration of stormwater flows. This application should be required in conjunction with the construction of paved vehicular parking area for any new structures in Amanave.

Nearshore Water Quality and the Marine Environment

Turbidity and Sedimentation

The concern for continued turbidity and sedimentation in the nearshore waters the Amanave watershed is important. Coral communities are significantly dependent upon the availability of light and related photosynthesis, and occasional periods of significant turbidity and sedimentation do not promote long-term coral nutrition, growth, reproduction, and depth distribution (Richmond, 1993).

When corals fertilize, they are free-swimming. Consequently, they need a good location to settle and make a good attachment. With significant soil deposition, sediments can physically interfere with the recruitment of coral larvae (Richmond, 1993; Dashbach, 1996).

Coral communities are an important component of the overall ecology of the nearshore waters that adjoin the Amanave watershed. They provide shelter to fish, invertebrates, and other marine organisms. Some of these resources represent a supplemental food source for residents of the watershed and other areas in West Tutuila.

Nutrient Inputs

A nutrient contribution is also occurring through the continued use of septic tanks, cesspools, or other soil-based, wastewater treatment systems in the watershed. In addition, most of the piggeries are also generating nutrient-enriched discharges into local stream. These sources of nutrients are also accompanied by some bacterial contamination from these discharges.

While the total volume of wastewater generation from the watershed is limited, the discharges are concentrated in the inhabited village area where housing densities are between four and five housing units per acre. Local soils are generally inadequate to provide effective treatment.

The long-term input of turbid and nutrient-enriched waters into the nearshore waters represents an important concern. These inputs are potentially detrimental to the quality because they can adversely change the composition of the nearshore marine environment. However, the degree of impact upon water quality is also highly dependent upon currents and water exchange within the nearshore environment.

As the population of the watershed grows, nutrient and bacterial inputs will only increase. Aside from these resource management considerations, the future use of the nearshore waters for fishing, swimming and general recreation will eventually represent a more significant public health concern unless practical steps are made to reduce potential nearshore water contamination.

It is preferable for Amanave to be incorporated into the ASPA wastewater collection system. However, the limited population of the west end of Tutuila will likely continue to make this system expansion unfeasible. In the absence of this reality, village areas in Amanave that are unsuitable for soil-based, wastewater treatment should be more specifically identified. As recommended in the ASPA Utilities Master Plan, this identification process should be based upon a more detailed sanitation survey of more densely inhabited areas such as Amanave. This survey would evaluate existing wastewater treatment practices, soil characteristics, the location and density of land uses, the distance to surface water supplies and the nearshore waters, topography, and other related factors. Using the conclusions and recommendations associated with this evaluation, ASPA and other participating Project Notification and Review System (PNRS) agencies will be better able to:

- require the use of septic tanks and leachfields that provide a sufficient amount of additional soil-based treatment;
- provide greater technical assistance to building permit applicants; and, if necessary,
- deny building applications in land areas that are unsuitable for soil-based treatment systems.

Long-Term Monitoring

The future monitoring of the nearshore waters is necessary and should be combined with water quality monitoring of Amanave Bay. Turbidity and sedimentation are the primary stresses to the coral communities in the nearshore waters of these embayments. However, future levels bacterial contamination and nutrient inputs should also be documented to help ensure future public safety and evaluate potential stresses to the fringing coral reef communities.

In addition, the ASG Department of Marine and Wildlife Resources should monitor the coral communities along the fringing reef flats and reef fronts seaward of Amanave Bay at least once every three years. Long-term monitoring of this site should also include an evaluation of the impact of sedimentation and turbidity that already influences the nearshore marine environment.

Groundwater and Surface Water Supplies

As stated earlier, Amanave Village is already connected to the ASPA water system. While the use of surface water supplies is not recommended for potable use, it is desirable for existing surface catchments and storage tanks to be maintained by villages for non-potable uses and emergency consumption. In the event of a hurricane or other unanticipated event that disables ASPA water delivery for an extended period of time, it is desirable to have an emergency water supply that could be chemically disinfected for potable use, as well as used for non-potable purposes. Traditional leaders should be encouraged to continue or undertake this responsibility if adequate resources are available from the communities.

To facilitate the long-term conservation of these resources, it is also recommended that a 100-foot buffer or setback should be established around each surface supply, i.e., stream or spring catchment, in the watershed. In essence, the establishment of piggeries, new structural development, or other land uses would not be permitted within the 100-foot radius to prevent potential contamination of the surface supplies.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Amanave watershed will be to:

- detain urban runoff through the use of drywells in conjunction with the development of new building structures;
- conserve stream catchments;
- maintain culverts underneath the primary shoreline roadway;
- perform detailed sanitation survey of inhabited village areas; and,
- conserve coral communities.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with designated residents of Amanave, and encourage the participation of traditional leaders and village residents in the implementation of resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 33-3. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 33-3
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
AMANAVE WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASEPA	Monitor water quality of Stream 33A, Puna, and Laloafu Streams, as well as the nearshore waters.	Measure changes in and total/fecal bacteria, total suspended solids, turbidity, and nutrients on a quarterly basis.
ASPA/ASEPA	Perform a detailed evaluation of community sanitation problems associated with the use of soil-based treatment systems.	1. Survey inhabited village areas in Amanave. 2. Evaluate existing treatment practices, soil characteristics, location and density of land uses, the distance to water supplies and nearshore waters, topography, and other factors. 3. Require use of septic tanks and leachfields that provide sufficient amounts of additional soil-based treatment; or, deny building applications in areas unsuitable for soil-based treatment.
ASEPA	Conserve surface water supplies	1. Identify village surface water supplies that are actively used. 2. Revise American Samoa GIS to delineate 100-foot buffers around each surface supply. 3. Restrict land uses within designated buffers.
ASCZM/DOC	Detain stormwater runoff in future residential and commercial areas.	Where undesirable stormwater discharges are anticipated, require the use of onsite drywells for new residential and commercial facilities in Amanave.
DPW	Maintain culverts along the primary shoreline roadway	1. Establish a periodic storm culvert maintenance program. Consider use of village labor to supplement DPW heavy equipment. 2. Clean debris and other material blocking culverts.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASCC Land Grant Program	Reduce sedimentation from agricultural activities	1. Determine locations where upslope agricultural activities may be generating some sedimentation. 2. Encourage soil conservation methods with resident growers of subsistence crops.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics (used by Green) approximately every three years.

Source: Pedersen Planning Consultants, 1998

AUNUU SISIFO
Watershed 34

GEOGRAPHY

The Island of Aunuu is situated southeast of the Island of Tutuila. The Aunuu Sisifo watershed represents the western half of the Island of Aunuu. The watershed comprises about 0.38 square miles of land area (Figure 34-1).

The upland part of the watershed is defined by an unnamed volcanic ridge. The ridge is part of a volcanic tuff cone that originally formed Aunuu Island (U.S. Soil Conservation Service, 1984). The northeast boundary of the watershed is near Pofala Hill. Fogatia Hill is a prominent peak in the southwest part of the Aunuu Sisifo watershed. A generally flat area of coral sand lies downslope and west of the ridge that surrounds the former tuff cone. Aunuu Village is situated along the west shoreline of Aunuu Island.

There are no natural embayments or coves along the shoreline. However, Aunuu Harbor lies between Alofisau Point and Salevatia Point along the west coast of Aunuu Island.

RESOURCES OF THE WATERSHED

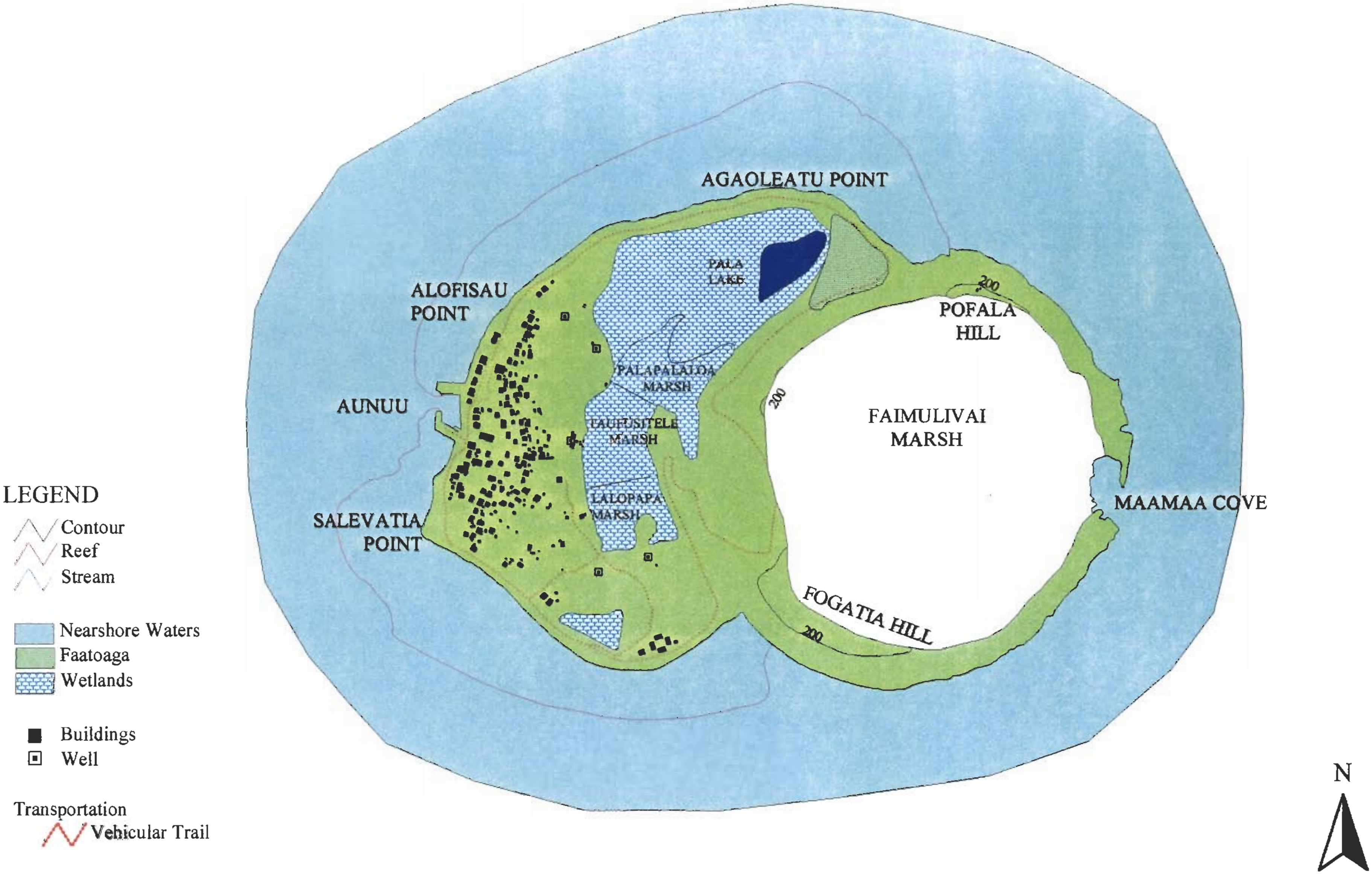
Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 34-2). Seven soil classifications were identified by the U.S. Soil Conservation Service for lands within the Aunuu Sisifo watershed (Table 34-1).

TABLE 34-1
SELECTED SOIL CHARACTERISTICS
AUNUU WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
11	Ngedebus mucky sand	0-2	Occ	Very slow	Slight	>3.5	>60	Severe flood Wetness Poor Filter	Moderate
12	Ngedebus Variant extremely cobbly sand	0-5	Occ	Very slow	Slight	>6.0	>60	Severe Flood Wetness Poor filter Large stones	Poor
13	Ngerungor Variant mucky peat	0-1	Freq	Very slow	Slight	+1, -1	>60	Severe flood Ponding filter	Poor for dry land crops
16	Ofu Variant silty clay	6-20	None	Slow to Med	Slight to Mod	>6.0	>60	Moderate Slope	Moderate
17	Ofu Variant silty clay – moderate	20-40	None	Med to Rapid	Mod to Severe	>6.0	>60	Severe Slope	Poor
18	Ofu Variant-Rock outcrop complex	40-70	None	Rapid	Severe	>6.0	>60	Severe Slope	Poor
35	Urban land-Ngedebus complex	0-5	Occ. brief	Slow	Slight	>3.5	>60	Severe Flood Wet Poor Filter	Poor

Source: U.S. Soil Conservation Service, 1984



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1

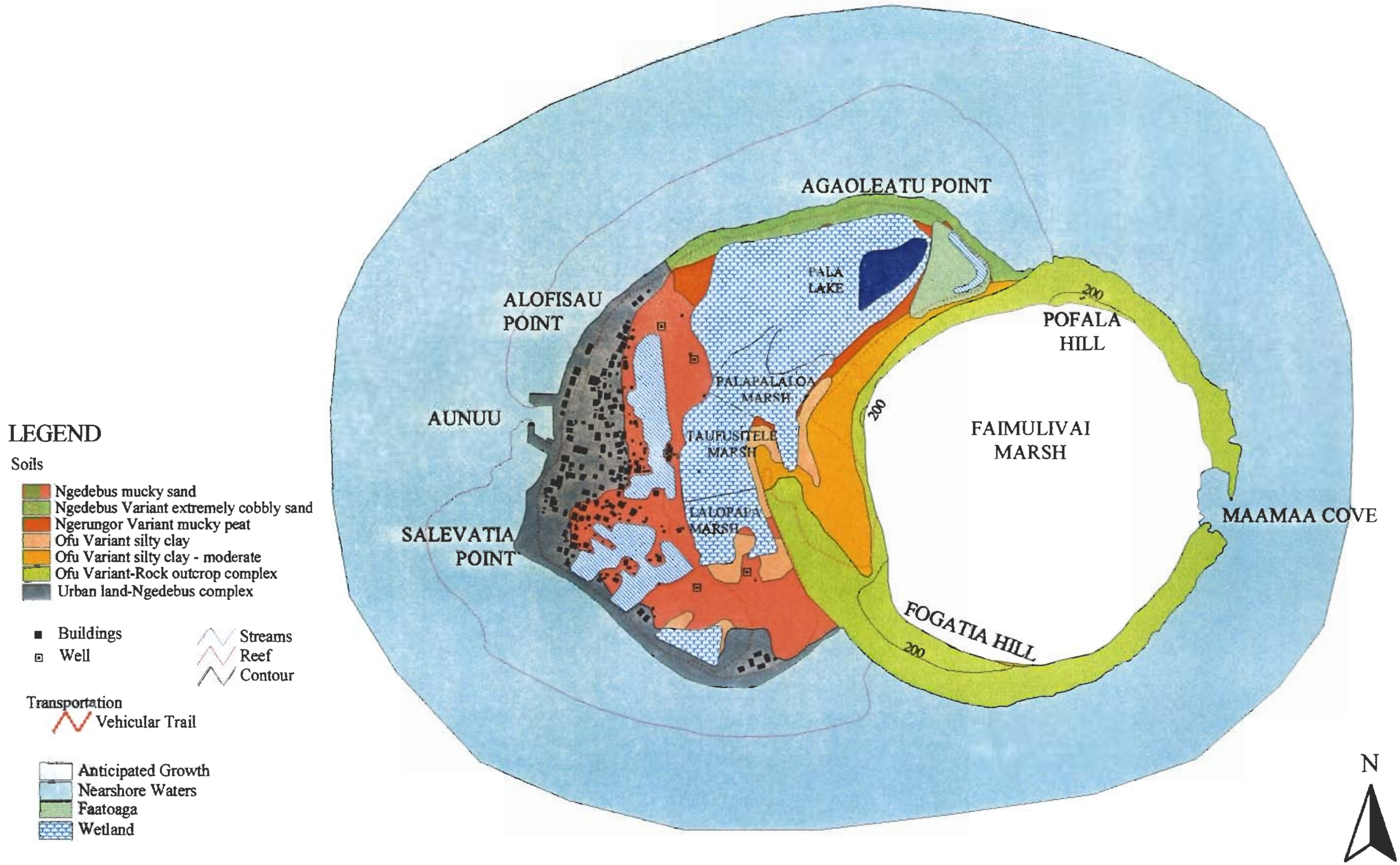
Miles
Scale: 1:14,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Aunuu Sisifo Watershed 34

Existing Conditions

Figure 34-1



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1

Miles
Scale: 1:14,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Aunuu Sisifo Watershed Management Issues

34

Figure 34-2

Urban Land-Ngedebus Complex

Urban land-Ngedebus complex soils (SCS mapping unit 35) comprises most all of the soils in the inhabited village area of Aunuu (Figure 34-2).

These soils generally comprise coral fragments, sand, cinders and other material that have been graded or filled to support residential, commercial and public facilities.

The Ngedebus soil extends to a depth of 60 inches or more. The surface layer, which extends about 4 inches below ground elevation, typically contains light, brownish-gray and brown sand. The underlying material is characterized by pale brown and light yellow, brown sand. The permeability of Ngedebus soil ranges between six and 20 inches per hour.

Surface drainage on this soil is generally slow, and the hazard of potential soil erosion is slight. In some places, the soil is subject to occasional, brief periods of flooding during prolonged, heavy rainfall or during high tide (U.S. Soil Conservation Service, 1984).

These soils are generally suitable to support residential and commercial development in areas that are protected from flooding. However, this soil is poorly suited in unprotected areas.

Where moderate to higher housing densities occur, the U. S. Natural Resources Conservation Service recommends the use of community sewage systems to prevent the potential contamination of groundwater and surface water supplies. Housing densities on Aunuu range between two to six housing units per acre.

Ngedebus Variant Extremely Cobbly Sand, 0 to 5 Percent Slopes

Ngedebus variant extremely cobbly sand (SCS mapping unit 12) is found along the north shoreline of the Aunuu Sisifo watershed. These soils frequently comprise sandy beaches less than 50 feet wide.

Ngedebus variant extremely cobbly sand soils are derived from coral rubble and sea shells. This soil is deep and excessively drained.

The surface layer is typically black extremely cobbly sand about 15 inches thick. There is a high content of organic matter. Pale brown extremely cobbly sand defines the substratum to a depth of 60 inches or more. The surface layer is extremely stony sand in some areas.

The permeability of Ngedebus variant extremely cobbly sand is rapid. The potential hazard of water erosion is slight; potential runoff from these soils is very slow. These soils are also subject to occasional, brief periods of flooding (U.S. Soil Conservation Service, 1984).

While the soil has an effective rooting depth of 60 inches or more, this soil has poor potential for subsistence agricultural production. The soil may support some plantings of coconuts.

Ngedebus variant extremely cobbly sand is poorly suited for the use of septic tank installations and related effluent drainfields. The high content of coral fragments and rapid permeability do not afford effective soil-based treatment.

Ngedebus Mucky Sand

Ngedebus mucky sand (SCS mapping unit 11) represents the soils that are between the inhabited village area and the fresh-water marshes known as Palapalaloa, Taufusitele, and Lalopapa. These soils are also situated south of Lalopapa Marsh.

Ngedebus mucky sand is a deep, somewhat excessively drained soil. This soil is derived from coral and sea shells.

The surface layer is typically black mucky sand that is approximately 12 inches thick. In some areas, the surface layer comprises loamy sand. The substratum is gray to very pale brown sand that extends to a depth of 60 inches or more.

The permeability of Ngedebus mucky sand is rapid. The potential hazard of water erosion is slight; potential runoff is very slow. Very brief periods of flooding can occur on these soils.

Ngedebus mucky sand is moderately suited to the production of subsistence crops such as taro, bananas, breadfruit and coconuts. However, agricultural uses are constrained by the retention of adequate moisture and low soil fertility.

Its suitability for septic tank installations and effluent drainfields is poor. Rapid permeability and the limited depth to the water table do not enable effective soil-based treatment.

Ngerungor Variant Mucky Peat

Along the north coast of the Aunuu Sisifo watershed, Ngerungor Variant mucky peat (SCS mapping unit 13) comprises the soils of Pala Lake, the east half of Palapalaloa Marsh, and other adjoining lands that begin about 150 feet inland from the shoreline.

This poorly drained organic soil is characteristic of a coastal swamp environment in American Samoa and is typically covered by water. Water levels over the soils fluctuate with tidal variations throughout the year.

The surface layer of the soil, which comprises a very dark, mucky peat, is about four inches thick. A very dark, grayish- brown layer of peat extends between 4 and 17 inches below ground elevation. The underlying soil contains very dark brown peat to a depth of 60 inches or more (U.S. Soil Conservation Service, 1984).

Ngerungor variant mucky peat is formed in organic material that is derived primarily from decomposing mangrove roots and litter. The permeability ranges from between six to 20 inches per hour. Runoff is very slow; the hazard of water erosion is slight (U.S. Soil Conservation Service, 1984).

The soil has poor potential for subsistence agriculture because of its wetness. However, some banana production was observed east of Pala Lake in May, 1996.

Soil saturation by water and the presence of larger stones in the soil also constrain the use of septic tanks and effluent drainfields. These characteristics do not promote effective soil-based treatment.

Ofu Variant Silty Clay (6 to 20 percent slopes)

Ofu variant silty clay soils (SCS mapping unit 16) characterize the west half of Palapalaloa Marsh, and most of Taufusitele Marsh and Lalopapa Marsh.

Ofu variant silty clay soils are a deep, well drained soil in upland areas. These soils are formed in volcanic ash and other volcanic material.

A dark brown silty clay, approximately 8 inches thick, is typical of the surface layer. The subsoils contains a dark brown silty clay in the upper 6 inches of the subsoil. The lower 14 inches of the subsoil represents a dark yellowish-brown clay loam. Highly weathered tuff that crushes easily to sandy loam comprises the substratum to a depth of 60 inches or more.

The permeability of Ofu variant silty clay soils is moderately rapid. The potential hazard for water erosion is slight to moderate; potential runoff from these soils is slow to medium.

Ofu variant silty clay soils has a moderate potential for the production of subsistence agriculture such as coconuts, breadfruit, bananas and taro. The production of various vegetables such as cabbage, cucumbers, beans, radishes, and peppers is also feasible.

These soils are somewhat suited for effluent drainfields associated with septic tank installations. However, effective soil-based treatment is reduced somewhat by moderately rapid permeability.

Ofu Variant Silty Clay (20 to 40 percent slopes)

A portion of the slopes on the west side of the volcanic tuff cone, which encompasses Faimulivai Marsh, contain Ofu variant silty clay soil (SCS mapping unit 17). Ofu variant silty clay soil is a deep, well-drained soil formed in volcanic ash and pyroclastic material.

The surface layer typically represents a dark brown silty clay that is about 8 inches thick. Dark brown silty clay comprises the upper 6 inches of the subsoil. The lower 14 inches of the subsoil is a dark yellowish-brown clay loam. Highly weathered tuff, which crushes easily to sandy loam, characterizes the substratum that extends to a depth of 60 inches or more.

Ofu variant silty clay has permeability that is moderately rapid. The potential hazard for water erosion is moderate to severe; potential runoff is medium to rapid.

This soil is not well-suited for subsistence agriculture. Steeper slopes and the potential hazard for water erosion represent the primary constraints. Nevertheless, some subsistence production was observed upslope and east of Tafusitele Marsh and Lalopapa Marsh.

Ofu variant silty clay is poorly suited for wastewater effluent drainfields that are associated with septic tank installations. Effective soil-based treatment is significantly reduced by the presence of moderately rapid permeability on steeper slopes.

Ofu Variant-Rock outcrop complex (40 to 70 percent slopes)

Pofala Hill, Fogatia Hill and adjoining steeper slopes that encompass the volcanic tuff cone around Faimulivai Marsh are characterized by Ofu variant-rock outcrop complex (SCS mapping unit 18).

This soil represents a combination of Ofu Variant silty clay and Rock outcrop. It is a deep, well drained soil that is formed in volcanic ash and other volcanic material.

Dark brown silty clay, about 8 inches thick, is typical of the surface layer. Dark brown silty clay characterizes the upper 6 inches of the subsoil. The lower 6 inches of the subsoil is a dark yellowish-brown clay loam. Highly weathered tuff, which crushes easily to sandy loam, defines the substratum that extends to a depth of 60 inches or more.

The permeability of Ofu variant soil is moderately rapid. This soil has a severe potential for water erosion is severe; potential runoff is rapid.

The Ofu variant-rockock outcrop has poor potential for subsistence agriculture. Some vegetation, e.g., small tees and shrubs, can grow in rock cracks and on ledges.

Soil permeability and steeper slopes do not promote effective soil-based treatment. Consequently, Ofu variant-rock outcrop is poorly suited for septic tank and effluent drainfield installations.

Streams

Surface runoff occurs along the west slopes of the volcanic tuff cone that encompasses Faimulivai Marsh. This runoff occurs via sheet flow to adjoining fresh-water marsh areas. However, there are no defined streams courses in the Aunuu Sisifo watershed.

Surface Water Quality

Streams

Since there are no streams, there is no surface water quality data for these water bodies.

However, a one-time sampling of water quality in the fresh-water marshes of the watershed suggest that there is considerable salinity in the lower elevations of the watershed (Biosystems Analysis, Inc., 1992). Permeable sandy soils and proximity to the water table apparently enable a significant amount of salt-water intrusion to enter the surface waters of the fresh-water marshes. Salt-water intrusion in the fresh-water marshes takes place via tidal flows.

Nearshore Waters

ASEPA collected marine water samples from 17 embayments around the Island of Tutuila, as well as the waters seaward of Aunuu Harbor, on July 25 and August 2, 1992 (Table 34-2). The samples on Tutuila were obtained from the outer portions of the embayments where more water exchange occurs at depths of three and 60 feet. It is believed that the samples at Aunuu were collected from nearshore waters that were, at least, 1,000 feet seaward of Aunuu Harbor. Collected samples were subsequently analyzed for nutrients and chlorophyll a.

Nutrient data gained from these samplings indicate that the nearshore waters seaward of Aunuu Harbor and the fringing reef met American Samoa water quality standards in late July and early August of 1992. In addition, laboratory results were generally comparable to the outer waters of many embayments on the Island of Tutuila.

TABLE 34-2
SURFACE WATER QUALITY
SURFACE WATERS SEAWARD OF AUNUU HARBOR AND FRINGING REEF
JULY-AUGUST, 1992

Sample Depth	Nitrate/ Nitrite mg N/l	Total N mg N/1	Kjeldahl N mg N/l	Total P mg P/l	CHL a mg/m^3
3 feet	0.005	0.114	0.109	0.012	0.20
60 feet	0.004	0.147	0.143	0.008	0.14

Source: ASEPA, 1992

Wetlands

Wetland Resources

Wetlands are a significant component of the Aunuu Sisifo environment. The wetlands in the watershed include open water wetland, a fresh-water marsh, and mangrove forest.

Pala Lake is an open water wetland that is located on the north side of the watershed. The lake is fed via tidal flows and sheet flow from the nearby slopes of the volcanic tuff cone (Taufi, 1996). The open water lake contains approximately three acres of land. The lack of vegetation in the Lake suggests that the brackish water in the lake probably contain elevated levels of salinity. The evidence of tidal flow was evident during a late 1995 tour of Aunuu and a subsequent field survey of the watershed in May, 1996.

The perimeter of Pala Lake includes a ring of oriental mangrove forest.

Oriental mangrove characterizes the perimeter of Pala Lake. West of Pala Lake, there is a transition from mangrove swamp to fresh-water swamp. The transition area is a flooded, hummocky area that primarily includes coconut trees and herbaceous plants. The south side of the mangrove swamp contains Tahitian chestnut and hibiscus (Biosystems Analysis, Inc., 1992).

Between the inhabited village area and the west slopes of the volcanic tuff cone, there is one larger fresh-water wetland that is primarily used for taro production. Recent and historical maps of the watershed identify three different marsh areas that have been used for taro production since, at least, 1961. However, past surveys of this wetland indicate that it represents about 27 acres of contiguous fresh-water wetland (Biosystems Analysis, Inc., 1992).

Other vegetation in the fresh-water marshes includes water chestnut, swamp cyclosorus, marsh fern, willow primrose, and some banana. Hibiscus and coconut trees are evident along the margins of the fresh-water marshes (Biosystems Analysis, Inc., 1992).

West of Aunuu Elementary School, there is a small wetland forest area that primarily includes oriental mangrove. Biosystems Analysis, Inc. also documented the presence of the rare puzzlenut tree in 1991. In May, 1996, considerable trash was located in this area.

Pala Lake and the fresh-water marsh represent unique wetlands in American Samoa. The scenic setting of these wetlands, as well as Faimulivai Marsh on the east side of Aunuu, offer a combined opportunity for resource conservation and the development of a small, eco-tour business on the Island of Aunuu.

Opportunity for Resource Conservation/Eco-Tour Development

It is believed that there may be a market for persons who wish to visit American for eco-tours associated with unique wetlands and wildlife habitat. Limited accommodations could be established at a selected site on Aunuu. A few, local residents could provide tours of Pala Lake, the fresh-water marsh, and Faimulivai Marsh. Selected sites could be designated for bird watching. Other residents could provide boat shuttle services to and from the Island of Tutuila.

It is recommended that the feasibility of establishing visitor accommodations and other facilities to support eco-tours should be investigated by the ASG Department of Commerce. This study should focus initially upon potential visitor markets related to the viewing of wetlands, wildlife and other natural resources by visitors. If a potential market is evident, the Department of Commerce should develop a conceptual master plan for proposed on-island facilities and related eco-tour program. Subsequently, the Department of Commerce should assist local resident(s) with the preparation of a related business plan to facilitate the search for investment capital.

Marine Resources

Coral Communities

With the exception of Aunuu Harbor, a continuous fringing reef flat characterizes the nearshore waters that adjoin the Aunuu Sisifo watershed.

Northeast of Alofisau Point, the width of the fringing reef flat ranges between 200 and 900 feet in width. The fringing reef flat narrows somewhat between Alofisau Point and Salevatia Point. Southeast of Salevatia Point and Fogatia Hill, the reef flat extends roughly 350 to 800 feet seaward of the shoreline.

Various private consultants have made field investigations of the fringing reef since the late 1970's. In a cumulative sense, available survey information suggests:

- In the late 1970's, an infestation of the crown-of-thorns starfish significantly reduced coral communities along the reef front seaward of Aunuu Harbor, as well as the limestone platform, reef flat, and reef margin along the southwest coast.
- In 1995, marine biologists noted that the coral reef near Salevatia Point was in better condition that most reefs seaward of Tutuila.

1978-1979

Seaward of Agaoleatu Point, coral coverage up to 40 percent was documented along some reef front areas. West of Agaoleatu Point, coral coverage was low; however, recently-killed coral heads covered up to 90 percent of the sandy bottom at a depth of 40 feet (Aecos and Aquatic Farms, 1980).

In August/September 1979, the crown-of-thorns starfish was abundant on the reef front seaward of Pala Lake. Approximately 25 percent of the coral on the upper reef slope remained alive at depths from 6 to 33 feet (Aecos and Aquatic Farms, 1980).

The northern dredged channel that leads to Aunuu Village contained no live coral. Prior to the development of the present Aunuu Harbor, the southern channel that provided boat access to the west side of Aunuu was characterized by a coral coverage of about 10 percent. South of the dredged channel, coral coverage increased considerably.

The reef front seaward of the existing Aunuu Harbor was limited to a few isolated and smaller coral colonies. *"The upper reef front off Aunu'u was heavily infested by crown-of-thorns starfish when observed in August and September 1979. However, about 60% of the coral was still alive at depths of 6 to 33 feet on the upper reef slope"* (Aecos and Aquatic Farms, 1980).

A circular, patch reef was located about 500-600 feet seaward of Aunuu Harbor. Corals were prolific along the slopes of the patch reef where coral coverage was up to 50 percent. On the reef flat of the patch reef, coral coverage averaged 40 percent (Aecos and Aquatic Farms, 1980).

Along the southwest coast of Aunuu, live coral covered about 10 percent on the limestone platform. Marine biologists noted that an earlier 1974 survey of this reef reported coral cover over 50 percent about 33 feet offshore.

Increased amounts of dead coral were evident on the outer reef flat in October 1979. Coral coverage on the reef margin was only about five percent. This compared to 80 percent coverage that had been documented in 1974 prior to the infestation by the crown-of-thorns starfish (Aecos and Aquatic Farms, 1980). Along the reef front, only 10 to 20 percent coral coverage was documented.

A shallow boulder tract southwest of Salevatia Point was reported devoid of live coral. However, about 10 percent of the outer reef near the reef margin was covered by coral.

Along the south coast of Aunuu, coral coverage was between 40 and 50 percent along some portions of the reef front.

1982, 1985, and 1988

During the month of April in 1982, 1985, and 1988, Birkeland and Randall investigated the coral communities seaward of Aunuu's east shoreline. Survey transects were made at depths of 6-10 feet and 20 feet.

Field surveys revealed a rapid recovery in coral coverage. The recovery was greater than 12 other sites on Tutuila during the same period. Coral abundance east of Aunuu increased from 0.5 percent in 1982 to over four percent in 1985, and almost 28 percent in 1988.

Significant increases in coral coverage were also observed. Coral coverage at 20 feet increased from 0.06 percent in 1982 to 1.83 percent in 1985, and about 18 percent in 1988 (Birkeland, Randall, and Amesbury, 1990).

1992

Field investigations were also made by Maragos, Hunter, and Meier in 1992. Marine surveys were made along reef fronts near Salevatia Point, as well as the south coast of Aunuu near the east edge of Nafanua Bank.

Considerable amounts of broken dead coral were observed on the south side of Aunuu at a depth of 10 to 20 meters. Live coral coverage was less than one percent at both six and 18 meters. Marine biologists concluded that this reef front site had been significantly impacted by recent storm waves.

In the vicinity of Salevatia Point, coral coverage was also less than one percent at six meters. However, in deeper waters (18 meters), coral coverage ranged between 10 and 20 percent. It was noted that the higher coral cover at this site may have been a result of its protection from easterly storm waves.

1995

A recent 1996 study of various coral reefs throughout the Samoan Archipelago included the performance of five transects along the reef front seaward of Salevatia Point. The study focused primarily upon the quantification of coral communities, the abundance and diversity of reef fish, and selected habitat characteristics.

Coral cover was documented to be less than 20 percent. Most colonies were documented as small.

Fish specie richness was equal or greater than 150 species. Fish density was equal to or greater than 10,000 individuals per ha. Fish biomass ranged between 500 and 999 kilograms per ha.

Green noted that the coral reef near Salevatia Point was in much better condition that most coral reefs seaward of Tutuila. It was suggested that the favorable condition of this reef area may be linked to more favorable water quality in the nearshore waters and the lower resident population on Aunuu.

Wildlife Resources

Various ornithologists have determined that the Pacific Reef Heron is uncommon in American Samoa. However, it has been occasionally sited along the coast of Aunuu (Engbring and Ramsey, 1989).

Similarly, the blue-gray noddy has been reported to nest along sea cliffs north of Pofala Hill, as well as south of Maamaa Cove to the cliff south of Fogatia Hill (Aecos and Aquatic Farms, 1980). However, this bird is considered an uncommon resident of Aunuu (Engbring and Ramsey, 1989).

Another uncommon resident bird is the gray-backed tern that has been reported to nest along the northeast shore of Aunuu (Amerson et al, 1982). No sitings of this bird were observed by Engbrind and Ramsey in 1986.

The common brown noddy nests along the sea cliff from Agaoleata Point to Fogatia Hill. A few common white terns nest on sheer cliffs located along the north, east, and south coasts of Aunuu. Brown boobies, an uncommon resident seabird, nest along the sea cliffs of northeastern Aunuu between Agaoleatu Point and Maamaa Cove (Aecos and Aquatic Farms, 1980).

The sheath-tailed bat roosts in a cave in the cliffs of Pofala Hill. A larger roosting colony of the fruit bat is located along on the southeast slope of Fogatia Hill (Aecos and Aquatic Farms, 1980).

A single, long-tailed cuckoo was observed flying over Pala Lake in July, 1986. However, this bird in an uncommon migrant to American Samoa (Amerson et al, 1982; Enbring and Ramsey, 1989).

The Australian gray duck, a rare resident waterbird, was reported in the late 1970's as occasionally sighted along the north shore of Aunu'u. However, this bird may now be extinct in American Samoa where it was probably never common (Engbring and Ramsey, 1989).

Shoreline Protection

The shoreline of the Aunuu Sisifo watershed is afforded some natural protection by a fringing reef that extends between 200 and 800 seaward of the shoreline. In addition, some man-made shoreline protection is located along the shoreline that fronts Aunuu Village.

In April, 1981, the U.S. Army Corps of Engineers completed construction of Aunuu Harbor. The Harbor facilities include, in part, a northern revetment mole, wave absorber, a stub breakwater, and southern revetment mole. Significant erosion apparently occurred south of the Harbor during the 1980's. In order to reduce this erosion, a grouted coral wall was constructed along 300 feet of the shoreline that is immediately south of Aunuu Harbor. No significant erosion was documented by Sea Engineering, Inc. and Belt Collins Hawaii in 1993.

In March, 1994, Sea Engineering, Inc. and Belt Collins Hawaii published a shoreline inventory report that outlined, in part, ongoing shoreline erosion conditions and related shore protection needs for American Samoa. Sea Engineering, Inc. and Belt Collins Hawaii noted the following conditions in the Aunuu Sisifo watershed that were determined to be "critical", or "potentially critical" conditions.

North of Aunuu Harbor

Extensive erosion was observed along the shoreline north of the harbor. This erosion was threatening four homes that are located in the backshore. Sea Engineering, Inc. and Belt Collins Hawaii documented that these homes were protected by a loose piled coral wall, 50 gallon drums filled with cement, an 8-foot high vertical grouted wall, and a 6-foot high vertical loose coral wall. The homes were set back roughly 15 to 20 feet from the walls. Higher tidal levels reached the base of the walls.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

Aunuu Village has a village water system. The water source for this system includes about 30 shallow dug wells which are located in the back of Aunuu Village.

Each well is typically about 4 to 6 feet in diameter and about 10 feet deep. However, two wells observed in May, 1996 were both about 2 feet deep. Open wells are lined with basalt and coral fragments. Each well is fed by a direct rainfall. Most of these wells are not covered and sealed. Consequently, they are regularly subject to surface contamination.

Representatives of ASEPA report that these wells are seriously contaminated despite the presence of an ASPA wastewater system. Aunuu Elementary School has one similar shallow dug well. Chief Taufi from Aunuu Village reported in May, 1996 that knew of no one in Aunuu that has gotten sick from the use of water from the shallow dug wells.

In response to past contamination, the American Samoa Power Authority (ASPA) developed a new water system which was completed in December, 1991 (Figure 34-3). The ASPA system uses three, shallow dug wells (ASPA wells 301,302, and 303).

"Each well in the system has two infiltration galleries that consist of 200 feet of perforated 6-inch diameter PVC. The pipe is installed horizontally approximately 2 feet below the water table surface. The system is chlorinated at well 302. The system uses a liquid metering pump to inject a batched solution of liquid bleach and water" (ASPA, 1995).

While village residences are connected to this system, most residents do not use water from the ASPA system for drinking water because they do not like the taste (Taufi, 1996). They rely on water from other shallow dug wells. Some residents purchase bottled water from the store near Aunuu Harbor.

Surface Water Supply and Quality

A secondary source of drinking water is obtained by from individual roof catchment systems that are available at several homes in Aunuu. Chief Taufi indicated in May, 1996 that there are eight roof catchment systems in the village that were built during in the mid to late 1980's.

While there is no water quality data from these surface supplies, individual roof catchment systems can provide considerably better drinking water quality than shallow dug wells. In the absence of planned ASPA improvements, it is believed that traditional leaders and residents of the village should be encouraged to use individual roof catchment systems until planned ASPA improvements are made.

Proposed Water System Improvements

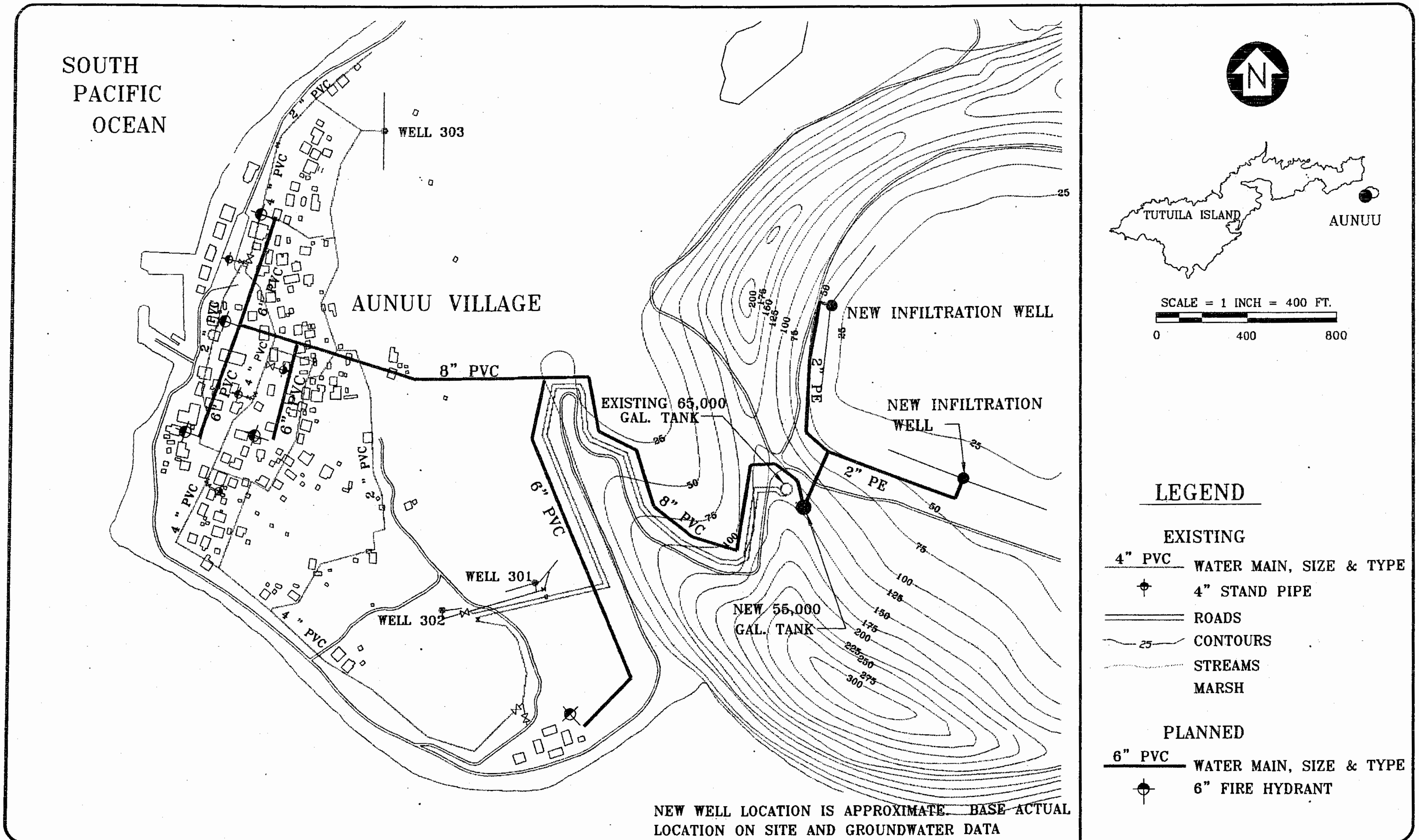
The draft ASPA Utilities Master Plan outlines the following proposed improvements to satisfy anticipated water demands:

- Conduct a leak detection survey and repair all leaks.
- Establish a water conservation program for Aunuu Village.
- Conduct a "safe yield" testing program for each of the wells.
- Construct two new infiltration wells along the slopes of the tuff cone.
- Install chlorination equipment at all wells. Use sodium hypochlorite batch system with a liquid metering pump.
- Construct a new 55,000 gallon water storage tank near the existing storage tank.
- Construct 1,700 feet of 4-inch PVC transmission main between new wells and the new storage tank.
- Construct a fire protection distribution system and install five fire hydrants.

USE OF THE WATERSHED

Resident Population

Between 1980 and 1990, the resident population of Aunuu Village increased from 414 to 463 residents. Such growth represented an average annual growth rate of about 11.8 percent. Development activity between 1990 and 1995 increased resident population to about 550 persons.



AMERICAN SAMOA POWER AUTHORITY

P.O BOX PPB, PAGO PAGO, AMERICAN SAMOA

PLANNING CRITERIA

1995 POPULATION (ESTIMATED): 550
1995 AVERAGE DAY DEMAND: 38,280 GAL.
2015 POPULATION (FORECASTED): 787
2015 AVERAGE DAY DEMAND: 70,966 GAL.
CONSTRUCTION COST (1995 USD): $355,000

FIGURE 34-3
AUNUU VILLAGE
PLANNED WATER SYSTEM IMPROVEMENTS

In May, 1996, Chief Taufi indicated that more people were leaving Aunuu than relocating to the Island. However, the local school principal reported that student enrollment at Aunuu Elementary School was on the rise.

Land Uses

Residential

The 1990 Census documented 59 houses in Aunuu Village. All but one of the homes were owner-occupied. The other house was vacant or is used as a vacation home by an absentee owner. Hurricane Val, which occurred in 1991, caused significant damage to the housing stock. Available financial aid from the U.S. Federal Emergency Management Agency (FEMA) enabled various landowners in Aunuu Village to repair their homes; some homeowners were authorized to build new housing units.

During the 1990-1995 period, building permits were issued for 12 new homes in Aunuu Village. It is estimated that the Village now contains about 71 housing units.

Onsite observations of Aunuu Village in October, 1994, as well as 1990 topographic maps, indicate that residential densities in the central and southern part of Aunuu village are approximately two to three units per acre. Lesser densities of about one unit per acre are located on the north side of the village. The central part of Aunuu village became more densely populated with the more recent construction of newer FEMA-financed homes. Existing residential development does not encroach upon Aunuu's fresh-water marshes and Pala Lake.

Agriculture

Piggeries

No piggeries were documented in Aunuu Village in May, 1996. However, available topographic maps based upon 1990 aerial photography indicate the presence of one piggery about 200 feet west of Taufusitele Marsh.

Subsistence and Commercial Crop Production

As stated earlier, there some 20 acres of fresh-water marsh that are used for the production of taro. It is believed that this production is for both subsistence and some commercial production.

Southeast of Pala Lake, an existing shoreline trail proceeds inland and eventually leads to a 65,000-gallon water storage tank at the 100-foot elevation. A productive *faatoaga* area is located on both sides of the trail. Crops include banana, breadfruit, and papaya.

The pedestrian trail that descends from northwest of Fogatia Hill to the east side of Lalopapa Marsh also represents another agricultural production area for banana and other subsistence crops.

Commercial

In 1995, there were 11 commercial enterprises that were based and operating in Aunuu Village. These enterprises included three grocery stores and eight marine transportation services.

Industrial

No industrial facilities were located on the Island of Aunuu in May, 1996.

Public Facilities

In addition to the Aunuu Harbor, other public facilities in Aunuu include an elementary school and an early childhood education (ECE) facility. The September 1994 enrollment for the Aunuu ECE was 23 students, and Aunuufou Elementary School had an enrollment of 101 students. High school students in Aunuu Village attend Fagaitua High School on Tutuila Island.

Use of the Nearshore Waters

Nearshore Fishing

Residents no longer use the reef flat in the nearshore waters for fishing. In May, 1996, there were seven families who owned an out-board motorboat. These families use their boats, in part, for fishing seaward of the reef (Taufi, 1996).

Swimming and General Recreation

About 20 people use the shoreline each day for swimming and general water recreation (Taufi, 1996).

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

Southeast of Pala Lake, a shoreline trail proceeds inland and eventually leads to a 65,000-gallon water storage tank at the 100-foot elevation. Should eventual population growth exceed the amount of developable land in Aunuu Village, lands on both sides of the road could be attractive for residential expansion since the potential residential area could be located immediately adjacent to an existing *faatoaga*.

Within Aunuu Village, however, significant residential expansion is feasible on the east and south sides of the inhabited village area. Some 31 single family homes could be developed east of the village between existing homes and the Palapalaloa Marsh and Taufusitele Marsh. However, it is believed that 20 new single family homes will gradually be constructed in this area as follows:

1996-2000	5 homes
2001-2005	5 homes
2006-2010	5 homes
2011-2015	5 homes

On the south side of Aunuu Village, about 25 homes could be constructed. However, only 20 houses are expected to be developed in this area during the next 20 years. The anticipated sequence of residential development in this area is as follows:

1996-2000	5 homes
2001-2005	5 homes
2006-2010	5 homes
2011-2015	5 homes

Aunuu Village will continue to gradually attract returning American Samoans who seek an early retirement, a more relaxed lifestyle, and/or the opportunity to care for aging extended family members. The availability of marine transport services to and from Tutuila will enable persons to obtain cash employment and/or attend school by commuting to and from Tutuila each day. At the same time, local residents will continue to have relatively good access to medical and other public services.

However, increased residential settlement in the community will be somewhat discouraged due to the lack of good-tasting water supply.

The cumulative effect of this anticipated residential development will be the construction of 40 new housing units by the year 2015. During the 1996-2015 period, it is believed that the average household size in Aunuu will have gradually decreased to approximately 6.62 persons per household. Consequently, the 2015 village population will include about 734 persons.

Commercial

The increased residential population and a growing reliance upon imported consumer items and household effects is expected to generate the construction of one retail store between 2001 and 2005. A second retail stores is anticipated between 2011 and 2015. Otherwise, shopping by local residents will continue to primarily take place on the Island of Tutuila.

Representatives of the ASG Department of Commerce suggested in May, 1996 that some consideration has been given to establishing a Territorial Park on the Island of Aunuu. Under this concept, wetland areas would remain undeveloped. Should this occur, one or more bed and breakfast accommodations could be established and feasibly operated on profitable basis and provide some limited cash employment on-island.

Pedersen Planning Consultants believes that two bed and breakfast facilities will be established during the planning period. One six room facility is expected to be built between 2001 and 2005. A second 4-room establishment will be constructed between 2011 and 2015.

Industrial

No industrial facilities are presently located on the Island of Aunuu. None are expected during the 1996-2015 period due to a limited demand for such services. Should any develop, such operations would be home-based occupations, e.g., welder, that would operate on a part-time or as needed basis.

Public Facilities

Population characteristics for Aunuu in 1990 suggest that approximately 5.5 percent of the total village population are ECE aged children. Twenty-two percent of the population are elementary school age; 11 percent are high school age.

The application of 1990 population characteristics to the anticipated 2015 village population suggest increased student enrollments in future early childhood, elementary education, and high school programs within and outside of Aunuu. Anticipated student enrollments from the village population are expected to be as follows in the year 2015:

- early childhood education 40 students
- elementary school 161 students
- high school 81 students

Impact of Future Population Growth Upon Water Consumption and Waste Generation

The consumption of potable water will also increase with a growing population. The American Samoa Power Authority (ASPA) estimates that the average day demand for water in Aunuu was about 38,280 gallons in 1995. By the year 2015, ASPA anticipates that the average demand will increase to roughly 70,966 gpd.

Future population growth and changes in land use in the Aunuu Sisifo watershed will increase the volume of future wastewater and solid wastes that are generated by local residents. Wastewater generation in Aunuu Village, for example, is expected to rise from about 26,796 gallons per day (gpd) to 49,676 gpd in the year 2015.

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of Aunuu Village, Pala Lake, the three fresh-water marshes, and the adjoining shoreline.

Inland Flood Potential

Potential flooding can be expected in Pala Lake and the three fresh-water marshes via a 100-year storm event. However, no potential flood elevations were calculated by Federal Emergency Management Agency (FEMA) for these areas.

The remaining areas of the Aunuu Sisifo watershed have been designated by FEMA as "zone x". This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Aunuu Sisifo watershed indicates that there is a coastal flood hazard through much of the nearshore waters and adjoining shoreline. A potential 100-year flood is anticipated to generate flood levels between two and three feet above mean sea level (MSL) in these areas.

The three-foot flood levels are anticipated along the shoreline between the north side of Aunuu Harbor and the north end of the inhabited village area.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Stormwater runoff and sedimentation is not an important issue on the Island of Aunuu unless steeper slopes on the west side of the volcanic tuff cone are eventually developed for residential purposes, or expanded considerably for agricultural use. Sheet flow generated during occasional heavier rainfall periods drain into Pala Lake and the fresh-water marsh. Chief Taufi reported in May, 1996 that Aunuu Village experiences no flooding except via occasional storm wave inundation.

The future conservation of these wetland areas is important to ensure that limited stormwater runoff is detained and recharged into the Island's basal aquifer. Residents of Aunuu are dependent upon the groundwater supply for drinking water. The continued detention of stormwater runoff in the wetland areas is also essential to provide continued flood protection for Aunuu Village.

It is recommended that Pala Lake be preserved; no land uses should be permitted in the lake. The fresh-water marsh should be limited to taro production, or other compatible agricultural activities that do not fill the marsh. No structural uses should be permitted in either of these wetland areas other than small buildings, e.g., sheds, that support the maintenance of *faatoaga.* In addition, agricultural crop production on the west slopes of the volcanic tuff cone should be limited to areas that contain Ofu variant silty clay (SCS mapping unit 16) which has moderate potential for crop production.

Nearshore Water Quality and the Marine Environment

No streams are present that discharge turbid stormwater runoff into the nearshore waters. The lack of streams and the availability of wetlands to detain stormwater runoff from sheet flow diminishes the influence of land uses upon nearshore water quality. Consequently, the marine environment is not significantly impacted by sedimentation and village land uses on the west side of Aunuu.

Potential nutrient inputs from cesspools are not considered to be a significant resource management issue. With the exception of Aunuu Elementary School, all of Aunuu Village is connected to a community wastewater system that is operated and maintained by ASPA.

Groundwater and Surface Water Supplies

The planned water system improvements of the American Samoa Power Authority need to be implemented as soon as possible to encourage public use of the ASPA water system. The use of shallow dug wells for drinking water needs to be discontinued as soon as practical in order to avert potential public health risks associated with the use of contaminated water supplies. New wells are needed to improve the taste of the ASPA drinking water supply.

If financial resources are not available to design and construct proposed water system improvements, it is recommended that materials are purchased by the American Samoa Power Authority to enable residents to install roof gutters and a 10,000-gallon storage tank at each home. ASPA could purchase required materials on a bulk basis and sell required materials to local residents at attractive prices.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Aunuu Sisifo watershed will be to:

- Discontinue use of village shallow dug wells for drinking water. Implement planned improvements to the ASPA water system to encourage public use of this water supply.
- Preserve Pala Lake and the adjoining oriental mangrove forest .
- Conserve the fresh-water marsh to enable the use of wetlands for stormwater detention, groundwater recharge, and flood control.
- Encourage the development of an eco-tours enterprise and related visitor accommodations to support the visitation of Aunuu's wetlands, wildlife habitat, and other natural resources.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with a designated resident of Aunuu, and encourage village participation in resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 34-3. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 34-3
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
AUNUU SISIFO WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASPA	Improve groundwater supplies and eliminate public use of contaminated drinking water supplies	1. Design and construct planned improvements for the Aunuu water system. 2. In the interim, procure materials needed to sell required materials for the installation of individual roof catchment systems to local residents.
ASCMP	Preserve Pala Lake and conserve fresh-water marsh	1. Restrict future land uses in Pala Lake and the adjoining oriental mangrove forest. 2. Permit the continued use of the fresh-water marsh for taro and other compatible agricultural uses that do not fill the marsh. 3. Restrict future structural development within the marsh.
ASDOC	Encourage the development of a local visitor industry	1. Investigate the feasibility of establishing visitor accommodations and other facilities to support eco-tours that would focus upon the viewing of local wetlands, wildlife and other natural resources by visitors. 2. Analyze the feasibility of attracting a potential market to view natural resources on Aunuu. 3. If potential market is evident, develop a conceptual master plan for proposed on-island facilities and related eco-tour program. 4. Assist local resident(s) with the preparation of a related business plan.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASDMWR	Sustain and enhance bird habitats in Pala Lake, the fresh-water marsh, and other coastal areas.	1. Investigate the feasibility of a translocation of the Australian Gray Duck to Pala Lake and Faimulivai Marsh (Aunuu Sasae). 2. Monitor and document changes in duck, bat, and seabird populations and habitat.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics along the reef front near Salevatia Point approximately every three years.

Source: Pedersen Planning Consultants, 1998

AUNUU SASAE
Watershed 35

GEOGRAPHY

The Aunuu Sasae watershed is located in the east half of Aunuu Island. The watershed comprises about 0.22 square miles of land area (Figure 35-1).

The Aunuu Sasae watershed is a volcanic tuff cone. The volcanic ridge of the tuff represents the inland boundary of the watershed. Fogatia Hill and Pofala Hill are the two highest points along the volcanic ridge. Downslope of the ridge, the interior of the watershed contains Faimulivai Marsh.

RESOURCES OF THE WATERSHED

Soils

The U.S. Soil Conservation Service (National Resource Conservation Service) published a Soil Survey of American Samoa in 1984. Selected information derived from this survey provides some useful information for future watershed planning and management (Figure 35-2). Four soil classifications were identified by the U.S. Soil Conservation Service for lands within the Aunuu Sasae watershed (Table 35-1).

TABLE 35-1
SELECTED SOIL CHARACTERISTICS
AUNUU SASAE WATERSHED

SCS Soil Unit	Name	Typical Slope (percent)	Flood	Runoff	Erosion	Soil Depth To: High Water (feet)	Soil Depth To: Bed Rock (inches)	Land Use Suitability: Soil Based WW Treatment	Land Use Suitability: Subsistence Ag. Potential
10	Mesei Variant peat	0-1	Freq	Ponded to slow	Slight	+1,-1	>60	Severe flood pond filter	Poor for dry land crops
16	Ofu Variant silty clay	6-20	None	Slow to Med	Slight to Mod	>6.0	>60	Moderate Slope	Moderate
17	Ofu Variant silty clay – moderate	20-40	None	Med to Rapid	Mod to Severe	>6.0	>60	Severe Slope	Poor
18	Ofu Variant-Rock outcrop complex	40-70	None	Rapid	Severe	>6.0	>60	Severe Slope	Poor

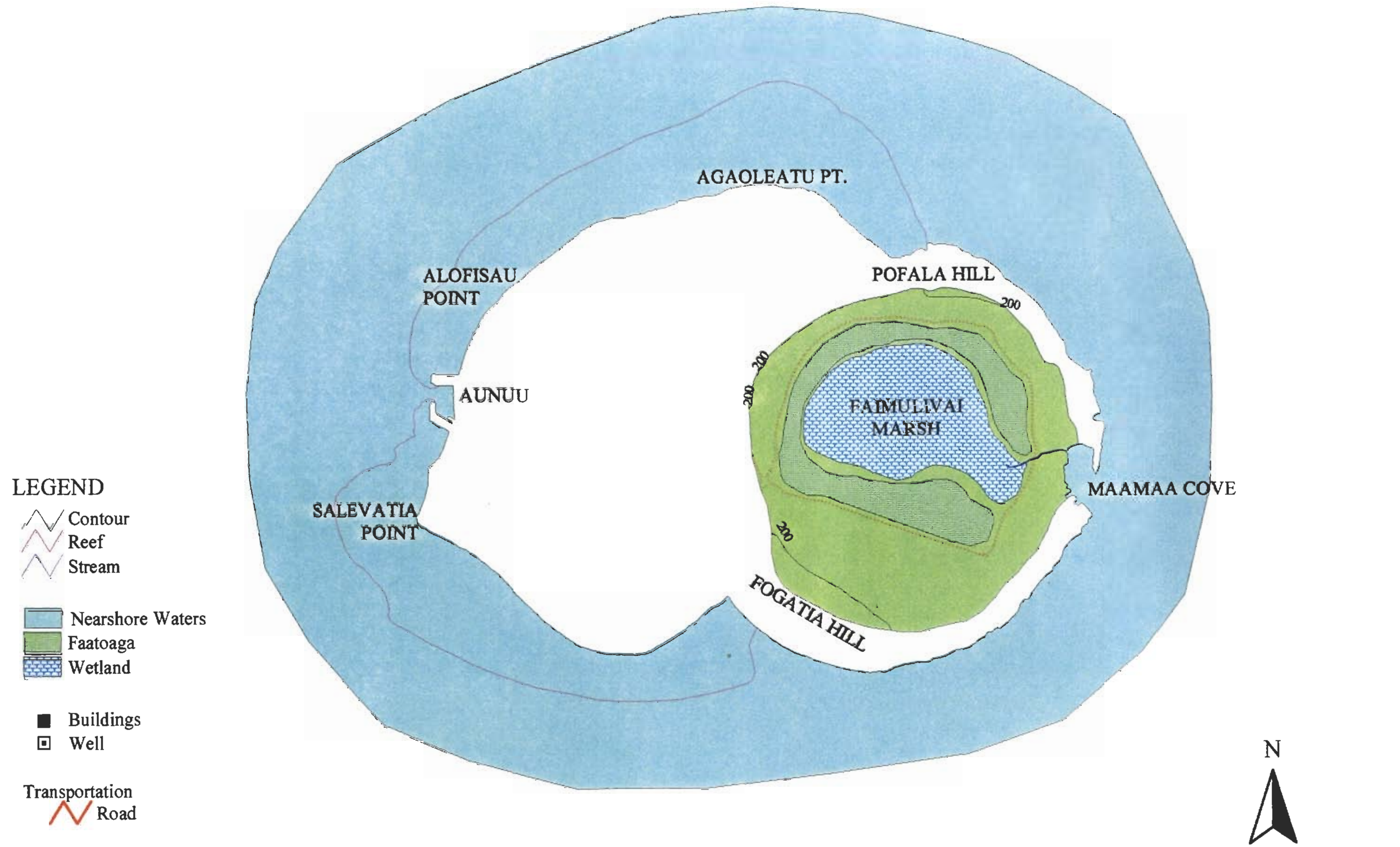
Source: U.S. Soil Conservation Service, 1984

Ofu Variant-Rock Outcrop Complex (40 To 70 Percent Slopes)

Pofala Hill, Fogatia Hill and adjoining steeper slopes that encompass the volcanic tuff cone around Faimulivai Marsh are characterized by Ofu variant-rock outcrop complex (SCS mapping unit 18).

This soil represents a combination of Ofu Variant silty clay and Rock outcrop. It is a deep, well drained soil that is formed in volcanic ash and other volcanic material.

Dark brown silty clay, about 8 inches thick, is typical of the surface layer. Dark brown silty clay characterizes the upper 6 inches of the subsoil. The lower 6 inches of the subsoil is a dark yellowish-brown clay loam. Highly weathered tuff, which crushes easily to sandy loam, defines the substratum that extends to a depth of 60 inches or more.



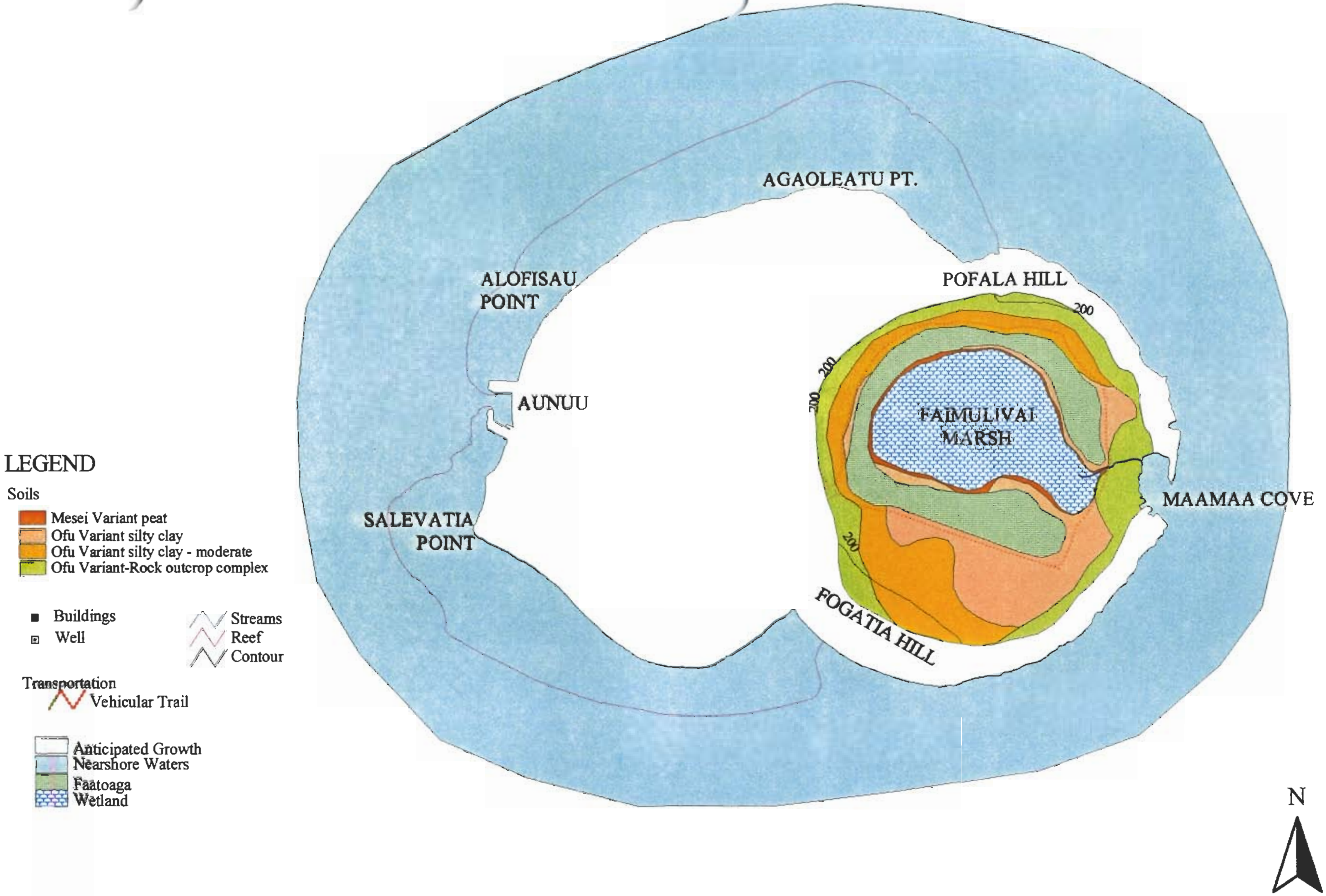
American Samoa Geographical Information System

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Aunuu Sasae Watershed
Existing Conditions

35

Figure 35-1



American Samoa Geographical Information System

0.25 0 0.25 0.5 0.75 1

Miles
Scale: 1:14,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Aunuu Sasae Watershed Management Issues

35

Figure 35-2

The permeability of Ofu variant soil is moderately rapid. This soil has a severe potential for water erosion is severe; potential runoff is rapid.

The Ofu variant-rockock outcrop has poor potential for subsistence agriculture. Some vegetation, e.g., small tees and shrubs, can grow in rock cracks and on ledges.

Soil permeability and steeper slopes do not promote effective soil-based treatment. Consequently, Ofu variant-rockock outcrop is poorly suited for septic tank and effluent drainfield installations.

Ofu Variant Silty Clay (20 to 40 percent slopes)

The steeper, lower slopes of the volcanic tuff cone, which encompasses Faimulivai Marsh, contain Ofu variant silty clay soil (SCS mapping unit 17). Ofu variant silty clay soil is a deep, well-drained soil formed in volcanic ash and pyroclastic material.

The surface layer typically represents a dark brown silty clay that is about 8 inches thick. Dark brown silty clay comprises the upper 6 inches of the subsoil. The lower 14 inches of the subsoil is a dark yellowish-brown clay loam. Highly weathered tuff, which crushes easily to sandy loam, characterizes the substratum that extends to a depth of 60 inches or more.

Ofu variant silty clay has permeability that is moderately rapid. The potential hazard for water erosion is moderate to severe; potential runoff is medium to rapid.

This soil is not well-suited for subsistence agriculture. Steeper slopes and the potential hazard for water erosion represent the primary constraints.

Ofu variant silty clay is poorly suited for wastewater effluent drainfields that are associated with septic tank installations. Effective soil-based treatment is significantly reduced by the presence of moderately rapid permeability on steeper slopes.

Ofu Variant Silty Clay (6 to 20 percent slopes)

Ofu variant silty clay soils (SCS mapping unit 16) generally characterize the lands between the outer edge of the Faimulivai Marsh and the upslope trail that circles the Marsh..

Ofu variant silty clay soils are a deep, well drained soil in upland areas. These soils are formed in volcanic ash and other volcanic material.

A dark brown silty clay, approximately 8 inches thick, is typical of the surface layer. The subsoils contains a dark brown silty clay in the upper 6 inches of the subsoil. The lower 14 inches of the subsoil represents a dark yellowish-brown clay loam. Highly weathered tuff that crushes easily to sandy loam comprises the substratum to a depth of 60 inches or more.

The permeability of Ofu variant silty clay soils is moderately rapid. The potential hazard for water erosion is slight to moderate; potential runoff from these soils is slow to medium.

Ofu variant silty clay soils has a moderate potential for the production of subsistence agriculture such as coconuts, breadfruit, bananas and taro. The production of various vegetables such as cabbage, cucumbers, beans, radishes, and peppers is also feasible. Agricultural production is primarily located on the lands situated northeast and southwest of Faimulivai Marsh.

These soils are somewhat suited for effluent drainfields associated with septic tank installations. However, effective soil-based treatment is reduced somewhat by moderately rapid permeability.

Mesei Variant Peat

The lands that comprise Faimulivai Marsh contain Mesei variant peat (SCS mapping unit 10).

Mesei Variant peat is a very deep, organic soil that is poorly drained. This soil is formed in organic material that is derived from reeds, ferns, and other marsh plants commonly covered with water.

The surface layer is typically black and very dark brown peat that is about 12 inches thick. Dark brown mucky peat comprises a second soil layer that is approximately 12 inches thick. Very dark brown muck defines the underlying material to a depth of 60 or more inches.

The permeability of this unit is rapid and ranges between 6 and 20 inches per hour. The potential hazard of water erosion is slight; potential runoff is ponded to slow. The water table is usually about 12 inches above the surface.

These soils are generally suitable for only water-tolerant plants. However, coconut production can be supported in limited areas.

Mesei Variant peat is unsuitable to support septic tank and effluent drainfields. Permeability is too rapid and the soil is too close to the water table to enable any effective soil-based treatment of wastewater effluent.

Streams

Surface runoff occurs along the slopes of the volcanic tuff cone. This runoff, which occurs via sheet flow, drains into Faimulivai Marsh. However, there are no defined streams courses in the Aunuu Sisifo watershed.

Surface Water Quality

Streams

Since there are no streams, there is no surface water quality data for these water bodies.

Nearshore Waters

There is no surface water quality available for the nearshore waters that adjoin the Aunuu Sasae watershed. However, marine water samples were collected from the waters seaward of Aunuu Harbor in July and August, 1992. This data is presented in the watershed evaluation for Aunuu Sisifo (watershed 34).

Wetlands

Wetland Resources

Faimulivai Marsh is located in the center of the watershed. This coastal marsh contains approximately 37 acres of land. Approximately half of this area is open water (Biosystems Analysis, Inc., 1992).

In 1976, botanist Art Whistler documented that the marsh contained approximately 34 acres. In 1992, Biosystems Analysis, Inc. reported that the marsh was somewhat larger, contained more open water, and was characterized by less vegetation. Biosystems Analysis, Inc. speculated that the installation of a new roadway culvert, upslope of Maamaa Cove, in 1991 may have changed the water level inside the marsh and increased the volume of water.
However, as noted by Whistler,

"With an elevation of 20 feet, the marsh within the crater is higher than most coastal marshes. The marsh has several ponds in the center and is drained by a stream that flows out the eastern end of the crater. Due to its relatively higher elevation there are no tidal effects upon it and the water is fresh" (Whistler, 1976).

It is also suspected that some fresh water intrusion into the marsh may be occurring from the basal aquifer given the permeable nature of Mesei variant peat soils.

In terms of vegetation, the marsh primarily contains water chestnut, marsh fern, and the willow primrose. The shoreline of the marsh is characterized by hibiscus and a few coconut trees (Biosystems Analysis, Inc., 1992).

In discussions with Chief Taufi in May, 1996, it was learned that the waters of Faimulivai Marsh also contains a fish population that primarily includes snapper and other species.

Faimulivai Marsh is a unique wetland in American Samoa. The scenic setting of the marsh environment and adjoining volcanic tuff cone, and its separation from residential activities on the west side of Aunuu, offer a combined opportunity for resource conservation and the development of a small, eco-tour business on the Island of Aunuu.

It is believed that there may be a market for persons who wish to visit American for eco-tours associated with unique wetlands and wildlife habitat. Limited accommodations could be established at a selected site on Aunuu. A few, local residents could provide tours of the Faimulivai Marsh, as well as Pala Lake and fresh-water marsh on the west side of the crater. Selected sites could be designated for bird watching. Other residents could provide boat shuttle services to and from the Island of Tutuila.

Resource Conservation/Eco-Tour Development

It is recommended that the feasibility of establishing visitor accommodations and other facilities to support eco-tours should be investigated by the ASG Department of Commerce. This study should initially evaluate potential visitor markets associated with the viewing of wetlands, wildlife and other natural resources by visitors. If a potential market is evident, the Department of Commerce should develop a conceptual master plan for proposed on-island facilities and related eco-tour program. Subsequently, the Department of Commerce should assist local resident(s) with the preparation of a related business plan to facilitate the search for investment capital.

Marine Resources

Since 1970, marine ecologists have investigated coral communities and other marine resources in numerous nearshore water locations. In the vicinity of Aunuu, past surveys have been made in the nearshore waters on the south side of Aunuu, near Salevatia Point, and seaward of Aunuu Harbor. Selected information gained from these studies are included in the watershed evaluation for Aunuu Sisifo (watershed 34).

Wildlife Resources

Various ornithologists have determined that the Pacific Reef Heron is uncommon in American Samoa. However, it has been occasionally sited along the coast of Aunuu (Engbring and Ramsey, 1989).

Similarly, the blue-gray noddy has been reported to nest along sea cliffs north of Pofala Hill, as well as south of Maamaa Cove to the cliff south of Fogatia Hill (Aecos and Aquatic Farms, 1980). However, this bird is considered an uncommon resident of Aunuu (Engbring and Ramsey, 1989).

Another uncommon resident bird is the gray-backed tern that has been reported to nest along the northeast shore of Aunuu (Amerson et al, 1982). No sitings of this bird were observed by Engbrind and Ramsey in 1986.

The common brown noddy nests along the sea cliff from Agaoleata Point to Fogatia Hill. A few common white terns nest on sheer cliffs located along the north, east, and south coasts of Aunuu. Brown boobies, an uncommon resident seabird, nest along the sea cliffs of northeastern Aunuu between Agaoleatu Point and Maamaa Cove (Aecos and Aquatic Farms, 1980).

The sheath-tailed bat roosts in a cave in the cliffs of Pofala Hill. A larger roosting colony of the fruit bat is located along on the southeast slope of Fogatia Hill (Aecos and Aquatic Farms, 1980).

A single, long-tailed cuckoo was observed flying over Pala Lake in July, 1986. However, this bird in an uncommon migrant to American Samoa (Amerson et al, 1982; Enbring and Ramsey, 1989).

The Australian gray duck, a rare resident waterbird, was reported in the late 1970's as occasionally sighted along the north shore of Aunu'u. However, this bird may now be extinct in American Samoa where it was probably never common (Engbring and Ramsey, 1989). Nevertheless, it is recommended that the feasibility of translocation of this duck be investigated by the ASG Department of Marine and Wildlife Resources.

"*A translocation program might be feasible to reestablish the Gray Duck in American Samoa. Birds could be brought from American Samoa, where the species is still found in low numbers"* (Enbring and Ramsey, 1989).

Enbring and Ramsey also pointed out that Faimulivai Marsh is the best remaining habitat for the duck in American Samoa.

Shoreline Protection

The shoreline of the Aunuu Sasae watershed is protected by the steeper slopes of the volcanic tuff cone that encompasses Faimulivai Marsh. In addition, this watershed is uninhabited and residents use this area for only the harvest of some subsistence crops such as banana and coconut.

There are no man-made shore protection facilities. No facilities are anticipated because of these factors.

Groundwater and Surface Water Supplies

Groundwater Supply and Quality

There are no groundwater wells in the Aunuu Sasae watershed. However, the inhabited west side of Aunuu relies upon shallow dug wells for drinking water.

Faimulivai Marsh is an important recharge area for stormwater runoff that drains from the slopes of the volcanic tuff cone. It is important that land use development along these slopes is limited to subsistence agricultural activities in areas that are susceptible to significant soil erosion. It is recommended that the ASG Land Grant Program closely monitor agricultural activities in this area and work cooperatively with residents who maintain the *faatoaga* in the watershed.

Surface Water Supply and Quality

There are no surface water supplies in the Aunuu Sasae watershed. A simple roof catchment system may be located by one or more sheds where residents rest during and following their harvests of bananas and coconuts from their *faatoaga*.

Proposed Water System Improvements

The Island of Aunuu has a drinking water quality problem. Residents use water from shallow dug wells on the west side of the Island that are contaminated. ASPA also uses three shallow dug wells for the operation of its water system that is regularly disinfected. However, residents do not like the taste of drinking water from the ASPA system. These issues are discussed more fully in the watershed evaluation for the Aunuu Sisifo watershed (watershed 34).

The draft ASPA Utilities Master Plan outlines, in part, the following proposed improvements to satisfy anticipated water demands on the west side of Aunuu (Figure 35-3):

- Construct two new infiltration wells along the slopes of the tuff cone.
- Conduct a "safe yield" testing program for each of the wells.
- Install chlorination equipment at all wells. Use sodium hypochlorite batch system with a liquid metering pump.
- Construct a new 55,000 gallon water storage tank near the existing storage tank.
- Construct 1,700 feet of 4-inch PVC transmission main between new wells and the new storage tank.

USE OF THE WATERSHED

Resident Population

This watershed is uninhabited. Residents of Aunuu live in Aunuu Village on the west side of the Island.

Land Uses

The Aunuu Sasae watershed is used only for some subsistence agricultural production on the lower slopes of the volcanic tuff cone. A few structures in the area are small sheds where residents can rest during or following the harvest of bananas and coconuts.

RESOURCE MANAGEMENT ISSUES

Future Land Uses to the Year 2015

Residential

From the existing 65,000-gallon water storage tank to Maamaa Cove, future residential development is also possible due to the proximity of the *faatoaga*. Similarly, lands upslope from the north and east sides of Faimulivai Marsh also have residential development potential.

Residential development potential on any lands that drain into the Faimulivai Marsh and other wetlands on Aunuu are considered very undesirable. Increased surface drainage would only diminish the quality of water that infiltrates into the Island's groundwater supply which local residents rely upon for drinking water. Various American Samoa Government (ASG) agencies, e.g., the American

Missing Figure 35-3

< INSERT FIGURE 35-3 >

Samoa Coastal Management Program, are well aware of these potential consequences. Development projects on Aunuu are already subject to the inter-agency Project Notification and Review System (PNRS) process. Consequently, it is believed that no residential development should be permitted in the Aunuu Sasae watershed.

Another incentive for the conservation of the lands in the watershed is, again, the potential opportunity for the development of eco-tours that would generate some business opportunities and income for local residents. The conservation of wetland and wildlife resources is required to develop and sustain any potential eco-tour enterprises on Aunuu.

Use of the Nearshore Waters

A brief visit to Aunuu in December, 1995 indicated some signs of occasional shoreline fishing in the vicinity of Maamaa Cove. Discarded fishing line and other materials were located upslope of Maamaa Cove near the pedestrian trail.

Chief Taufi reported in May, 1996 that there were seven families who owned an out-board motorboat. These families use their boats, in part, for fishing seaward of the reef (Taufi, 1996). Consequently, shoreline fishing is apparently very limited.

Impact of Future Population Growth Upon Water Consumption and Waste Generation

No new resident population is anticipated in the watershed that would increase drinking water consumption and the generation of wastewater.

Flood Potential

A flood insurance study of American Samoa and related flood insurance rate maps were published by the U.S. Federal Emergency Management Agency (FEMA) in 1991. The study evaluated selected geographical locations throughout the Territory. Hydrologic and hydraulic analyses that were presented in the study were made by the U.S. Army Corps of Engineers, Pacific Ocean Division. A detailed study was made of Faimulivai Marsh and the adjoining shoreline.

Inland Flood Potential

Potential flooding can be expected in Faimulivai Marsh via a 100-year storm event. However, no potential flood elevations were calculated by Federal Emergency Management Agency (FEMA) for these areas.

The remaining areas of the Aunuu Sasae watershed have been designated by FEMA as “zone x”. This designation indicates that the areas are outside of the 100-year floodplain (Federal Emergency Management Agency, 1991). In essence, FEMA is suggesting that the flood hazard potential in these areas is limited.

Coastal Flood Hazard

The flood insurance rate map for the shoreline of the Aunuu Sasae watershed indicates that there is a coastal flood hazard through much of the nearshore waters and adjoining shoreline. A potential 100-year flood is anticipated to generate flood levels of approximately two feet above mean sea level (MSL) in these areas.

Stormwater Runoff/Sedimentation and the Relationship to Surface Water Quality

Stormwater runoff and sedimentation is not an important issue on the Island of Aunuu unless steeper slopes upslope of Faimulivai Marsh are developed for residential purposes, or expanded considerably for agricultural use.

As stated earlier, no streams discharge turbid stormwater runoff into the nearshore waters. Sheet flow generated during occasional heavier rainfall periods drain into Faimulivai Marsh. Detention of the stormwater runoff in the Marsh permits the filtering of sediments and turbid waters before their recharge into Aunuu's basal aquifer. The future conservation of the Faimulivai Marsh is important to ensure that this important wetland function continues. In its absence, groundwater supplies can be further contaminated.

In terms of conservation, is recommended that Faimulivai Marsh be conserved. No land uses should be permitted in the Marsh. Agricultural crop production should be limited to areas that contain Ofu variant silty clay (SCS mapping unit 16) which has moderate potential for crop production. No structural uses should be permitted in either of these wetland areas other than small buildings, e.g., sheds, that support the maintenance of *faatoaga*.

Nearshore Water Quality and the Marine Environment

There are not significant issues that are expected to impact future nearshore water quality and the marine environment. The lack of streams and the availability of Faimulivai Marsh enables the detention of stormwater runoff.

Groundwater and Surface Water Supplies

The planned water system improvements of the American Samoa Power Authority need to be implemented as soon as possible to encourage public use of the ASPA water system. The use of shallow dug wells for drinking water needs to be discontinued as soon as practical in order to avert potential public health risks associated with the use of contaminated water supplies on the west side of Aunuu. New wells are needed to improve the taste of the ASPA drinking water supply that will encourage greater use of the ASPA water system.

MANAGEMENT NEEDS AND RECOMMENDATIONS

The primary focus of future resource management in the Aunuu Sasae watershed will be to:

- Implement planned improvements to the ASPA water system to encourage greater public use of this water supply.
- Conserve Faimulivai Marsh to continue its important function for stormwater detention and groundwater recharge.
- Encourage development of an eco-tour enterprise and related visitor accommodations to support the potential visitation of Aunuu's wetlands and other natural resources.

Representatives of participating public agencies should make periodic visits to the watershed to observe, document, and monitor selected resource conditions, determine potential methods of correcting a potential hazard or undesirable conditions, share potential solutions with a designated resident of Aunuu, and encourage village participation in resource management solutions.

The scope of issues that should be addressed by each agency in the field is summarized in Table 35-2. The general focus of recommended technical assistance is also identified. The experience and insights of agency representatives will determine the specific methodology to be used in the field.

TABLE 35-2
RECOMMENDED FOCUS OF FUTURE TECHNICAL ASSISTANCE
AUNUU SASAE WATERSHED

Participating Public Agency	Resource Management Issue	Focus of Technical Assistance
ASEPA	Facilitate a coordinated resource management effort within the watershed.	1. Coordinate overall watershed management activities. 2. Hold periodic meetings with participating ASG and federal agencies to discuss, prioritize, and schedule resource management activities. 3. Coordinate program efforts with local traditional leaders and/or designated resident of the watershed. 4. Make annual assessment of resource management program.
ASPA	Improve groundwater supplies and eliminate public use of contaminated drinking water supplies	1. Design and construct planned improvements for the Aunuu water system.
ASCMP	Conserve Faimulivai Marsh for stormwater detention and groundwater recharge.	1. Restrict future land uses in the Aunuu Sasae watershed. 2. Permit agricultural activities on lands that contain Ofu variant silty clay soils. 3. Restrict future structural development or land filling within Faimulivai Marsh.
ASDOC	Encourage the development of a local visitor industry	1. Investigate the feasibility of establishing visitor accommodations and other facilities to support eco-tours that would focus upon the viewing of local wetlands, wildlife and other natural resources by visitors. 2. Analyze the feasibility of attracting a potential market to view natural resources on Aunuu. 3. If potential market is evident, develop a conceptual master plan for proposed on-island facilities and related eco-tour program. 4. Assist local resident(s) with the preparation of a related business plan.
ASDOC	Monitor changes in population and land use	Annually map type and location of land uses in village and estimate resident population.
ASDMWR	Sustain and enhance bird habitats in Faimulivai Marsh and other coastal areas of the watershed.	1. Investigate the feasibility of a translocation of the Australian Gray Duck to Faimulivai Marsh. 2. Monitor and document changes in duck, bat, and seabird populations and habitat.
ASDMWR	Sustain healthy marine communities in nearshore waters	Monitor changes in coral coverage, fish habitat, diversity and other characteristics along the reef front near Salevatia Point approximately every three years.

Source: Pedersen Planning Consultants, 1998

AGENCY ACRONYMS

Acronym	Full Agency Name
ASCC	American Samoa Community College
ASCZM	American Samoa Coastal Zone Management
ASCZMP/FBNMS	American Samoa Coastal Zone Management Program/ Fagatele Bay National Marine Sanctuary
ASDMWR	American Samoa Department of Marine and Wildlife Resources
ASDOA	American Samoa Department of Agriculture
ASDOC	American Samoa Department of Commerce
ASDPO or DPO	American Samoa Department of Planning Office (renamed ASDOC or American Samoa Department of Commerce)
ASDPW	American Samoa Department of Public Works
ASEPA	American Samoa Environmental Protection Agency
ASG	American Samoa Government
ASPA	American Samoa Power Authority
CCCAS	Congregational Christian Church of American Samoa
FEMA	U. S. Federal Emergency Management Agency
NRCS	Natural Resource Conservation Service (formerly U.S. Soil Conservation Service)
SCS	U. S. Soil Conservation Service

SAMOAN GLOSSARY

Samoan Word	English Translation
aiga	family, extended family
aumaga	young or untitled men of a Samoan village
ava	channel, passage, gap
faaSamoa	Samoan custom, Samoan way of life
faatoaga	plantation, farm
faifeau	minister, pastor
faisua	mollusc, giant clam
fale	house
Fono	the Legislative branch of the American Samoa Government (ASG)
malae	open space; village green, place used for social and traditional gatherings, as well as for recreation
matai	titled head of a Samoan extended family, high ranking title holder
palagi	foreigner
puleaoga	school principal
pulenuu	village mayor representing ASG in villages of American Samoa
sami	ocean
sao	senior title-holder in Samoan village who, in part, makes decisions concerning the use of communal lands
taufusi	swamp, marshland
vaipuna	spring

Source: Samoan Dictionary, G. B. Milner, 1978; Pedersen Planning Consultants, 1998