### **Executive Summary**

Overview of key findings

Summary of recommendations

### **Table of Contents**

* List of sections and sub-sections
* List of tables and figures

### **Introduction**

**Background:**

**Traditional Use and Design of Village Water Systems**

The Samoan Islands were settled 2000-3000 years ago by Polynesian voyagers crossing vast swaths of ocean (Green, 1991). These early sailors must have been elated to see the first signs of islands on the horizon, in much part because high islands like those of the Samoan archipelago typically offer abundant sources of freshwater. The surface water resources presumably used by these first inhabitants are the same water sources investigated in this report. The importance of natural watercourses can be seen in the human geography of the islands, whereas nearly every Samoan Nu’u, translated into English as ‘village’, is formed around the central feature of a freshwater stream. These streams served as the lifeblood of sustainable communities for millennia, ensuring their survival and prosperity. Traditionally, canals were dug to make water access more convenient and once available, pipes were used to transport water from a catchment or intake location, typically upstream of a village, into the developed area for consumption and use. This infrastructure, referred to as the Village Water Systems, were not only a crucial element in historical Samoan life, but in many cases are still used, though to a limited extent, even today.

Before the 1970s, surface water from village water systems served as the primary source of water for all villages in American Samoa (URS, 1978). These systems were and are typically constructed with a small check dam placed across a stream, and the delivery pipe that is usually embedded within the dam structure. Intake sites for these systems were chosen based on the natural channel geometry, ensuring the creation of a standing pool of water to keep the intake continuously submerged. The delivery pipe would typically lead to a communal faucet in the central area of the village, although in some instances, wealthier families or chiefs might have the village water supply directly connected to their homes (Davis, 1963). Davis further reports that in a few villages even as late as the 1960s, no infrastructure was used and water was directly collected by dipping from pools in streams; with upstream pools designated for drinking water and downstream pools allocated for washing and bathing. During this time, municipal scale water systems and a few small reservoirs were developed, but surface water treatment plants were difficult to operate and were eventually phased out.

**Transition Away from Village Water Systems**

Because village water systems in American Samoa rely on surface water sources they are susceptible to contamination from soil, debris, and pathogens. As a result, the water quality provided by these systems tends to be highly variable, posing a risk of waterborne illnesses to residents. Additionally, although the islands receive abundant annual rainfall, many short term droughts have been recorded. Due to the small size and low-natural storage capacity of the island’s soils and aquifers, these events caused insufficient streamflow leading to water shortages.

By the late 1970s, recognizing the problems associated with surface water quality and availability in American Samoa, groundwater development emerged as a strategic solution. During this period, the American Samoa Public Works Department (ASDPW) embarked on a program to develop a robust network of groundwater infrastructure, encompassing both the development of the groundwater sources and the establishment of an island-wide water transmission system. This initiative, which spanned multiple decades, was managed by ASDPW until the American Samoa Power Authority (ASPA) assumed responsibility for the territory's water system operations around the year 2000. In the 1980s to the early 2000s, the American Samoa Environmental Protection Agency (ASEPA) actively promoted the transition from village water systems to the more reliable groundwater system. This shift was encouraged as the groundwater system met the Safe Drinking Water Act's standards and was generally considered a better alternative to the surface water systems. Despite the benefits, the transition was not universal. A significant portion of the population continued to rely on village water systems for traditional reasons or due to the financial implications of switching to the metered and billed groundwater system. At present, even though village water systems retain l practical, cultural, and historical significance there exists very little documentation regarding their design, usage, or significance. This report is one of a very few, and possibly the only attempt to comprehensively document the status of village water systems on Tutuila. As early as the 1970’s it was written that villages do not maintain any records pertaining to their water systems (Bor report), and we also found this to be true during the course of our study.

**Present Day Use of, and Knowledge Gaps about Village Water Systems**

In contemporary times, while the existence and use of village water systems are well recognized, they often remain overlooked by the public and underappreciated by regulatory and government bodies. These systems are generally viewed as inferior and problematic, with ongoing efforts to discourage their use, especially on Tutuila the Territory’s capital and most populous island. However, in parts of Eastern Tutuila, the necessity of village water persists, particularly where groundwater salinity levels compel residents to revert to these traditional sources. Despite their infrequent use, village water remains a crucial alternative, especially in light of Davis's early assessment (1963) that the combined discharge of Tutuila’s major streams could meet the island's domestic water needs—a situation that may no longer be true due to increased demand, but underscores the potential value of surface water in less favorable conditions or emergencies. The impact of climate change, coupled with observed supply chain disruptions from the Covid-19 pandemic, has highlighted the vulnerability of small island communities to water shortages triggered by drought, climate variability, or natural disasters. The groundwater system relies not only on availability of water but also of power, which currently is generated almost wholly by diesel generation, to pump water into the system. The storage capacity of the water distribution system's tanks in Tutuila is constrained, even under normal conditions. Additionally, several of the island's wells pump directly into the transmission systems, meaning that a power outage would swiftly lead to a water outage as well. In such times, village water sources become invaluable as emergency reserves, emphasizing the need to quantify and understand American Samoa’s surface water resources to safeguard against disruptions in the groundwater supply system.

**Purpose and scope of the report**

The purpose of this report is to comprehensively document and assess the status of village water systems across Tutuila, underscoring their critical role in the resilience and cultural heritage of the island. Historically, village water systems have been marginalized and are poorly documented, mainly due to concerns over safety and reliability which led to a government and Navy-driven push in the 1970s to phase them out in favor of groundwater systems. However, these traditional systems remain culturally significant and serve as a vital water source that does not rely on the vulnerable supply chains necessary for powering groundwater pumps. This report aims to:

1. Document the current usage of village water systems across Tutuila.
2. Assess the availability of streamflow for village water and other surface water diversion systems.
3. Explore how potential future climate scenarios could impact these resources.

Understanding the historical and present use of village water is essential not only for future surface water development but also to ensure equity and justice in managing a resource that supports often under-represented groups within the community.

**Geographical and Cultural Cultural Setting:**

American Samoa consists of a group of small high-volcanic islands located in the South Pacific at about 170° west longitude and 14° south latitude. Tutuila is the main island in the chain and has an area of 55 square miles. American Samoa is located roughly 2,300 miles southwest

of Hawaii, and 1,600 miles northeast of New Zealand. Tutuila, the largest island and the capital of the U.S. Territory is the center of government and business. Aunu'u, a satellite of Tutuila, lies one mile off the east coast of Tutuila.

The climate of American Samoa is tropical and characterized by a wet season lasting November through April and a dry season in May through October. The islands lie within the South Pacific

Convergence Zone (SPCZ), which in the wet season is typically characterized by weak and variable winds with frequent and intense convective rainstorms. Trade wind weather is more prevalent in the dry season and results in less, but still significant amounts of rainfall.

The Samoan people share their polynesian roots with other island cultures including Hawaiians, Cook Islanders, French Polynesians, Tongans, and the Māori of New Zealand. The traditional Samoan lifestyle is focused around the aiga, which consists of both close and extended family. In this system the family and community is prioritized over the individual. Communities in American Samoa typically are organized into villages which consist of one or more aigas and are traditionally governed by a Matai or chief. The matai is responsible for the welfare of all village residents and manages communal village assets such as communal land and the village water systems. The matai system of governance is politically complex and titles and responsibilities are bestowed based on the interplay of personal interest and family lineage. (need citation) This traditional system of governance currently co-exists, interacts with, and compliments the western democratic Government of American Samoa (ASG). The territorial annexation of American Samoa was initiated in the 1870s by requests to U.S. President Grant by a group of high-ranking Matai, and was completed by 1904 with the cession of the islands as a U.S. Territory (Leibowitz, 1980). This led to the establishment of a westernized governance structure overseen by the U.S. Navy, which terminated in 1951 and subsequently evolved into the ASG. The ASG, which incorporates elements of traditional Samoan and American governance, is framed by the American Samoan Constitution, ratified in 1967 (Faleomavae, 1990).

American Samoa is organized in a hierarchy of districts, counties, and villages. Central to this structure is the Office of Samoan Affairs (OSA), which serves as a crucial bridge between the traditional village leadership, led by chiefs or Matais, and the parliamentary democratic government that oversees broader territorial affairs. At the village level, decision-making power remains predominantly with the Matais; however, the daily administrative duties are managed by appointed leaders known as village mayors, or "Pulenuu." These mayors are responsible for acting as liaisons and ensuring the seamless operation of community activities. They also play a pivotal role as intermediaries between the villages and the OSA, facilitating communication and collaboration on issues that impact the community and its residents.

It is important to note that the primary focus of this report, village water systems, fall under the jurisdiction and management of the traditional Samoan governance system, and are generally not regulated by or within the purview of ASG departments. This underscores the enduring significance of the Matai system in managing essential community resources, despite the overlay of modern governance structures.

Because the data collected for this report were provided by indigenous leaders of modern-day, functioning, traditional areas of governance, it is important to recognize that these data remain under the ownership of each of the villages and their leadership. Therefore, the authors wish to acknowledge the sovereignty that each of the American Samoan Pulenuu retain over these data and we have taken steps to ensure that none of the information shared in this report encroaches on that sovereignty or contains any identifiable information regarding individuals, families, or locations of infrastructure.

### **2. Methodology**

**Collection of Village level data**

In order to determine village water usage patterns we obtained contact information for all village’s Pulenuu. This was initiated with a public records search through contacting OSA leadership. The OSA reviewed our proposed methods and agreed to support the project by providing contact information for 53 village-level officials. While there are 65 villages represented in the ASG database, some villages are currently uninhabited and others have leadership structures that overlap or extend to adjacent villages. A comprehensive list of all villages is presented in Table X. It is important to note that 13 villages lack perennial streams, therefore reducing the number of villages relevant for assessing water use to 52. Throughout the course of the study, we successfully reached out to and engaged with a total of 42 Pulenuu. The other 10 did not respond, or had incorrect contact information listed in the OSA records. These data were collected through phone calls, emails, and site visits with pulenuu and chiefs.

Our initial engagement with village Pulenuu was conducted via phone. All of the Pulenuu we were able to contact expressed a willingness and interest in discussing the use of water within their respective villages. Many agreed to meet in person and allowed us to conduct a site visit to see the construction and condition of the water systems. We gathered information from each mayor concerning the current operational status of their village water sources, the number of families that continue to depend on these systems, historical and present uses of the village water, and the ongoing necessity for these water systems. Although not every Pulenuu could answer all questions comprehensively, we have synthesized the collected data into the findings presented in Table X.

**Basin characteristic in geospatial analysis**

* To Understand and quantify aspects of the watersheds (i.e. basins) that supply the village water systems we
* Conducted geospatial analysis of watershed characteristics for the areas that lie above assumed village water intake locations
* Because the exact location of village water intake sites were not documented out of respect for the community’s privacy and indigenous data sovereignty, we assumed reasonable estimated locations for village water intakes in order to conduct basin-level analyses.
* The assumed locations were defined as the point on the stream directly above the highest elevation urbanization or development in the village. This is a reasonable assumption, because most village water system intakes are located at or near the urban-wildland interface in order to both avoid water quality issues from return flow, and to avoid excessive pipe and construction costs.
* These locations were often coincident and representative of locations where Wong (1996) reported historical USGS stream gauging sites
* It should be noted that village boundaries and watershed boundaries don’t perfectly match, although village and watershed names are used interchangeably in this report all geospatial analysis was conducted using the hydrologically defined watershed boundaries.
* This is due to the fact that the basic geographic governance unit in many polynesian cultures on high-volcanic islands encompassed control of the resources of an entire watershed from the mountain ridge to the sea. This governance structure is well known in Hawaii and is there called an ahupua'a, whereas in Samoa the term is nu’u and is translated into English simply as village.
* many villages contain multiple watersheds and while watersheds typically do not contain multiple villages, the geographic boundaries do not perfectly line up.
* Therefore we tried to select one intake location for each village, which means that some villages may have multiple different systems on multiple streams.
* This means that our hydrological assessment is likely to be a conservative estimate of water availability, as villages with more than one stream will have access to additional water, beyond what is calculated here.
* Once the intake location was defined for each watershed we clipped watershed boundaries to only encompass the area above the intake location, yielding the contributing basin area to stream at the intake location
* These areas were used to extract basin parameters from available and relevant geospatial datasets. These included
  + Land cover percentage derived from an analysis of land cover types defined by Meyer et al., 2016)
  + Average annual precipitation values derived from ([prizm data 2006??])
  + Basin slope from 3m DEM (CITATION)
  + [STILL NEED TO DO THE ANALYSIS ON FUTURE CLIMATE RAINFALL]
* Population counts for each village were obtained from the 2020 census data provided by the AS-DoC in their statistical yearbook (ASDOC, 2022)
* The results of these analysis are presented in table x

**Streamflow Quantification Methods: Expected availability of water**

The availability of surface water resources for use as a village water supply was determined through analysis of low-flow statistics developed by the USGS from gauged and ungauged perennial streams. The analysis was only conducted for those streams within watersheds that also contained inhabited villages. Most villages on Tutuila are located in watersheds with perennial streams, except for those villages located in the very hydrogeologically permeable Tafuna-Leone Plain (Fig. 1). Likewise, most watersheds with perennial streams, except for those that are located on the island’s remote north shore within and adjacent to the National Park of American Samoa generally contain inhabited villages. While there are a number of possible methods for assessing a watershed’s quantity of usable water, the typical construction of a village water system limits the type of water that can be used. Specifically, it is the baseflow component of the stream water that is used, as runoff in the steep hydraulically flashy mountains of Turuila usually contains such a high sediment load that it is not usable. While baseflow is variable, a conservative measure of a given stream’s minimum baseflow availability can be quantified using low-flow statistics as described below.

This analysis benefits from tremendous effort expended by the USGS during the many years of work the agency spent stream gauging at streams in American Samoa. Since the 1950s up until 2008, the USGS maintained eleven continuous record stream gauges, and measured baseflow discharge at 75 low-flow monitoring sites (Wong, 1996). Through analysis of these datasets Wong developed regression equations to estimate low-flow statistics in ungauged basins based on location and watershed parameters. Wong presented two separate equations for basins in the eastern portion of the island (those located East of the villages of Malaeimi and Nuuuli) and those in the Western portion. The two equations were of similar form but used different coefficients and took the following parameters into account:

* Drainage area above the gauging point
* Gage altitude above sea level
* Basin relief, equaling the difference between the watershed’s highest point and the gage elevation
* Basin Slope, equaling the product of basin relief and drainage density

**Low-flow statistics as a measure of surface water availability**

The 7-day average low-flow is calculated as the average streamflow over a 7-day rolling window. The magnitude of 7-day low-flow events can be described through yearly recurrence intervals in the same way flood events are described, e.g. the 100-year flood. Thus the 7-day 2-year low-flow represents the amount of flow that is expected to be exceeded in the stream for all but one week during a ‘typical’ 2-year period, with the word typical defined through analysis of existing streamflow records, which started in the late 1950s, and at some stations and continued through 2008. This statistic gives a reasonable indication of how much water users could expect to have available during typical years with normal amounts of seasonal variability. The 7-day 10-year low flow was also calculated for this assessment and was used to represent the amount of water users could expect to have available during exceptionally dry years. It should be noted that streamflow will nearly always be higher than the 7-day low flows, but due to the lack of storage reservoirs on nearly all of Tutuila’s basins, water can not be stored for dry periods and these times are when water availability is most critical.

Wong (1996) developed regression equations for calculating the mean, median, 7-day 2-year, and 7-day 10-year streamflows of streams throughout Tutuila. Because of differences between the hydrology of Western Tutuila and Eastern Tutuila two distinct sets of equations were developed to estimate streamflow in these different regions. Note the use of the derived parameter of basin slope (β), which is calculated from basin relief () and drainage density (λ), in Western Tutuila, but not Eastern Tutuila. In Western Tutuila The standard error of estimate, expressed as a percentage, for the 7-day 2-year low flow is 34.2%, for the 7-day 10-year low flow is 37.5%, for the mean flow is 36.5%, and for the median flow is 29.8%, and for eastern Tutuila, the standard errors of estimate for the same parameters are 95.2%, 110%, 62.6%, and 65.5%, respectively. These equations are presented in Table x and take the following parameters into account:

**(): Drainage area** calculated above the gauging point (in square miles)

**(): Gage altitude** (in feet above sea level)

**(): Basin relief** which is the difference between the highest point and the gage elevation in a basin

**(λ) Drainage Density:** calculated by dividing the total length of all stream channels in a basin by the drainage area **()**

**(β) Basin Slope:** calculated by multiplying the basin relief **()** by the drainage density **(λ)**

**Table x**

|  | **Western Tutuila** | **Eastern Tutuila** |
| --- | --- | --- |
| 7-day 2-year low flow |  |  |
| 7-day 10-year low flow |  |  |
| Mean flow |  |  |
| Median Flow |  |  |

* Basin characteristics use in the above equations were calculated through geospatial analysis as described above.
* for each assumed intake location the basin area (as a polygon) was defined as the portion of the watershed that lies at a higher elevation than the intake.
* Watershed boundaries from the American Samoa GIS portal (citation) were modified to only contain the hydrologically contributing area. This was used to calculate the drainage areas.
* Elevation and slopes were extracted from a 3-m DEM also procured from the (citation) American Samoa GIS portal. These data were used for each watershed to calculate the basin slope
* (What’s up with the drainage density thing??) look at Wong
* Identified individual villages through the Villages polygon on DoC ArcGIS users group village boundary file.
* For each village identified those with both populated areas and a perennial stream
* The actual locations of village water intakes was not known, and this also represents sensitive data as it is the location of a public water source, the locations of village water intakes was inferred by viewing satelite imagry and placing an estimated intake location generally at the point on the stream intersecting the village's development boundary.
* Basin characteristic data needed to apply USGS low-flow regression equations was collected through geospatial analysis, specifically:
* Intake Altitude was obtained through extracting DEM elevations directly to estimated intake locations
* The Basin Area was calculated by modifying a minor-watersheds shapefile obtained from the DoC ArcGIS users group to only include watershed area above the intake location. An area calculation was preformed on these modified watershed polygons (see Fig x for polygon shapes)
* Basin relief was calculated by looping through each villages modified watershed polygon and using these geometries to clip the Tutuila 3m DEM into a basin specific DEM. Maximum and minimul elevations of the basin specific DEM were extracted, then subtracted to obtain the basin relief.

**Notes from Wong: NOTE NEED TO RECALCULATE WESTERN TUTUILA**

**Check this stuff**

Basin slope (BSV-in feet/mile; determined by multiplying the basin relief and drainage density (BS = BR xDD) (Pg24).

Table 8. Regression equations for estimating low-flow characteristics for ungaged sites in region 2, western Tutuila,

American Samoa

[Region 2 shown in plate 1]

Regression equation

7Q2 - 0.00365 (DA)0-909 (GA)°- 110 (BS)°-594

7Q10 = 0.000925 (DA)0-922 (GA)°- 135 (BS)0- 645

Mean = 0.0862 (DA)0- 972 (BS)0'497

Median = 0.0464 (DA)0'964 (BS)0-510

Be sure to include as a footnote on the table the standard error:

Standard error of

estimate (percent)

| 7-day 2-year low flow |
| --- |
| 7-day 10-year low flow |
| Mean flow |
| Median Flow |

Is for eastern

95.2

110

62.6

65.5

Is for Western

34.2

37.5

36.5

29.8

* We applied these equations to all basins with known or possible village water systems, using an approximated village water intake location in each watershed as the assumed ‘gauge location’ as described above
* Elevation data and basin relief were calculated from a 3m DEM (Data Citation)
* Basin boundaries were defined using those determined by the national hydraulic dataset (NHD) (citation needed)
* Parameters were calculated and 7-day low flows and average and median flows are presented in table x

**Plan for getting stream flows at village systems**

Data files to pull:

* AS DEM - 3 m or 1 m
* Shapefile of village basins (probably needs to be modified somewhat)
* Create shapefile of village water points (these will be used for the gage altitude) This is manual creation based on the top of the village development
* NHD shapefile of streams

**Parameters needed:**

* Gage altitude for each village water intake
* Basin Area for each village water basin
* Basin relief from top to gage location
* Drainage density for each basin
* Drainage slope (multiply drainage density by basin relief)

**Tasks to create data**

* Create points shapefile by looking at all the villages on satellite and dotting the top (make sure that each village on Tine’s list is represented)
* Create basins file with the watersheds and cutting to the points
* For each basin clip drainages on NHD to basin shape then measure length of all to get **Drainage density**
* For each clip DEM raster then calculate highest and lowest points to get **Basin relief**
* For each point extract DEM values to get **Gage altitude**
* For each basin calculate the area to get **Basin Area**
* Multiply drainage density by basin relief to get **Basin slope**
* Then Apply the equations in Wong for each western or eastern stream to get the low flows and mean values.

**Results**:

### **3. Current Water Use in Village Systems**

* Of the 44 villages surveyed 24 of them noted that some residents still use village water for drinking, bating, agriculture, or other uses.
* This represents about 49% of those villages that contain perennial streams.
* 10 of them noted that the village used to have a village water system, but currently nobody to their knowledge is currently using it. This represented 20% of those villages with perennial streams.
* 4 mayors were uncertain as to if the village contained a system and did not know if anyone in the village was using village water.
* We were unable to make contact with 11 of the pulenuu in villages with perennial streams, therefore we are missing data for these 11 villages or 22% of the villages with streams
* Thus of the 53 pulenuu we had contact info for, 42 of them discussed water use with us yielding a response rate of 79%.

(Rectify statements on these two outlines )

* Of the 51 villages on Tutuila, we obtained village level data for 78% (40 villages). We encountered a non-response rate of 22%, primarily due to not having the correct contact information.
* Of the 24 villages on Tutuila with active village water systems as confirmed by village leaders, we obtained household level data for 67% (16 villages)
* Data and code are made publicly available in this GitHub repository: https://github.com/cshuler/Am\_Samoa\_WUDR\_ASPA/Village\_Water
* Results are currently being documented in a stand-alone report covering village water usage and availability. Highlights include the following results:
  + The spatial distribution of baseflow, which is the primary source of village water used and was represented by the calculated lowest 7-day average flow in a “typical” 2 year timespan, ranged between 13 GPM to 233 GPM, as shown on Figure 1: Map of village water availability based on calculated low-flow estimates of streams in GPM.
  + Distribution and status of village water systems varied throughout the island of Tutuila, as shown on Figure 2: Map of known village water usage showing villages that actively use village water.
* Figure X shows a map of which villages actively use village water. Villages with active village water systems are in yellow, and the four villages where pulenuu are uncertain as to if village water is used are marked with light yellow. Villages that historically used village water, but no longer do are shown in light blue, and villages without perennial streams are shown in gray. Those villages for which we were unable to contact pulenuu are left white.

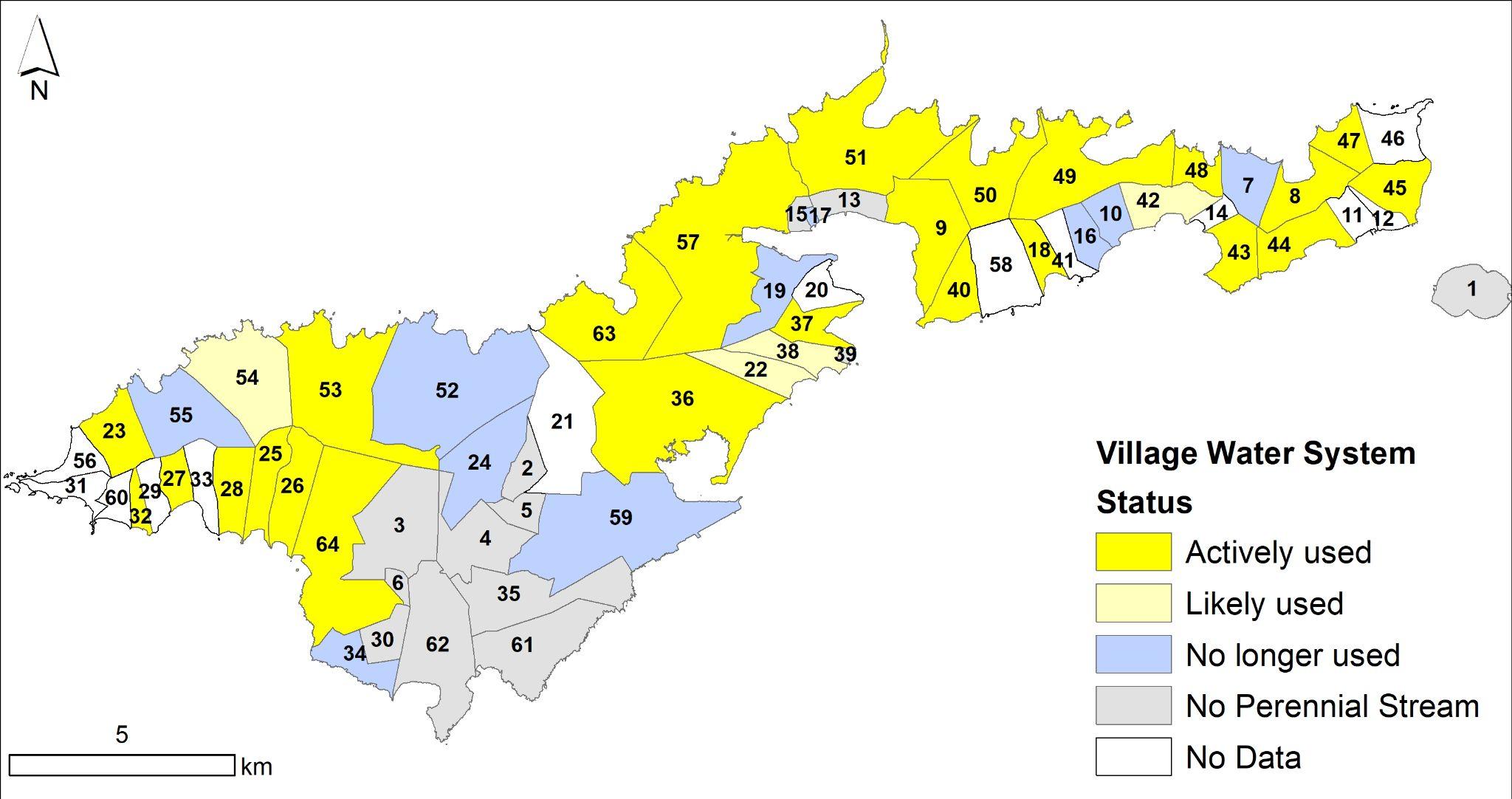


Figure 2: Map of known village water usage showing villages that actively use village water in yellow and where available, estimates of the number of households using village water.

**Data Table 1: Generalized characteristics of villages with streams that may or do support village water systems.**

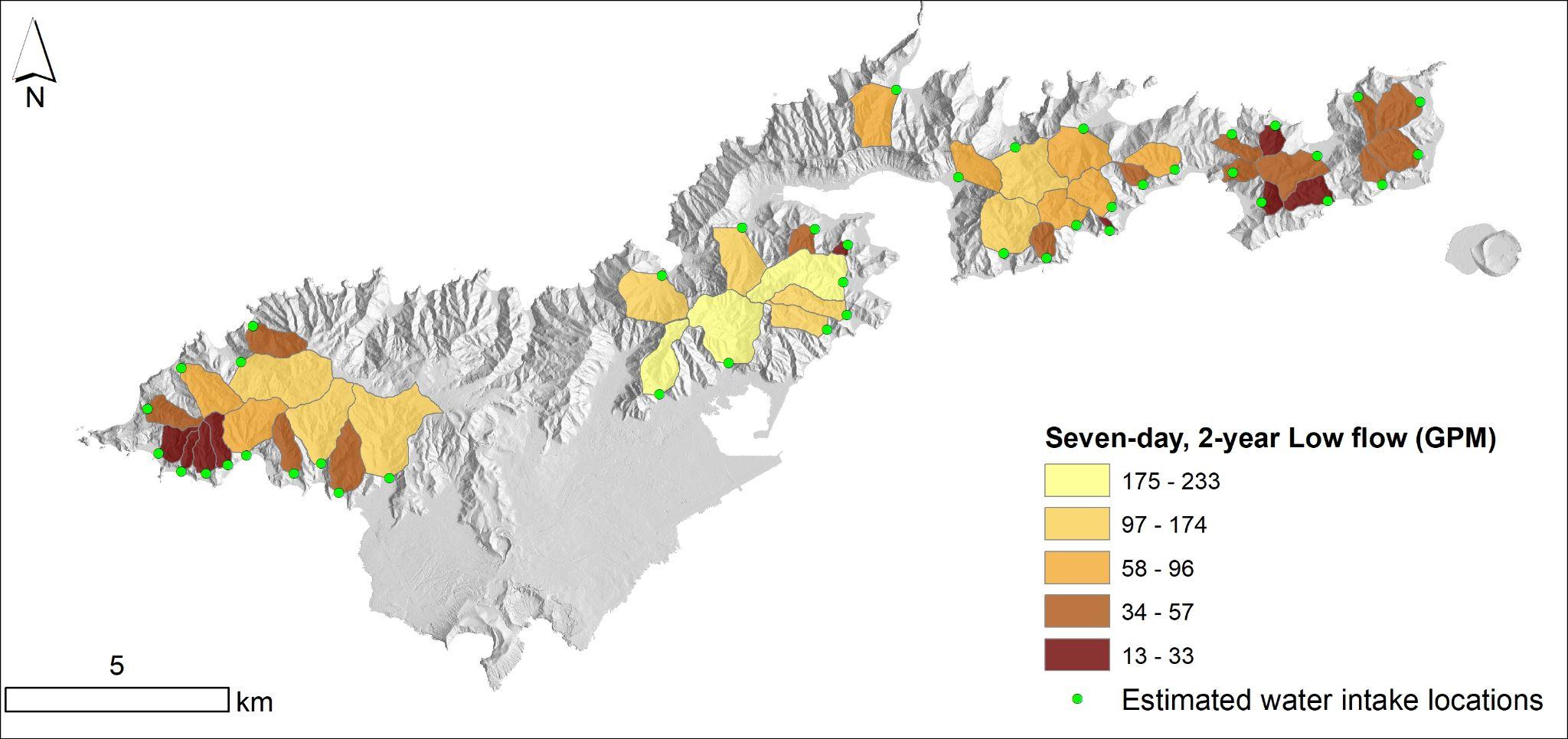
| **Map Number** | **Watershed or Village Name** | **Village Leaders Surveyed** | **Village Water System Status** | **Number of Households using Village Water** | **2020 Population** |
| --- | --- | --- | --- | --- | --- |
| 1 | Aunuu | Yes | No Perennial Stream | - |  |
| 2 | Mesepa | Yes | No Perennial Stream | - |  |
| 3 | Malaeloa Aitulagi | No | No Perennial Stream | - |  |
| 4 | Pavaiai | No | No Perennial Stream | - |  |
| 5 | Faleniu | No | No Perennial Stream | - |  |
| 6 | Malaeloa Ituau | No | No Perennial Stream | - |  |
| 7 | Sailele | Yes | No longer used | 0 | 60 |
| 8 | Aoa | Yes | Actively used | 20+ | 344 |
| 9 | Aua | Yes | Actively used | unknown | 1549 |
| 10 | Amaua | Yes | No longer used | 0 | 68 |
| 11 | Auasi | No | No Data | - | 88 |
| 12 | Utumea East | No | No Data | - |  |
| 13 | Leloaloa | Yes | No Perennial Stream | - |  |
| 14 | Pagai | No | No Data | - | 81 |
| 15 | Anua | No | No Perennial Stream | - |  |
| 16 | Auto | Yes | No longer used | 0 | 214 |
| 17 | Atuu | Yes | No longer used | 0 |  |
| 18 | Alega | Yes | Actively used | 1+ | 29 |
| 19 | Fagatogo | Yes | No longer used | 0 | 1445 |
| 20 | Utulei | No | No Data | - | 479 |
| 21 | Malaeimi | No | No Data | - |  |
| 22 | Faganeanea | Yes | May be used | unknown | 93 |
| 23 | Fagalii | Yes | Actively used | 30+ | 163 |
| 24 | Mapusagafou | Yes | No longer used | 0 |  |
| 25 | Asili | Yes | Actively used | 17 | 157 |
| 26 | Amaluia | Yes | Actively used | 10 | 163 |
| 27 | Seetaga | Yes | Actively used | 10+ | 177 |
| 28 | Afao | Yes | Actively used | 70+ | 96 |
| 29 | UtumeaWest | No | No Data | - | 42 |
| 30 | Taputimu | Yes | No Perennial Stream | - |  |
| 31 | Amanave | No | No Data | - | 246 |
| 32 | Agugulu | No | Actively used | 10+ | 42 |
| 33 | Nua | Yes | No Perennial Stream | - |  |
| 34 | Vailoatai | Yes | No longer used | 0 |  |
| 35 | Iliili | No | No Perennial Stream | - |  |
| 36 | Nuuuli | Yes | Actively used | unknown | 4991 |
| 37 | Fagaalu | Yes | Actively used | unknown | 731 |
| 38 | Matuu | Yes | May be used | unknown | 317 |
| 39 | Fatumafuti | No | No Perennial Stream | - |  |
| 40 | Laulii | Yes | Actively used | 60+ | 736 |
| 41 | Avaio | No | No Data | - | 34 |
| 42 | Fagaitua | Yes | May be used | unknown | 287 |
| 43 | Alofau | Yes | Actively used | 6 | 296 |
| 44 | Amouli | Yes | Actively used | 20+ | 261 |
| 45 | Alao | Yes | Actively used | 10+ | 275 |
| 46 | Tula | No | No Data | - | 308 |
| 47 | Onenoa | Yes | Actively used | 1 | 100 |
| 48 | Masausi | Yes | Actively used | 2 | 134 |
| 49 | Masefau | Yes | Actively used | 10 | 260 |
| 50 | Afono | Yes | Actively used | unknown | 327 |
| 51 | Vatia | Yes | Actively used | 30 | 460 |
| 52 | Aasu | Yes | No longer used | 0 |  |
| 53 | Aoloau | Yes | Actively used | unknown |  |
| 54 | Fagamalo | Yes | May be used | unknown | 37 |
| 55 | Maloata | Yes | No longer used | 0 | 6 |
| 56 | Poloa | No | No Data | - | 130 |
| 57 | PagoPago | Yes | Actively used | 8 | 3000 |
| 58 | Aumi | No | No Data | - | 176 |
| 59 | Tafuna | Yes | No longer used | 0 |  |
| 60 | Failolo | No | No Data | - | 87 |
| 61 | Vaitogi | Yes | No Perennial Stream | - |  |
| 62 | Futiga | Yes | No Perennial Stream | - |  |
| 63 | Fagasa | Yes | Actively used | 70 | 577 |
| 64 | Leone | Yes | Actively used | unknown | 1598 |

Make a master Data Table:

Village, Perennial stream, Surveyed, Active, number of households, 7Q2\_GPM, 7Q10\_GPM

**Results: water availability**

* In general those villages located in watersheds surrounding the islands highest peaks, Mt. Matafaou (check spelling) and Rainmaker Mountain or (in Samoan) are estimated to yield the highest baseflow, and thus have the highest potential for village water use.
* This is reasonable as these areas also receive the highest precipitation and contain relatively large steep watersheds
* 5 high and 5 low for flow
* Quantifying the availability of streamflow via a 7-day 2 year low-flow statistic in all villages. This availity ranged from 12 GPM in villages with the smallest streams to 233 GPM in villages with the largest.



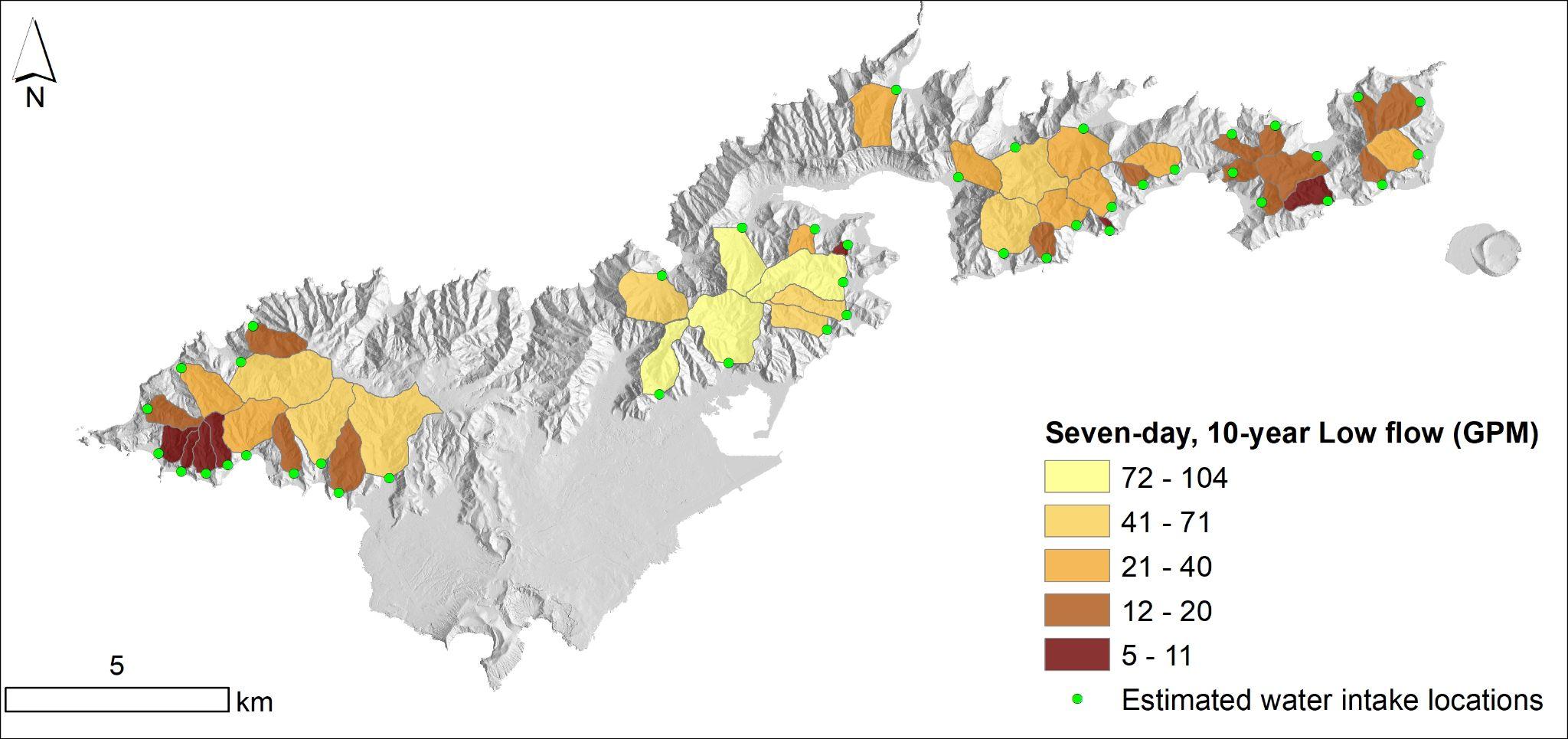
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Figure 1: Maps of village water availability based on calculated low-flow estimates of streams in GPM. Green dots represent estimated water intake locations and do not indicate actual water system infrastructure locations to protect village privacy and data sovereignty.

**Table x flow**

| **Map Number** | **Watershed or Village Name** | **Village Water System Status** | **Drainage Area (mi2)** | **Ave. Slope (deg)** | **Ave. Precip. (inches)** | **7-day, 2 year low flow (GPM)** | **7-day, 10 year low flow (GPM)** | **Average Flow (GPM)** | **Median Flow (GPM)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | Sailele | No longer used | 0.12 | 26 | 105 | 32 | 12 | 219 | 104 |
| 8 | Aoa | Actively used | 0.39 | 24 | 110 | 44 | 17 | 457 | 222 |
| 9 | Aua | Actively used | 0.30 | 34 | 176 | 96 | 40 | 709 | 355 |
| 10 | Amaua | No longer used | 0.10 | 32 | 147 | 44 | 18 | 270 | 131 |
| 11 | Auasi | No Data | 0.13 | 25 | 108 | 35 | 14 | 295 | 143 |
| 14 | Pagai | No Data | 0.12 | 29 | 116 | 40 | 16 | 252 | 121 |
| 16 | Auto | No longer used | 0.29 | 31 | 168 | 76 | 31 | 469 | 230 |
| 18 | Alega | Actively used | 0.27 | 31 | 177 | 64 | 26 | 462 | 226 |
| 19 | Fagatogo | No longer used | 0.12 | 30 | 200 | 54 | 23 | 306 | 149 |
| 20 | Utulei | No Data | 0.03 | 37 | 179 | 19 | 8 | 113 | 54 |
| 22 | Faganeanea | May be used | 0.25 | 37 | 209 | 139 | 62 | 796 | 403 |
| 23 | Fagalii | Actively used | 0.37 | 26 | 149 | 68 | 27 | 487 | 289 |
| 25 | Asili | Actively used | 0.62 | 26 | 204 | 112 | 45 | 837 | 496 |
| 26 | Amaluia | Actively used | 0.35 | 20 | 184 | 45 | 17 | 435 | 258 |
| 27 | Seetaga | Actively used | 0.46 | 27 | 178 | 65 | 24 | 608 | 361 |
| 28 | Afao | Actively used | 0.21 | 26 | 184 | 38 | 15 | 263 | 157 |
| 29 | UtumeaWest | No Data | 0.16 | 24 | 158 | 29 | 11 | 205 | 123 |
| 31 | Amanave | No Data | 0.17 | 24 | 136 | 23 | 8 | 192 | 114 |
| 32 | Agugulu | Actively used | 0.16 | 25 | 148 | 28 | 11 | 195 | 116 |
| 36 | Nuuuli | Actively used | 0.77 | 36 | 221 | 233 | 104 | 1379 | 701 |
| 37 | Fagaalu | Actively used | 0.66 | 36 | 203 | 185 | 80 | 1291 | 657 |
| 38 | Matuu | May be used | 0.25 | 37 | 204 | 131 | 58 | 745 | 375 |
| 40 | Laulii | Actively used | 0.54 | 34 | 175 | 126 | 53 | 937 | 470 |
| 41 | Avaio | No Data | 0.02 | 30 | 157 | 13 | 5 | 86 | 41 |
| 42 | Fagaitua | May be used | 0.25 | 27 | 132 | 64 | 26 | 402 | 195 |
| 43 | Alofau | Actively used | 0.10 | 30 | 112 | 33 | 13 | 199 | 95 |
| 44 | Amouli | Actively used | 0.21 | 26 | 109 | 26 | 9 | 273 | 131 |
| 45 | Alao | Actively used | 0.30 | 29 | 106 | 57 | 23 | 442 | 215 |
| 46 | Tula | No Data | 0.29 | 23 | 99 | 37 | 14 | 364 | 176 |
| 47 | Onenoa | Actively used | 0.13 | 28 | 101 | 45 | 18 | 286 | 138 |
| 48 | Masausi | Actively used | 0.14 | 27 | 111 | 36 | 14 | 274 | 132 |
| 49 | Masefau | Actively used | 0.47 | 28 | 153 | 82 | 33 | 602 | 295 |
| 50 | Afono | Actively used | 0.58 | 33 | 170 | 163 | 71 | 965 | 484 |
| 51 | Vatia | Actively used | 0.44 | 32 | 167 | 81 | 32 | 791 | 395 |
| 54 | Fagamalo | May be used | 0.28 | 29 | 155 | 52 | 20 | 394 | 235 |
| 55 | Maloata | No longer used | 0.85 | 26 | 184 | 153 | 62 | 1130 | 668 |
| 56 | Poloa | No Data | 0.21 | 26 | 134 | 36 | 14 | 247 | 147 |
| 57 | PagoPago | Actively used | 0.44 | 31 | 201 | 174 | 78 | 864 | 434 |
| 58 | Aumi | No Data | 0.14 | 31 | 172 | 42 | 17 | 282 | 136 |
| 60 | Failolo | No Data | 0.08 | 27 | 142 | 14 | 5 | 88 | 53 |
| 63 | Fagasa | Actively used | 0.54 | 32 | 186 | 119 | 50 | 940 | 471 |
| 64 | Leone | Actively used | 0.99 | 26 | 208 | 169 | 67 | 1395 | 825 |

**Basin characteristics and Land use**

Water availability is dependent on watershed condition and characteristics. It is well known that degraded lands have a lower capacity for producing and retaining water and also may have negative impacts on water quality.

|  | | | | | | **Percentage of land under given land use** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Map Number** | **Watershed or Village Name** | **Village Water System Status** | **Drainage Area (mi2)** | **Ave. Precip. (inches)** | **Ave. Slope (deg)** | **Developed** | **Agriculture** | **Forest** | **Scrubland** |
| 7 | Sailele | No longer used | 0.12 | 105 | 26 |  |  | 97 | 3 |
| 8 | Aoa | Actively used | 0.39 | 110 | 24 | 1 | 6 | 89 | 4 |
| 9 | Aua | Actively used | 0.30 | 176 | 34 | 5 | 20 | 64 | 12 |
| 10 | Amaua | No longer used | 0.10 | 147 | 32 |  |  | 96 | 4 |
| 11 | Auasi | No Data | 0.13 | 108 | 25 |  | 2 | 95 | 3 |
| 14 | Pagai | No Data | 0.12 | 116 | 29 | 3 | 10 | 83 | 5 |
| 16 | Auto | No longer used | 0.29 | 168 | 31 | 0 | 0 | 95 | 5 |
| 18 | Alega | Actively used | 0.27 | 177 | 31 |  |  | 98 | 3 |
| 19 | Fagatogo | No longer used | 0.12 | 200 | 30 | 1 | 1 | 97 | 1 |
| 20 | Utulei | No Data | 0.03 | 179 | 37 | 0 | 5 | 88 | 7 |
| 22 | Faganeanea | May be used | 0.25 | 209 | 37 |  | 0 | 94 | 6 |
| 23 | Fagalii | Actively used | 0.37 | 149 | 26 | 1 | 7 | 91 | 2 |
| 25 | Asili | Actively used | 0.62 | 204 | 26 | 0 | 4 | 94 | 3 |
| 26 | Amaluia | Actively used | 0.35 | 184 | 20 | 2 | 9 | 75 | 14 |
| 27 | Seetaga | Actively used | 0.46 | 178 | 27 | 1 | 6 | 91 | 2 |
| 28 | Afao | Actively used | 0.21 | 184 | 26 | 0 | 8 | 91 | 2 |
| 29 | UtumeaWest | No Data | 0.16 | 158 | 24 |  | 4 | 94 | 3 |
| 31 | Amanave | No Data | 0.17 | 136 | 24 | 1 | 19 | 74 | 6 |
| 32 | Agugulu | Actively used | 0.16 | 148 | 25 | 0 | 16 | 81 | 3 |
| 36 | Nuuuli | Actively used | 0.77 | 221 | 36 | 1 | 3 | 88 | 7 |
| 37 | Fagaalu | Actively used | 0.66 | 203 | 36 | 3 | 4 | 79 | 13 |
| 38 | Matuu | May be used | 0.25 | 204 | 37 |  | 0 | 94 | 6 |
| 40 | Laulii | Actively used | 0.54 | 175 | 34 | 1 | 8 | 76 | 16 |
| 41 | Avaio | No Data | 0.02 | 157 | 30 |  | 1 | 95 | 4 |
| 42 | Fagaitua | May be used | 0.25 | 132 | 27 | 0 | 2 | 93 | 6 |
| 43 | Alofau | Actively used | 0.10 | 112 | 30 | 0 | 2 | 94 | 4 |
| 44 | Amouli | Actively used | 0.21 | 109 | 26 | 3 | 11 | 84 | 2 |
| 45 | Alao | Actively used | 0.30 | 106 | 29 | 0 | 6 | 90 | 5 |
| 46 | Tula | No Data | 0.29 | 99 | 23 | 0 | 25 | 71 | 4 |
| 47 | Onenoa | Actively used | 0.13 | 101 | 28 |  | 0 | 99 | 1 |
| 48 | Masausi | Actively used | 0.14 | 111 | 27 | 2 | 13 | 78 | 7 |
| 49 | Masefau | Actively used | 0.47 | 153 | 28 | 1 | 7 | 80 | 13 |
| 50 | Afono | Actively used | 0.58 | 170 | 33 | 1 | 7 | 78 | 15 |
| 51 | Vatia | Actively used | 0.44 | 167 | 32 | 1 | 4 | 91 | 5 |
| 54 | Fagamalo | May be used | 0.28 | 155 | 29 | 1 | 4 | 94 | 1 |
| 55 | Maloata | No longer used | 0.85 | 184 | 26 | 0 | 0 | 98 | 2 |
| 56 | Poloa | No Data | 0.21 | 134 | 26 | 2 | 6 | 90 | 3 |
| 57 | PagoPago | Actively used | 0.44 | 201 | 31 | 4 | 20 | 72 | 3 |
| 58 | Aumi | No Data | 0.14 | 172 | 31 |  | 2 | 96 | 2 |
| 60 | Failolo | No Data | 0.08 | 142 | 27 | 0 | 1 | 98 | 2 |
| 63 | Fagasa | Actively used | 0.54 | 186 | 32 | 2 | 15 | 79 | 4 |
| 64 | Leone | Actively used | 0.99 | 208 | 26 | 1.1 | 14.2 | 79.8 | 4.9 |

**Results of basin characteristics**

* The 5 villages with the highest precip rates are
* Lowest are
* 5 most pristine 5 most developed
* Most populated leas populated are

**Modern indigenous perspectives on water rights and use**

Who “owns” the water in Samoa? Who is tasked with caring for it?

* Water is considered communal property, the whole village owns the water but the Matai has control and power over all natural resources including water, and is also tasked with caring for it.
* Matai acts through the Pulenuu, who takes much of the responsibility for village upkeep, to maintain the village water systems

Does water hold a special place in Samoan religious or cultural practice?

* In Hawaii wai means water, and waiwai means wealth
* In Samoa vaivai means a pool or stream or weakness/fatigue (informal term) perhaps this reflects the relative more abundance of water in Samoa?
* In the modern day technology is driving a disconnect between many AS people’s day to day life and traditional cultural practice in AS. Whereas in Hawaii the cultural revolution of the 70’s brought attention to the fragility of traditional practice and perspectives
* In the villages in AS, the connection and reliance on natural resources and vai is stronger, due to necessity though.
* Samoan baptisms are the main religious (AS is primarily Christian) connection to water, but often in the ocean.
* Village water is also a source of social connection. The Samoan people sometimes gather near the springs to chat, tell stories, and pass down traditions. A reminder of their shared cultural heritage and the importance of community in the Samoan culture.

What are different people’s perspectives on and thoughts about ASPA?

* In general people in AS appreciate ASPA and the manner in which they manage the island’s water.
* ASPA does a good job of making municipal water easy to access (in comparison to other locales in the Pacific)
* However, the cost of ASPA water is the primary reason people with access to village water don’t use it. Primarily for conservation of water and mainly money.
* In Masefau, it is thought that ASPA water development has reduced the streamflow and reduced the growth of vegetation so some villagers are suspicious that ASPA’s manager is impacting their day-to-day practices. This is not a widespread problem, yet, and not on people’s minds, though in Hawaii, GW pumping is well known to impact and reduce baseflow.

Is there a difference in cultural viewpoints on village water vs ASPA water?

* Perspective is often very practical. Based on cost, taste, odor, and other factors related to availability, and cost of maintaining the village water system.
* Many times village water is used for farming , showering and washing cars, because its free vs ASPA water which is costly
* ASPA water quality is variable, when its very salty the village water is more valuable
* Its also clear and known that village water quality variable, if near piggereis, its not desirable, but if coming from a more pristine source its considered more valuable
* ASPA is often used for drinking and cooking due to the higher guarantee for safety
* Seen as a backup for when ASPA water goes out or when there are low-pressure calls, And it was used as a backup during Hurricane Heta, and other events that caused outages.

Do different villages hold different views on water use, availability, ownership etc?

* Obviously all villages are different and use the village water in different ways based on the above notes on practicality-based use.
* In independent Samoa there is more village water usage, more of the population relies on village water systems due to less developed municipal systems.
* There is such abundant rainfall that in general there is not much contention about availability of water.
* Village water is collected from several sources, including rainwater harvesting, surface water, and groundwater. Rainwater harvesting is the most common source of village water usage in American Samoa, as it is the cheapest and most readily available. Rainwater is collected in large tanks and stored until needed. Surface water is the second most common source of village water in the islands. Surface water is collected from streams, rivers, and lakes and can be used for drinking, cooking, and bathing. Groudwater is the least common source and is usually found in wells.

1. Why is village water important?
   1. Most villages in Tutuila are located near the base of the mountains or on lowlands near the shore. The villages around the island with “fales” (houses), piggeries, and plantations would reach up into the hills, taking advantage of what little productive land was available. Villages use surface water streams or springs as their sources of water supply mainly for household or drinking water which is likely collected from reservoirs on the stream above the village. Some of the reservoirs still exist today and some villagers still use this source of water for piggeries, plantations, or outdoor showers.
2. When were these kinds of water systems built?
   1. For many years, villages do not maintain any records related to their water system or information about when these systems were built. However, according to some of the villagers interviewed, these systems were around before the arrival of western influence. In early Samoa, people relied on streams, springs, or along the ocean shore as a source for their water supply. These systems were owned and operated by the villages at no charge so villagers could use them anytime.
3. Why aren't they used very much today?
   1. Most villages have not been using their village water system today for many reasons. The increase in population in Tutuila over the years has led to high demand for access to the water supply by villagers and other government facilities. Additionally, this also led to many homes having indoor plumbing and quick access to a direct water supply. The quality of water was also threaten with contamination from the used of chemical or pesticide
4. What are some of the difficulties in maintaining the systems?

1. What do the village leaders think about these systems? Do they think they are useful? Or Do any of them want them removed?
   1. The village leaders
2. Is there anyone else besides the villagers (like government agencies, or other groups) who have opinions or ideas about the village water systems?

Streamflow low flows and the need for clever tech or active management when turbidity spikes. Candymans system

NOtes:

* Laulii still actively maintaining a hard to maintain system, replacing with new pipes, investing new materials in the construction, etc, not just using legacy systems

List of documents that say things about village water

**Appendix Selected Photos of Village water Systems.**

**Refs**

Green, R. C. (1991). "The Lapita Horizon and Traditions - Signature for one set of Oceanic migrations." In: The Lapita Cultural Complex in Time and Space: Expansion Routes, Chronologies and Typologies. Eds. P. V. Kirch and T. L. Hunt. pp. 41–68. Auckland: University of Auckland.  
  
ASDOC (2022). American Samoa Statistical Yearbook 2022 (39th ed.). The American Samoa Department of Commerce Statistics and Analysis Division. Retrieved July 17, 2024, from https://www.doc.as.gov/resource-center