ACHUGAO WATERSHED MANAGEMENT PLAN 2020-2030

November 2022 DRAFT

PREPARED FOR:
CNMI Bureau of Environmental and Coastal Quality ,
Division of Coastal Resource Management and the
NOAA Coral Reef Conservation Program

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2030 Achugao

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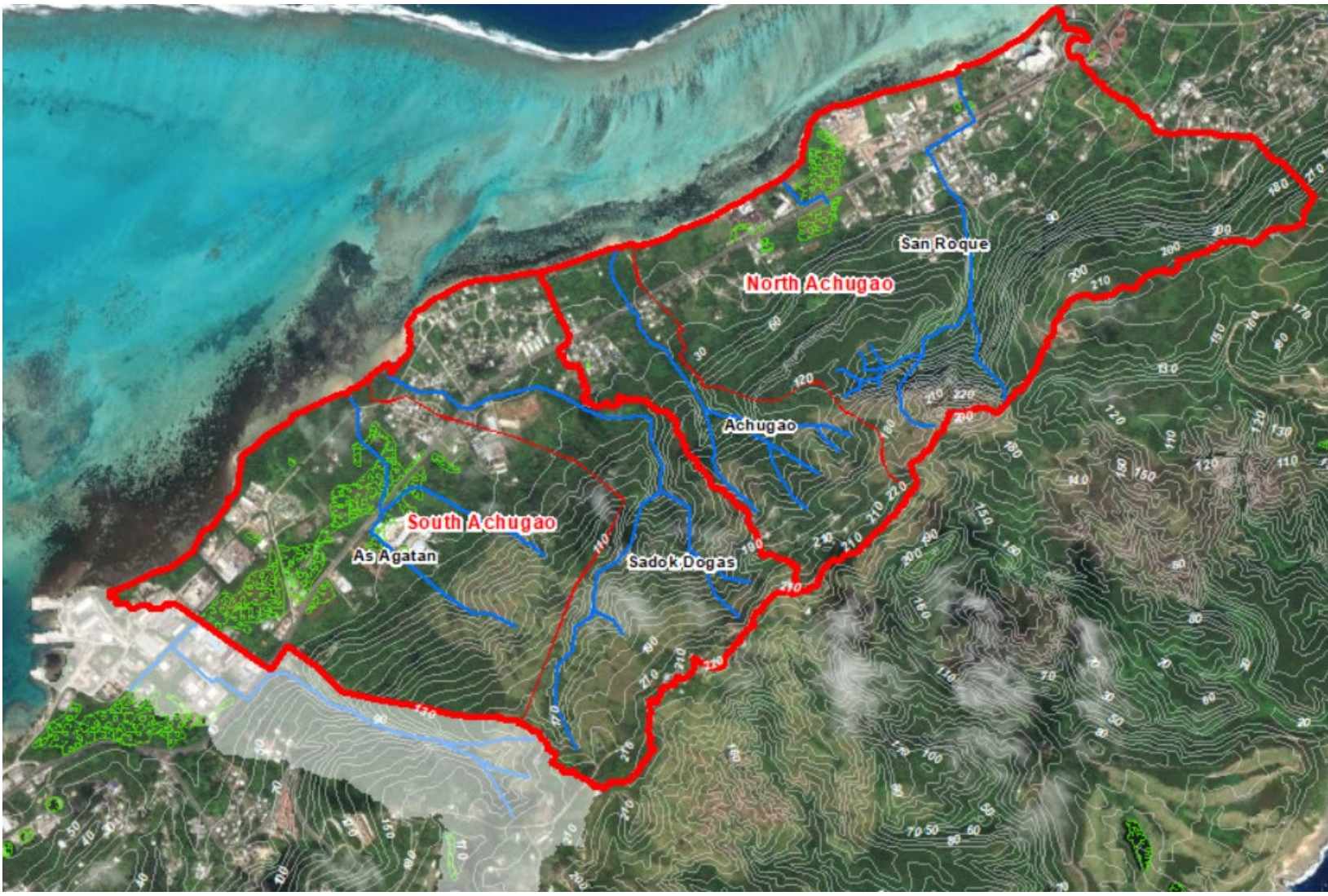
Executive Summary



The Watershed

Achugao was identified as one of four priory watersheds in the CNMI for assessment and management planning. Development pressures and coastal hazards along Saipan's northwest coast are high, threatening the health of natural resources and the condition of infrastructure servicing the communities of Tanapag and San Roque. Coastal waters and streams are currently listed as impaired for one or more parameters including dissolved oxygen, marine benthic habitat, heavy metals, and bacteria derived from past military operations, piggeries, unmanaged stormwater runoff, sewer overflows and septic systems, and wildfires.

Our Vision

Stakeholders envision Achugao as a watershed that reflects:

1. Controlled developed in keeping with the current sense of place (focused on small-scale tourism and redevelopment);
2. Sustainability and climate resilience (flood and fire resistance); and
3. Healthy natural resources (fishing, water quality, corals, etc.).

Management priorities and site-specific restoration opportunities were identified within the watershed. Modeling suggests implementation of key projects could help reduce pollutant loads by 40%, but this improvement could be easily negated by future, unmanaged development.

Restoration Roadmap

Four overarching watershed management goals were established to achieve the vision and to integrate with other CNMI planning initiatives for 2020-2030 (e.g., the Sustainable Comprehensive Development Plan, Micronesian Challenge, Smart Growth Guidance, and Forest Action Plan). Implementation actions were recommended under each goal.

GOAL #1: Reduce urban pollutant loads to Tanapag Lagoon by managing 30+ acres of existing impervious cover, applying better land use controls on new development, and maintaining infrastructure.

1.1. Retrofit existing development with green stormwater infrastructure (e.g., schools, hotels, industrial area, and roads).

1.2. Aggressively enforce erosion and sediment control at construction sites and ensure remediation actions occurs.

1.3. Update technical design manuals for stormwater & wastewater technologies to address climate adaptation and to apply standards to redevelopment, large renovations, and road improvements to address existing problems.

1.4. Find opportunities to promote sustainable and locally appropriate development by addressing inconsistencies, gaps, and barriers in land development procedures (e.g., permitting, land lease, and zoning).

1.5. Increase maintenance capacity for drainage system by developing an inspection and maintenance schedule, purchasing new equipment (e.g., remote cameras, vactor trucks), and hiring/training more staff on maintenance of green infrastructure and MS4 program requirements.

GOAL #2: Adopt predicted rainfall amounts, sea level rise estimates, groundwater elevations, and storm surge levels for the 30-yr planning horizon (year 2050), at a minimum, for development and infrastructure planning.

2.1. Update environmental permitting requirements to reflect climate-forward calculation requirements.

2.2. Reduce wastewater system vulnerability by raising/replacing sewer manholes subject to flooding, get ahead of buildout by upgrading sewer line at Imperial Casha and implementing a subsidy program for septic inspections and hookups.

2.3. Use a living shoreline approach where erosion exists or is expected to worsen, and where conditions are favorable for short-term success.

2.4. Expand stream monitoring efforts to establish flow and peak discharge rates for the four major tributaries.

2.5. Begin to engage the community in discussions related to managed retreat and initiate an open dialogue about the low-lying cemetery, wetland migration areas, and the most vulnerable homes and businesses.

GOAL #3: Protect or restore 30% of the terrestrial and wetland habitats in the watershed through invasive species management, native reforestation, and land conservation.

3.1. Conduct on-site surveys of terrestrial and wetland habitats to determine the status of health and to identify potential needs and approach to management.

3.2. Identify legal and financial mechanisms to conserve remaining undeveloped lands that are deemed critical for habitat or climate resiliency.

3.3. Review and update tree protection regulations to minimize further loss of native, large diameter trees, provide clear guidance for tree removal criteria on public lands, and incentivize urban canopy cover.

3.4. Implement habitat restoration projects and invasive management program.

3.5. Promote Forest Stewardship Program for restoration on private lands.

GOAL #4: Empower community-based watershed stewardship by conducting at least 30 engagement, advocacy, and educational outreach activities.

4.1. Implement wildfire prevention education and outreach.

4.2. Continue to engage schools and community groups in hands-on restoration projects (e.g., plantings, rain gardens, trash removal in streams, WQ monitoring) through the Watershed Warrior program.

4.3. Provide pollution prevention and sustainability technical services for local businesses.

4.4. Increase number of opportunities for public input in development permitting process, hazard vulnerability planning, restoration project designs, etc.

4.5. Educate landowners, residents, and farm workers on sustainable practices related to pet and livestock waste management.

4.6. Provide more trash collection services for lower income families and offer more community clean up events.

4.7. Educate decision makers and landowners on the economic value of watershed services.

Introduction

Background

The Achugao watershed was identified by the CNMI BECQ Division of Coastal Resource Management (DCRM) and the NOAA Coral Reef Conservation Program as a priority watershed on Saipan for management planning. Land-based sources of pollution (LBSP) have been identified as a major threat to coral reefs from the national-level: "Pollution Pillar" of the 2019 NOAA Coral Reef Conservation Program Strategic Plan and local-level "Land-Based Sources of Pollution Pillar" of 2019-2029 CNMI Coral Reef Management Priorities. A watershed-based approach is advised for addressing LBSP and their sources within management jurisdictions.

Figure 1. Location of the Achugao Watershed on Saipan, CNMI

The Achugao watershed extends from the lower base industrial complex northward to the Kensington Hotel in San Roque and drains to Tanapag Lagoon (the northern segment of Saipan Lagoon). It includes the coastal village of Tanapag, several resorts (operational, abandoned, and under construction), two public schools, and the steep, vegetated grasslands between Middle Road and Wireless Ridge/Mt. Susu. This moderately developed watershed north of Garapan is experiencing increased development pressure. Residences, schools, roads, and businesses located seaward of between Middle Road are vulnerable to storm damage and sea level rise, particularly in the lower base area.

The 1,610-ac (2.5 sq mi) Achugao Watershed contributes surface drainage from Wireless Ridge down to the Tanapag Lagoon via four major streams: Agatan, Dogas, Achugao, and San Roque (**Map 1**).
The watershed contains several large freshwater wetland complexes, including the Falig mitigation site. Coastal receiving waters and streams are impaired for one or more parameters including dissolved oxygen, marine benthic habitat, heavy metals, and bacteria. Site contamination from past military operations, piggeries, unmanaged stormwater runoff, sewer overflows and septic systems, and wildfires are some of the known issues affecting watershed health. Achugao has begun to show water quality improvement over the past few years, likely due to wastewater system repairs and upgrades.

The watershed is currently divided into two subwatersheds: Achugao North (approximately 840 acres in San Roque) and Achugao South (770 acres in Tanapag). There are two notable modifications to the original the LIDAR-derived watershed boundaries used by BECQ. It was determined through field investigations that the Tasi Stream is routed along Middle Road and through the Lower Base to a discharge outlet at DFW beach south of the CUC power plant. As such, the decision was made to associate the Tasi catchment with the West Takpochao watershed given the similarities in land use and shoreline morphology. In addition, the drainage boundary between the North and South Achugao subwatersheds was adjusted to include all of the Tanapag Middle School in the Achugao South.

Field investigations and input from stakeholders identified key restoration opportunties related to drainage improvements, watershed education, revegetation activities, and land use management. Pollutant reduction modeling suggests that better wastewater and erosion control could have a marked effect on water quality, but gains could be diminished by future development if environmentaly senstive site designs and best practices for stormwater and wastewater management are not adopted.

Purpose

This watershed plan summarizes watershed conditions and management priorities intended to guide the CNMI's stewardship of this watershed over decades to come. It is worth noting that COVID 19 had a significant impact on watershed planning activities. Field work and preliminary stakeholder engagement workshops were conducted in early 2020 right before the world went into two years of lockdown accompanied by everchanging social restrictions. Several attempts to convene public input meetings were thwarted, consequently, and preparation of this management report was delayed. Fortunately, on-island agencies continued assessment and implementation activities during this time. This watershed plan integrates those efforts and documents early action successes.

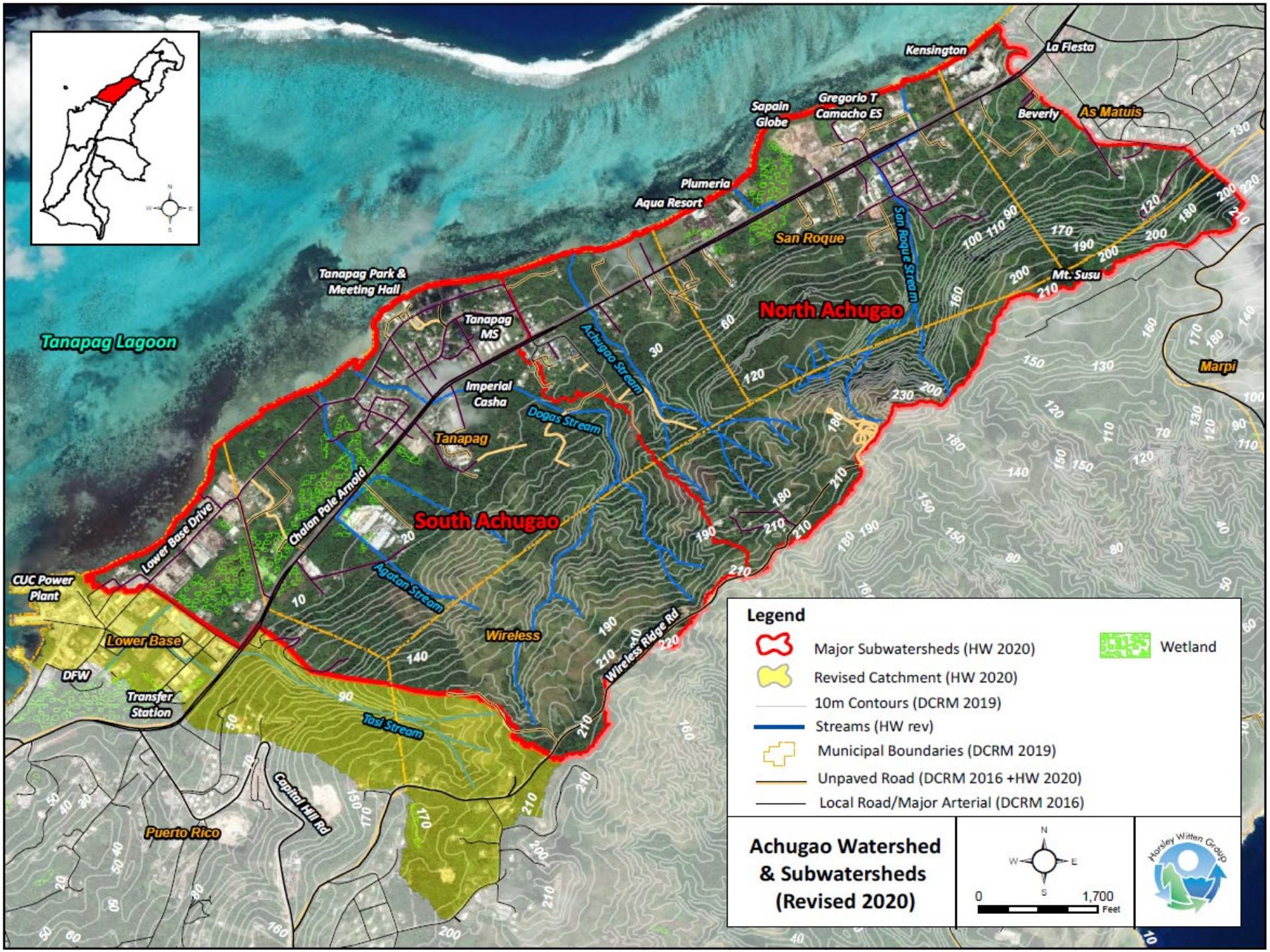
How to Use This Plan

This plan is organized by existing conditions, restoration potential, and an implementation plan.

- Existing conditions include chapters on the built environment, hydrology and soils, ecological resources, and coastal hazards. This information serves as reference material summarizing previous reports and studies.
- Restoration potential includes a summary of candidate projects sites and an evaluation of how various actions can improve watershed conditions. A summary and concept sketches of some priority projects is also included.
- The implementation strategy includes a discussion of watershed vision and goals, as well as a list of recommended actions to meet those goals. A preliminary schedule and budget, a targeted education plan, and proposed metrics for tracking progress and implementation success are also provided.

Attached to this report is the drainage infrastructure inventory, concept descriptions for key projects, a watershed modeling report, and copies of field data sheets.

(Top) Looking across the grassed slopes of the Achugao watershed. (Bottom Left) Chalan Pale Arnold Rd. in North Achugao. (Bottom Right) outlet of one of four major stream systems.



Map 1. Revised Achugao Watershed (Tasi stream catchment shifted to Northwest Takpochau

The Built Environment

Land Use

The headwaters of the Achugao watershed are steep and mostly vegetated. The highest point in the watershed is Mt. Susu. The flatter coastal plain is interspersed with freshwater wetland complexes (including a mitigation wetland) and is where most urban land and infrastructure is concentrated. Middle Road transects the watershed, runs parallel to the coast, and represents the primary development corridor in Achugao. Medium to high density residential and commercial development exists along this corridor between the shoreline and steep terrain. Vegetation consists mostly of mixed introduced forest, a swath of native limestone forest along the Achugao stream, and extensive grasslands. In addition to habitat and climate benefits, the forests and savannahs are used for local recreation (hashers, hikers, bikers) and homesteads. Large areas dominated by *Tangantangan* and patches of urban vegetation can be found interspersed throughout developed and previously disturbed areas upland of San Roque and Tanapag.

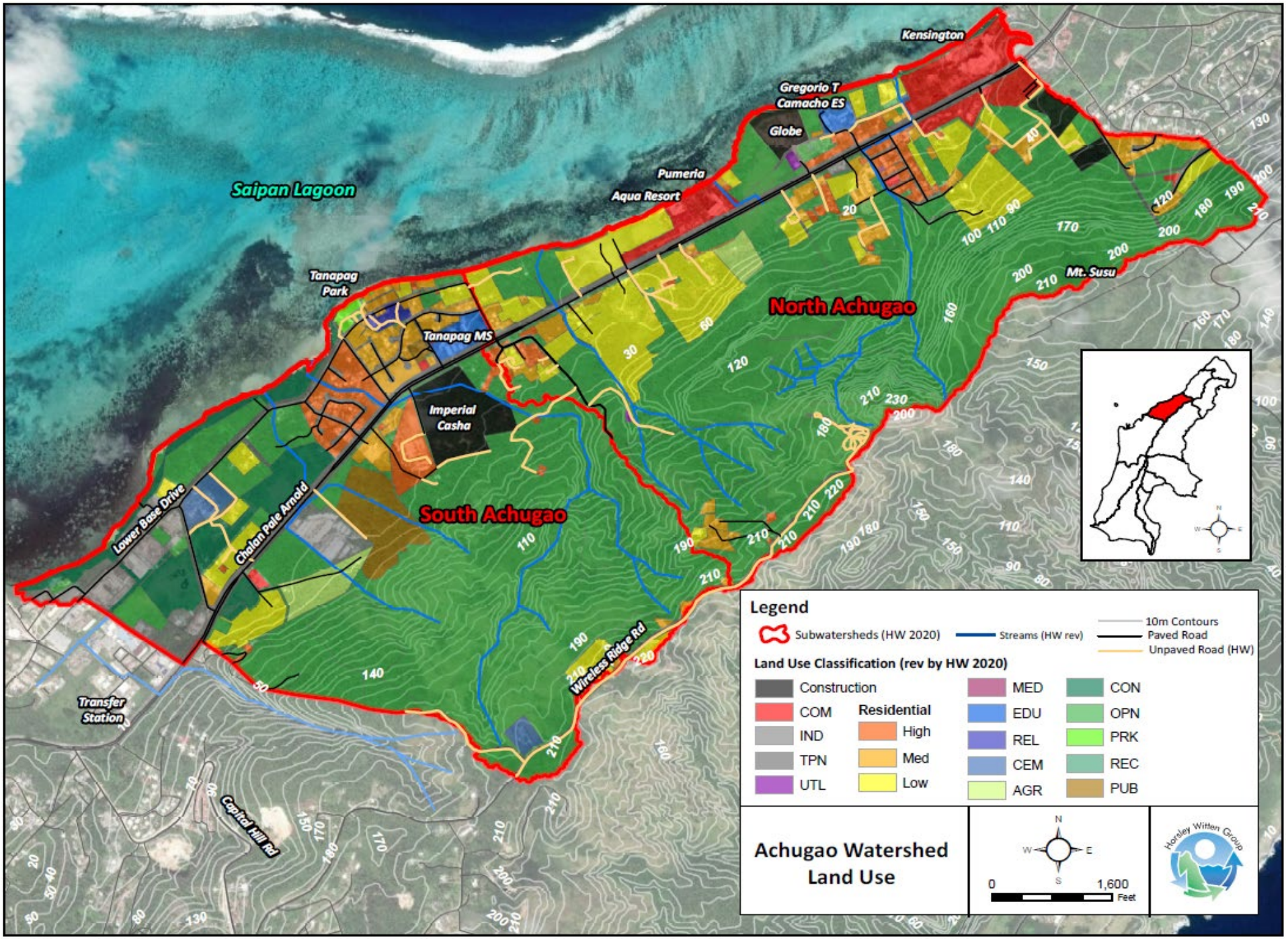
Land use in the Achugao South subwatershed is dominated by undeveloped land. Development consists primarily of medium to high density residential in the village of Tanapag, closed garment factories, workers barracks, and a portion of the lower base industrial complex. The Tanapag Middle School, meeting house, and beach park/boat ramp are important features of Achugao South, as well as the Imperial Casha hotel construction site.

Achugao North is slightly more developed and includes the San Roque village, the San Roque Elementary school, as well as four large beachfront resorts, including Aqua Resort, Kensington, and the abandoned Plumeria. There are several smaller hotels and villas/condos in the subwatershed and two additional hotel construction sites Saipan Globe and Beverly. The abandoned Fiesta mall is just outside of the watershed and is considered part of the As Matuis watershed to the north, however the areas immediately surrounding the mall to the south are within the San Roque drainage network. A few agricultural areas, including piggeries, have been noted in the watershed, but not to the extent of other areas on Saipan. Low-density, single-family homes and a small cemetery are found along Wireless Road, which is mostly an unpaved road running along the island's ridgeline.

Updated land use acreages based on field observations is summarized in **Table 1** and presented in **Map 2**. Field adjustments primarily reflect residential parcels and areas of active construction.

Table 1. Land Use Breakdown by Catchment

Land Use	As Agatan	Dogas	Achugao	San Roque
Forest/Park/Open	234	226	145	388
Open Water/Wetland	43			14
Recreational/Beach	23	4		
Agriculture	11			6
LDR > 1 ac	21	10	22	98
MDR 0.25-1 ac	7	25	12	26
HDR <0.25 ac	18	14	4	18
Municipal/Inst.	7	10		4
Commercial	1	4		43
Industrial	40			1
Roadway -Paved	23	15	3	22
Roadway -Unpaved	4	4	3	8
Active Construction	4	22		16
Total Acres	**436**	**336**	**190**	**645**
				Watershed Acres 1,607



Map 2. Achugao Watershed Land Use Map with some revisions by HW based on verification during field assessments in 2020.

Land Cover

Overall, the Achugao watershed is covered by approximately 42% mixed introduced forest, 28% grassland/shrub, 19% urban area, and 8% *Tangantangan* (**Map 3**). Most of the forest is a mixed introduced forest and much of the savannah and shrub/grass landscape is associated with previously disturbed wildfire areas. Impervious cover is at 9% which is close to the 10% threshold at which water quality, hydrology, and aquatic biota begin to show signs of degradation. Impervious estimates are based on urban built classifications from USFWS 2016 data (Amidon et al., 2017), and is not updated to include recent construction. **Map 4** shows impervious cover extent comparing NOAA 2005 and the USFWS 2016 datasets**.**

Figure 2 illustrates the land cover breakdown by drainage catchment. As Agatan has the highest percentage of impervious cover at 18%.

Table 2. Land Cover (Amidon et al. 2017)

Vegetative Cover Classification	Acres			
	As Agatan	Dogas	Achugao	San Roque
Agroforest-Coconut		5	1	4
Barren/Sand/Rock	1	2	1	5
Casuarina Thicket	0			1
Crop/Agriculture Field				1
Leucaena Leucocephala	18	6	20	75
Mixed Introduced Forest	189	119	94	270
Other Shrub and Grass	54	16	25	117
Savanna Complex	68	121	25	29
Strand Vegetation				0
Urban and Built-up	57	27	9	58
Urban Vegetation	31	39	16	67
Water	1	0	0	1
Wetland/Marsh Land	16			17
Total Acres	**436**	**335**	**191**	**645**

Watershed Acres: 1607

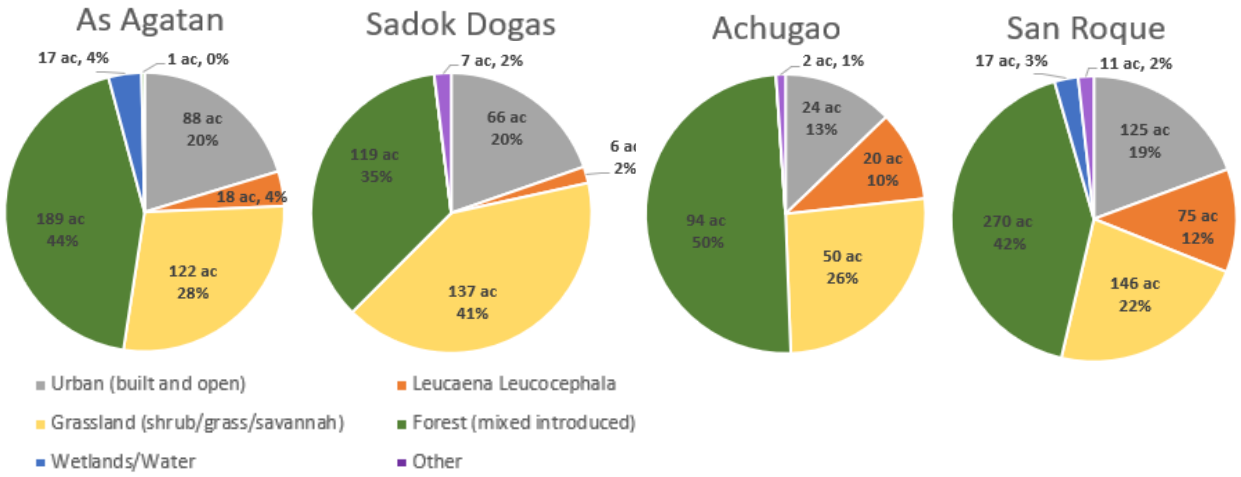
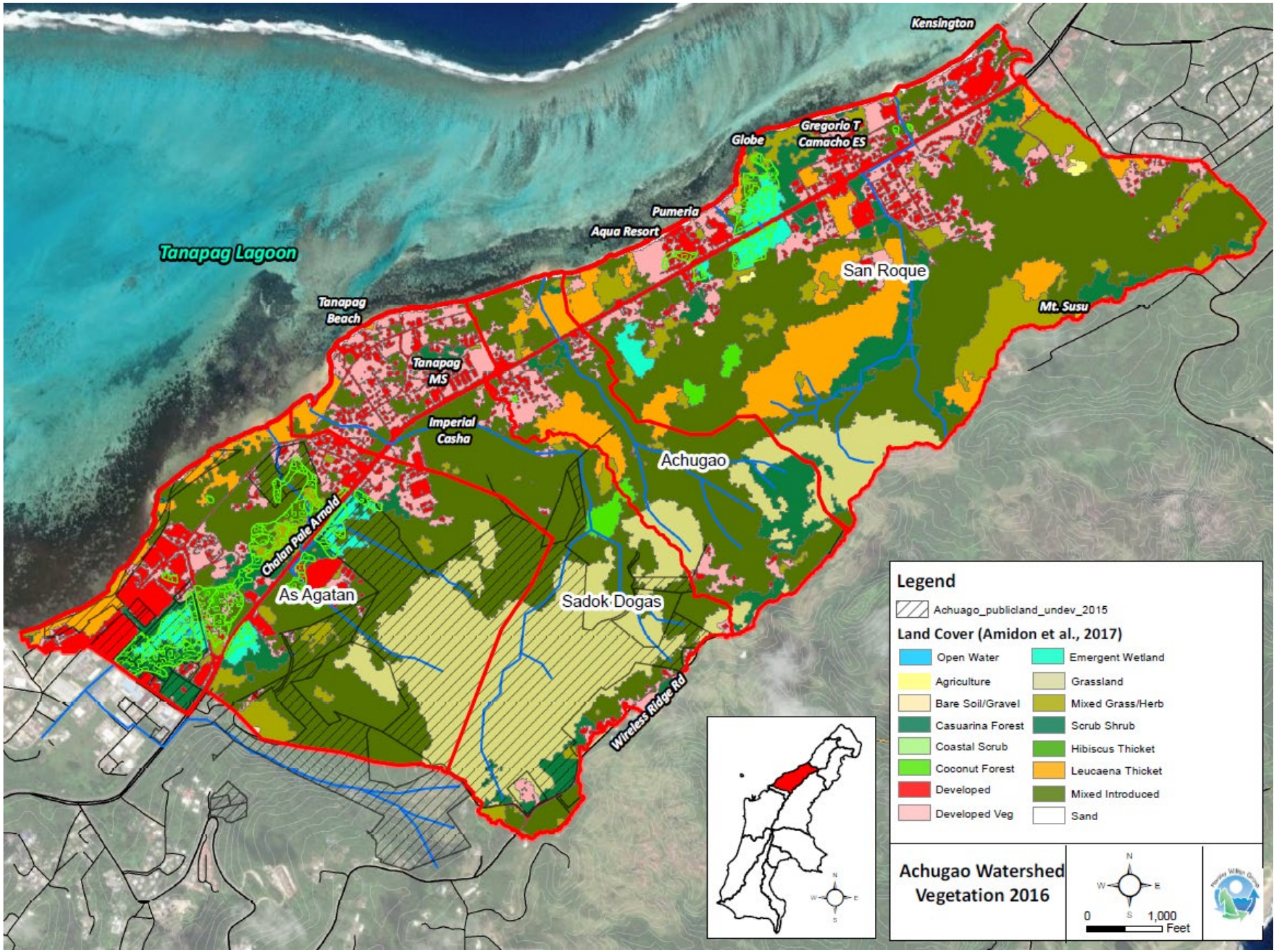
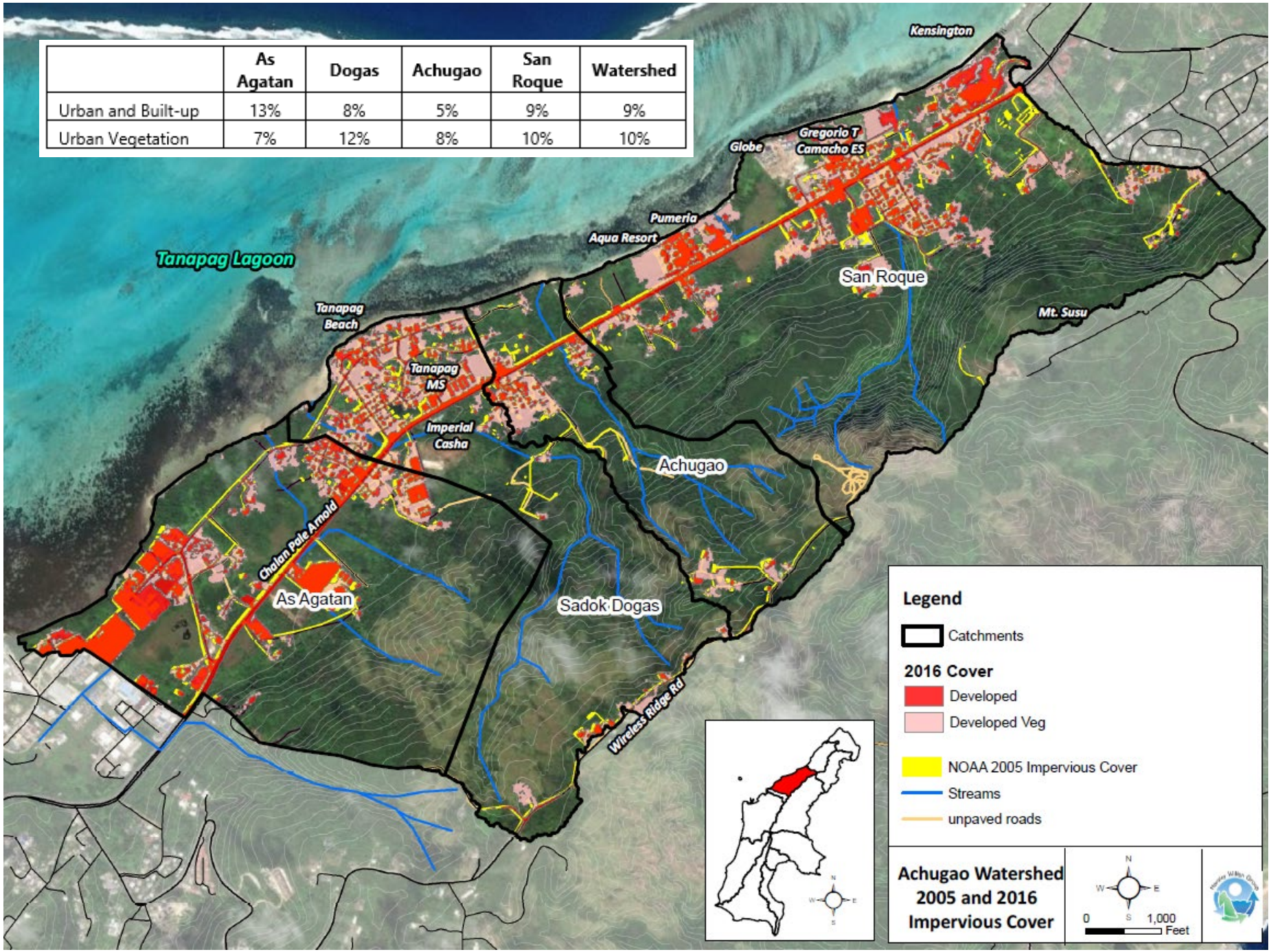


Figure 2. Major Vegetative Cover Types by Drainage Catchment (Amidon, et al., 2017)



Map 3. Vegetative Land Cover in the Achugao Watershed (Amidon et al, 2017)



	As Agatan	Dogas	Achugao	San Roque	Watershed
Urban and Built-up	13%	8%	5%	9%	9%
Urban Vegetation	7%	12%	8%	10%	10%

Map 4. Achugao impervious cover and major stream catchments (NOAA 2005 and Amidon et al.,2017)

Future Development

In addition to active construction sites observed, **Table 3** summarizes major siting and resort development permits in the watershed (FY2015-2019). Estimates of proposed infrastructure demands such as water, power, sewer, parking, etc. are not included in this summary. There are over 360 acres of public land in the watershed (mostly in South Achugao), of which only 54 acres are already developed (**Map 5**). There is a large consolidated area (over 290 acres) of undeveloped public land spanning the upper portion of the Achugao South subwatershed and Tasi stream catchment.

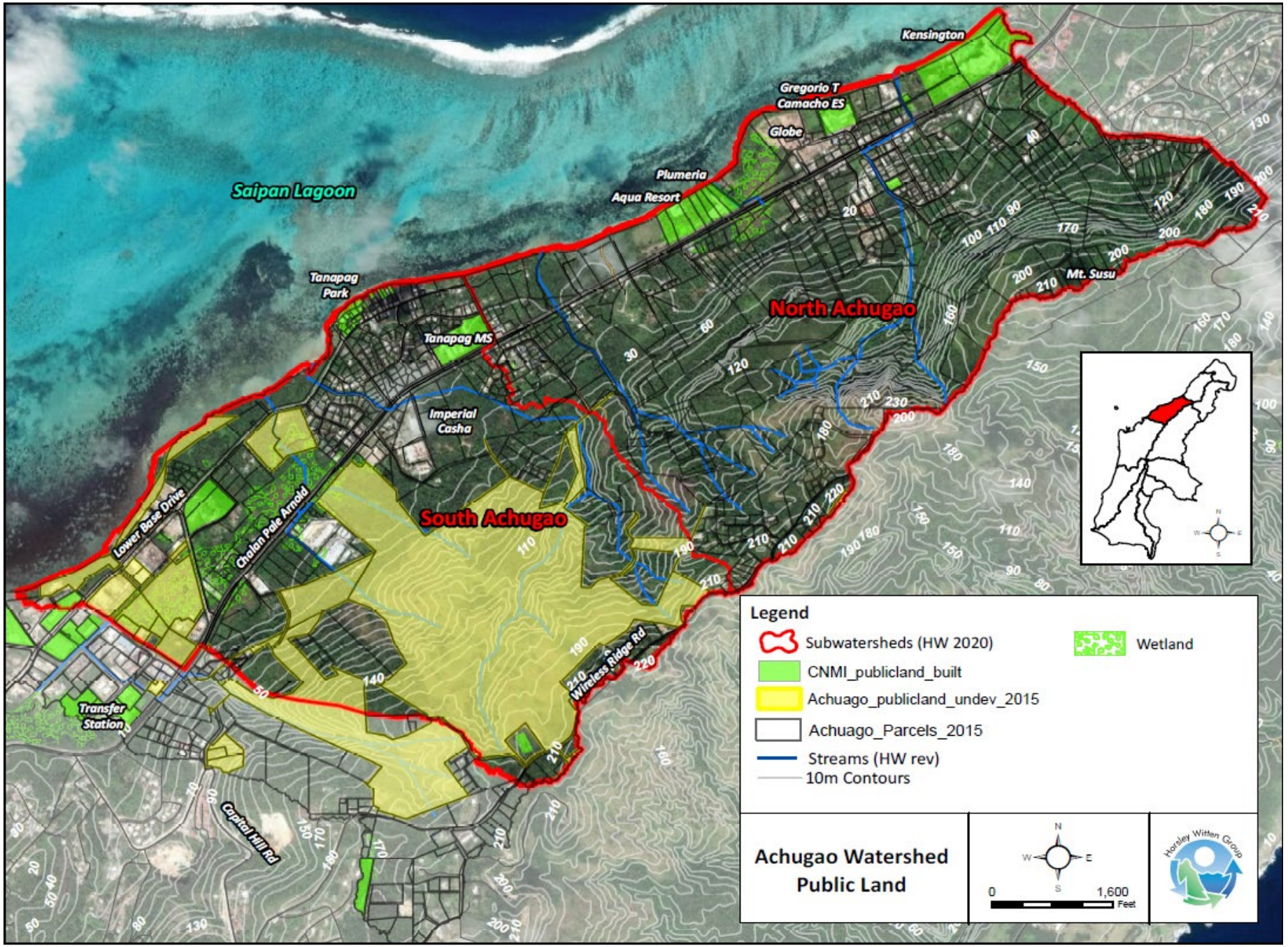
Soils at this 25-acre resort construction site have remained exposed since mass clearing in 2017 resulting in egregious site erosion and sedimentation impacts downstream.

The 2021-2030 CNMI Comprehensive Sustainable Development Plan identifies several general goals that are directly relevant to watershed management recommendations in Achugao (OPD, 2021):

- SDG 8: Promote inclusive and sustainable economic growth supported by expanded educational and employment opportunities for all.
- SDG 9: Build resilient infrastructure, promote inclusive and sustainable industries, and foster innovation.
- SDG 14: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
- SDG 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, and preserve and halt degradation of biodiversity and resources of particular concern.

Table 3. Active resort development/renovation applications as of 2019

Location	CRM Permit No.	Description	Status
Chalan Pale Arnold Road, Tanapag	SMS-2019-X-001	The New Century Hotel. Proposed renovation/conversion of an existing 3-story office building to a 48-room hotel. The hotel will include 36 parking spaces – 2 ADA compliance parking stalls, 27 guests parking, and 7 for hotel operation use. The building is connected to the CUC power, water, & sewer line. 1,800 sq meters site in Tanapag Village south of Elementary School, east of the Youth Center, and west of Chalan Pale Arnold Rd.	Approved 12/27/2018; Construction must be completed by January 31, 2021 per mandatory condition #2.
Tanapag	SMS-2018-X-020	Saipan Garden Resort (Imperial Casha). To be constructed and operated on three lots totaling about 24.71 acres on Chalan Pale Arnold Rd in Tanapag. The project includes a hotel with ten 6-story buildings, two 6-story Service Apartments, 6-story staff housing, cafeteria, 2 single story restaurants, 2 single story hotel dining rooms, 1 single-story banquet hall, 3 pools, Admin building, generator room	Application approved on 2/13/2018; Construction must be completed by 8/6/2021. requesting extension on the sewer connection permit.
San Roque	SMS-2017-X-055	Saipan Globe. Large new "container" hotel (1,184 rooms) that will impact approximately 3,500 sq meters of private land. The plan for the hotel is to have a resort complex with 438 hotel room tower, 98 villas, 60 employee dorms, 2 restaurants, 3,800 square feet of retail space, 14,500 square feet of event space, pool, parking and services.	Application approved on 9/13/2017; Construction must be completed by October 15, 2020.
As Matuis	SMS-85-X-25	Kensington Hotel with gift shops, restaurants, watersports and other amenities	Ongoing renovations during hotel operation.
Achugao	SMS-2015-007	Villora Condotel .2-3 Story Condominium & Villa Complex (150 rooms)	Application from 2015; to be completed 9/2018



Map 5. Developed and undeveloped public lands in the Achugao watershed

WILDFIRES

Wildfires for land clearing have been a recurring issue in Achugao (**Map 6)**. Achugao had large acreages burned in 2017 and 2019 (**Table 4**). Fires in 2016 were smaller but more distributed. Fires in 2018 only burned a small area in Achugao but covered a large portion of the adjacent watershed. The loss of vegetation and soil exposure associated with fires were identified in the 2017 bacteria TMDL as a likely and significant source of sediment and *Enterococci* (Paradigm Environmental, 2017). **Table 5** summarizes areas burned by subwatershed. **Figure 3** shows Achugao's wildfire vulnerability rating.

*Table 4. Wildfire coverage in Achugao**

Year	Area (ac)	% of Watershed*
2016	60	3%
2017	193	10%
2018	45	2%
2019	170	9%

**calculation includes former watershed boundary (1901 acres).*

Table 5. Burned areas between 2016-2019 by Drainage Catchment

Drainage Catchment	Area Burned (2016-2019)	
	Acres	% of Watershed
As Agatan	141	32%
Dogas	197	59%
SOUTH ACHUGAO	338	44%
Achugao	38	20%
San Roque	78	12%
NORTH ACHUGAO	116	14%
ACHUGAO WATERSHED	**454**	**28%**

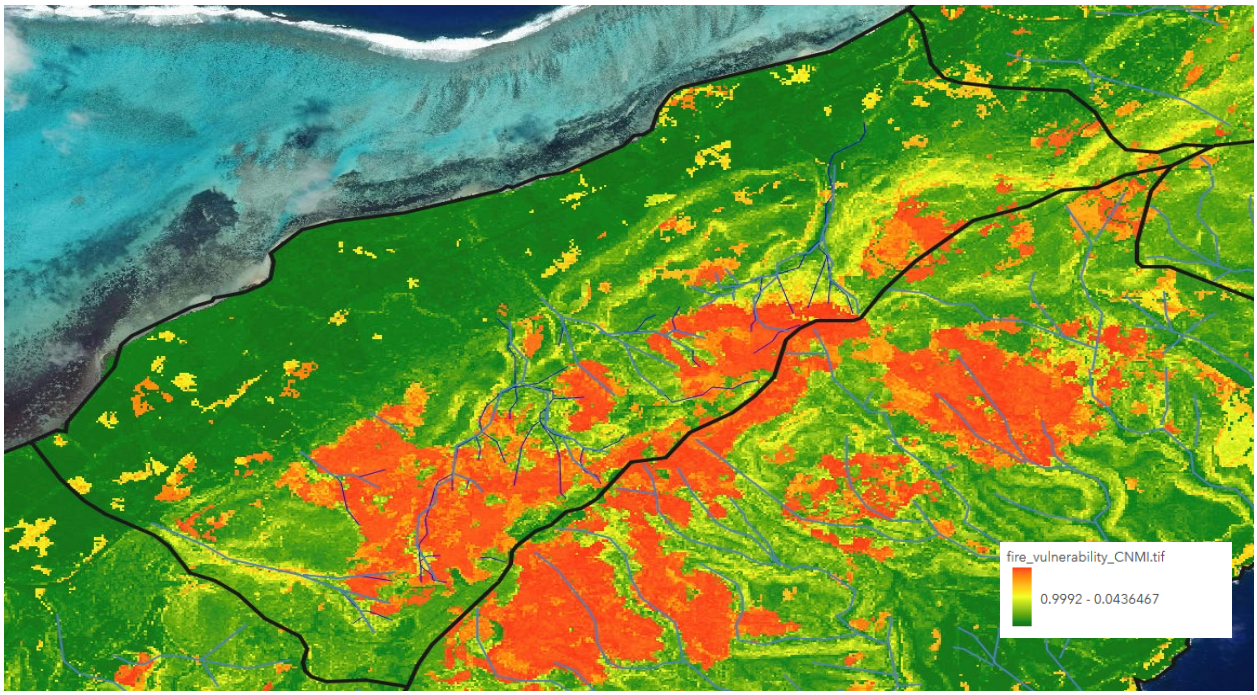
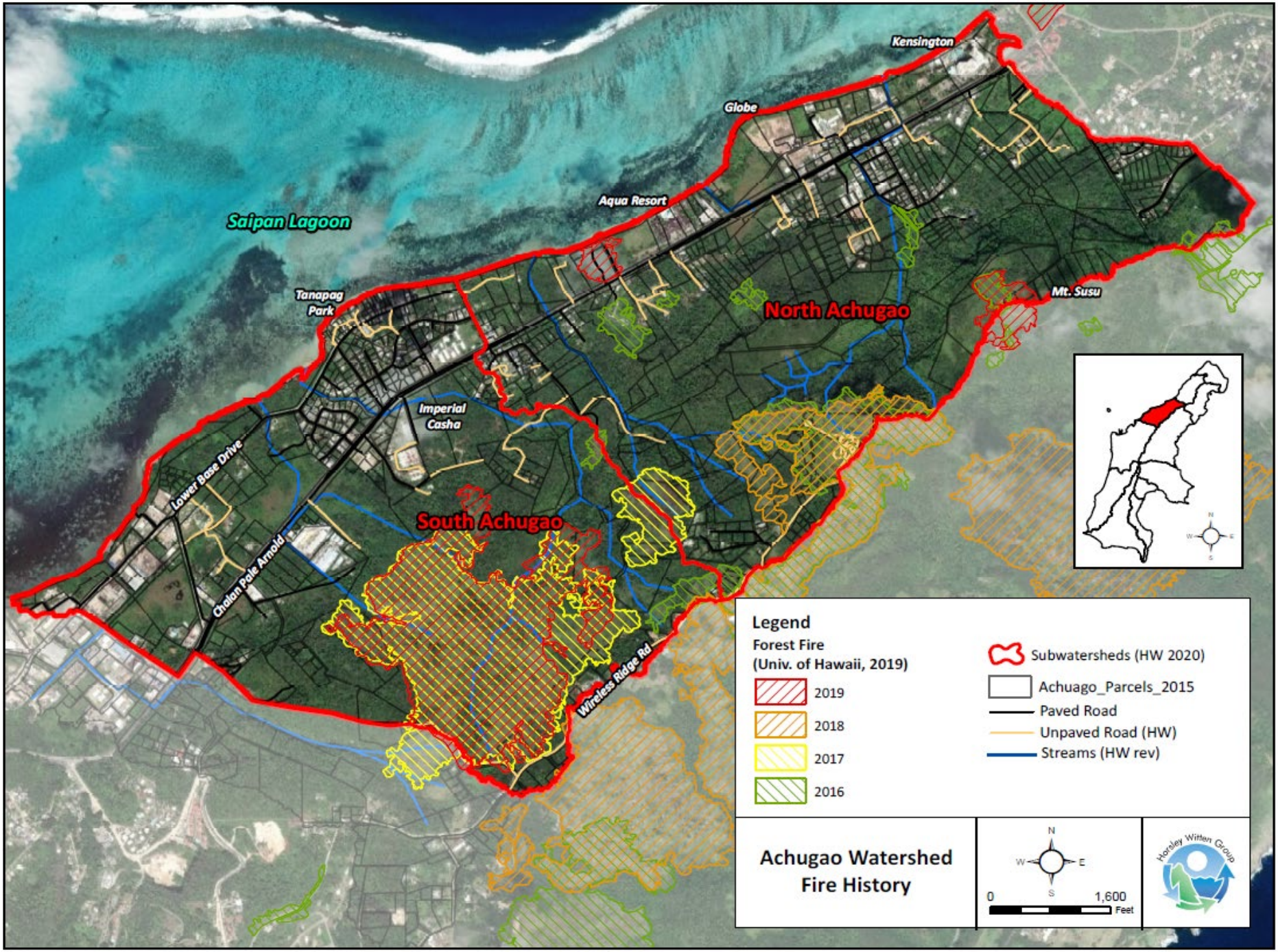


Figure 3. Fire vulnerability rating in the Achugao watershed (CRMOGIS, 2020)



Map 6. Forest fire extent between 2016-2019

Contamination Sites

Un-remediated contamination sites, brown fields, and above and underground storage tanks in the watershed, including a former WWII dump and the Tanapag fuel tank farm are shown in (**Map 7**).

Areas of Particular Concern

Figure 4 shows the designated Areas of Particular Concern (APC) within Achugao, which include Saipan Lagoon, shoreline, FEMA flood zones, the Seaport District/Industrial area, and wetlands. The 2017 Update to the Saipan Lagoon Use Management Plan identifed Achugao as one of the prioruty watersheds for protection due to its influene on Lagoon quality and the potential for additional development in the watershed to cause further impacts.

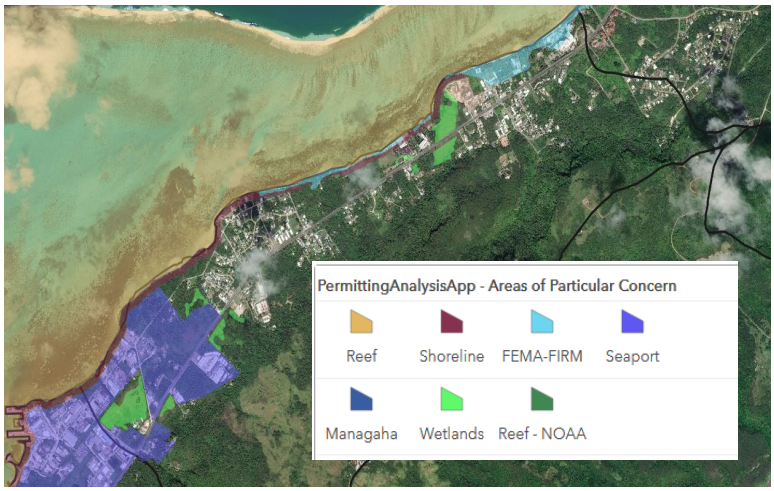


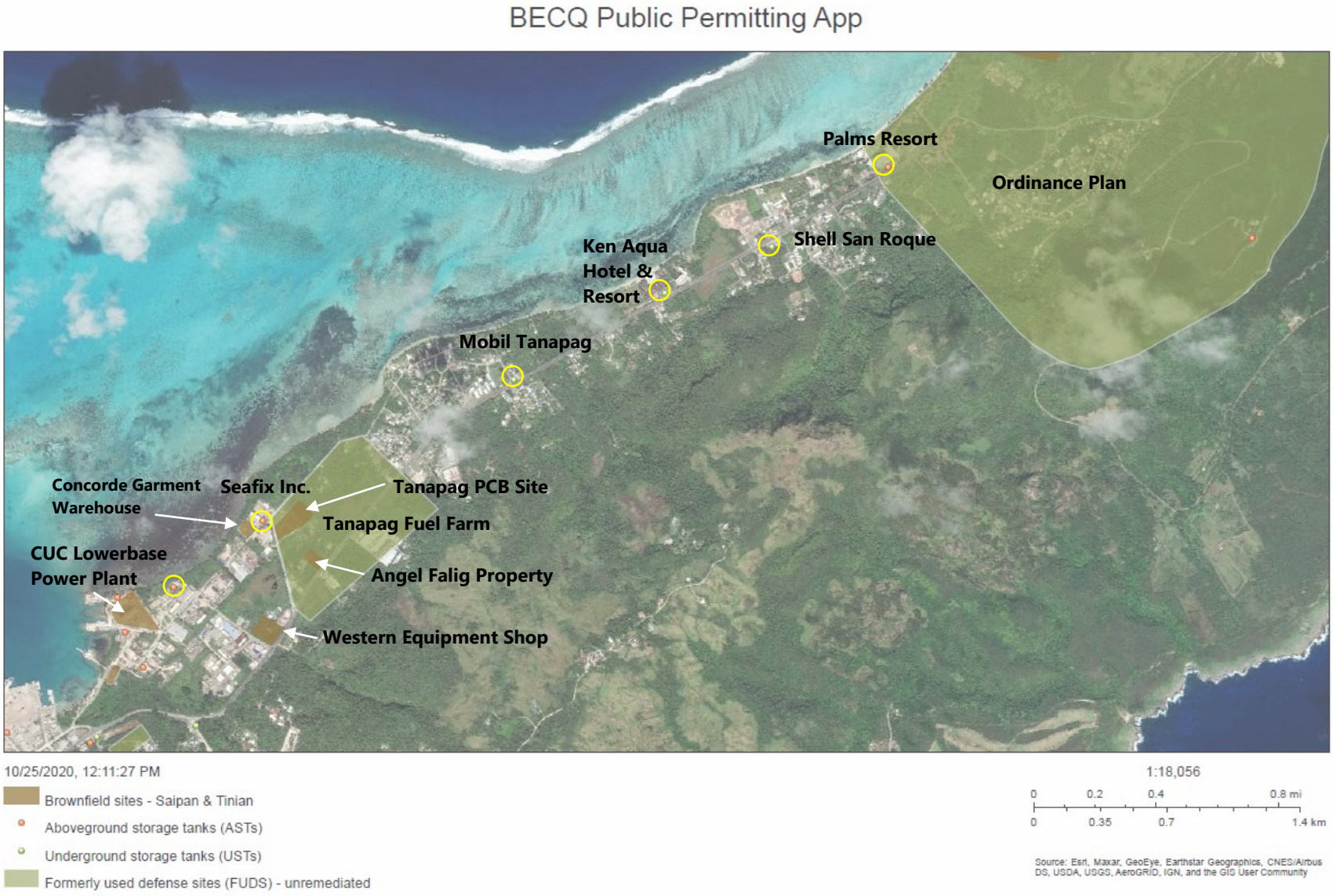
Figure 4. Areas of Particular Concern (CRMOGIS, 2018)

Historic Sites

Much of the immediate coast contains archaeological resources (**Figure 5**). Unai Achugao is a major archaeological site that was listed on the National Register of Historic Places in 1996. Here, early habitation of the island was dated to 3500 BCE, excavations yielded more than 3,000 pottery fragments used to develop the regional pottery classification system, and a nearly-intact habitation surface was found within a fossilized coral reef.

Figure 5. Sensitive archeological areas (from CRMOGIS, 2018) and historic sites

Another site, the Samoan Village, is in Lower Base and is the location where ten chiefs from German Samoa (now Independent) Samoa were exiled between 1909 and 1915.



Map 7. Potential contamination sites and storage tanks in Achugao

Infrastructure

Wastewater

Most of the development in Tanapag and San Roque falls within the sewer service area for the Sadog Tasi WWTP (**Map 8**). The sewer main runs north along Lower Base Rd. and transitions up to Middle Rd. in Tanapag. **Table 6** summarizes length of lines and an estimate of septic systems within each drainage catchment.

Upgrades and repairs to several pump stations over the last few years are considered a primary factor in improved water quality at monitoring stations in the Lagoon. A new lift station/or replacement of an existing lift station was completed as part of the Globe construction. It is unclear if additional network upgrades between the Globe and the WWTP are needed (i.e., Imperial Casha infrastructure improvements). **Table 7** is a list of active and pending CUC Improvement Projects (as of 2019) in the watershed provided by CUC during the watershed working group meeting held in January 2020.

Table 6. Wastewater Infrastructure Summary

	As Agatan	Dogas	Achugao	San Roque
Service Area	SS-14	SS-14, SS-15	SS-15	SS 17, SS-16
Sewer line (mi) *	1.3	2.1	0.6	2.6
Estimated # of on-site septic systems**	68 of 150 buildings	8 of 170 buildings	7 of 43 buildings	55 of 333 buildings

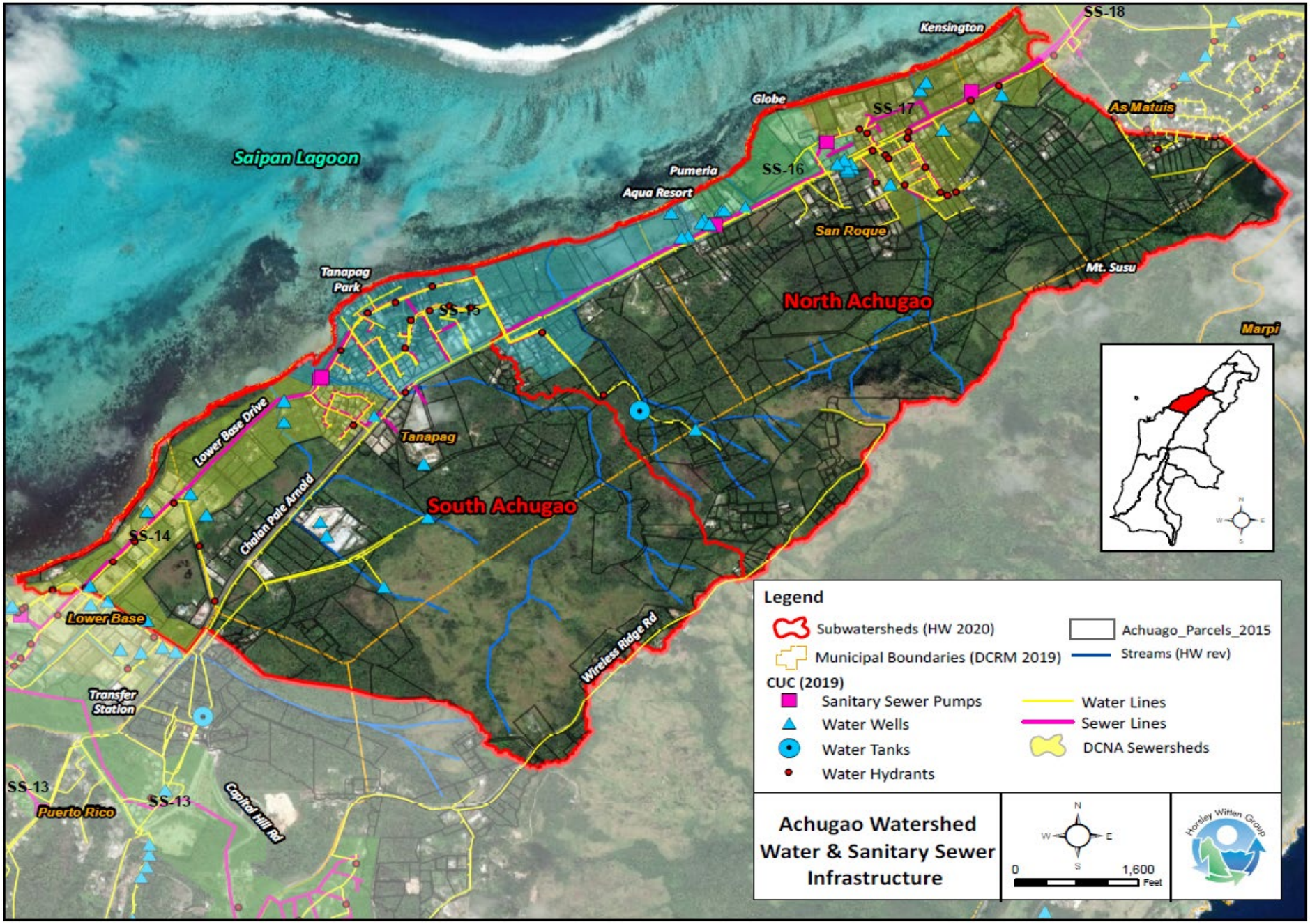
** Length of sewer lines are from CUC dataset, and include gravitational sewer line, pressurized sewer line and lateral lines.*
***based on count of buildings outside of sewer service area (estimate shown includes total buildings # estimated based on mapping data)*

Table 7. CUC Capital Improvement Projects Update (Achugao, as of 2019)

Project #	Project Name	Funding	Status
S14-038	Pretreatment and FOG evaluation (island-wide/Garapan)	$3,100	• Hiring of manager pending • Funds redirected to San Vicente tank replacement
S15-042	Lift Station Renovation (SR-2 - Achugao, A-2, A-6)	$1.75M	SR-2 to go out to bid by Jan 2020
S16-046	Isa Dr. sewer realignment (NW Topachao, Achugao wetland)	$410,000	100% complete
W16-050	Leak detection and repair (island-wide)	$600,000	DO1 complete, DO2on-going, DO3 permitting underway
S17-058	Lower Base Sewer Replacement PHII. This would eliminate S1, route around the wetland, and improve WQ	$2M	SOW and Bid schedule to be finalized
EDA Grant # 07-01-07128 and PL 17-90	Lower Base Sewer PHI- Lift station and Force main	$1.9M	• OFCI material by HES at CUC warehouse • GPPC continues with trench excavation • Generator building 90% complete • IARII continues to monitor excavation
S17-059	Sadog Tasi WWTP upgrades (this is where Achugao wastewater is treated)	$1.7M	• IFB for clarifier canceled, new SOW • Sludge dewatering equipment

Drinking water

Municipal water lines extend along Middle Rd. into Tanapag and San Roque, connecting to wells and storage tanks in the central watershed. On Saipan, leakage rates as high as 50% are estimated for the antiquated distribution systems. Over pumping of wells can cause saltwater intrusion and urbanization reduces rainfall recharge to underground aquifers (CNMI Forest Action Plan, 2020).



Map 8. Water and Sewer (CUC, no date)

Stormwater

During the week of January 20, 2020, HW, KOA, and BECQ field crews mapped and assessed over 100 drainage structures (e.g., inlets and catch basins, culverts, manholes, BMPs, outfalls, stream outlets, and other). Much of the stormwater infrastructure found throughout the Achugao Watershed is mostly closed pipe conveyance systems. The condition, dimensions, and invert elevations were documented for most structures.

Appendix A includes location maps and additional details on each assessed structure, including maintenance needs.

Based on field observations, almost 60% of the structures evaluated require maintenance or repair/replacement due to clogging, sediment accumulation, visible damage, or erosion. Existing stormwater management facilities were located during watershed assessments and the contributing drainage area and amount of impervious cover managed were estimated (**Table 8**). Approximately 15 acres of impervious cover are currently managed by stormwater facilities.

Drainage infrastructure evaluation and mapping and condition assessment in Tanapag.

Table 8. Existing Stormwater BMPs

	As Agatan	Dogas	Achugao	San Roque
BMP type, total contributing drainage area (DA) to practice (impervious cover acres)	None identified	• Vegetated swale: 3.2 ac DA (1 ac IC) • Ponding Basin: 3.7 ac DA (1 ac IC) • Bio/rain garden: 0.5 ac DA (0.4 ac IC) • Infiltration: 0.2 ac DA (0.2 ac IC)	Unpaved road BMPs & sediment traps: 1 ac DA (0.7 IC acres)	• Ponding Basin: 10 ac DA (8 ac IC) • Infiltration: 3.5 ac DA (3 ac IC)
Total area managed	0	7.6 ac (2.6 ac IC)	1.0 ac (0.7 acres IC)	13.5 ac (11 ac IC)

Existing stormwater management facilities identified in the Achugao Watershed.

HYDROLOGY & SOILS

Precipitation

Rainfall is highly variable in the CNMI and driven by eastern hemisphere monsoons and the El Nino-Southern Oscillation. **Figure 6** shows average monthly rainfall at the Saipan Airport in 2019 during an El Niño event compared to normal year averages between 1981-2010 (Grecni et al, 2021). Mean annual precipitation for the watershed is approximately 85 inches per year, of which most occurs between July and November (2006, CNMI Stormwater Manual). El Niño events often result in increased rainfall followed by a period of drought (**Figure 7**).

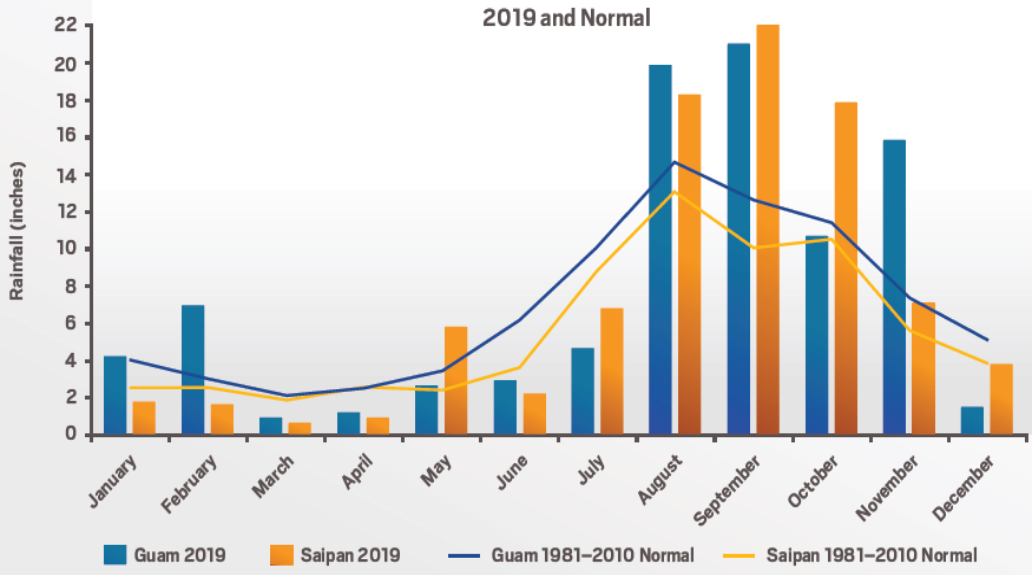


Figure 6. Monthly rainfall for Guam and Saipan (2019) and normal years (1981-2010) from Grenci et al. (2021).

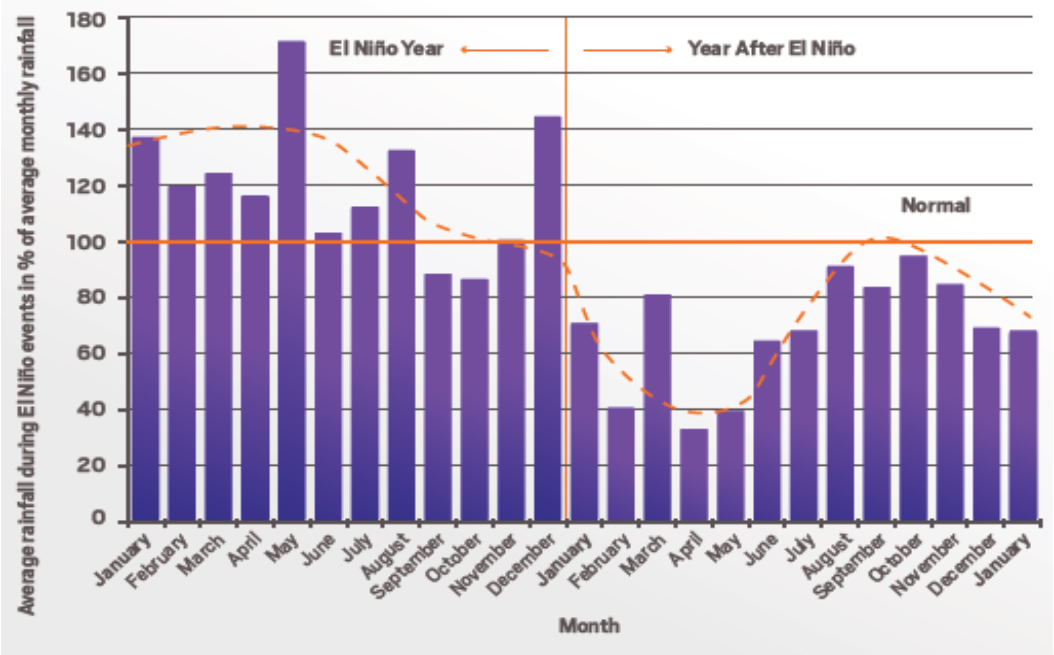


Figure 7. CNMI Rainfall Response to El Nino (from Grenci et al., 2021)

Table 9 summarizes key climate change indicators for the CNMI, including predictions for annual rainfall, number of extreme rainfall days, and days of hotter temps (>90 degrees). Changes in rainfall predictions range from 7% lower to 20% higher annual rainfall with an increase in number of extreme events >2 inches. Extended droughts and an increase in the number of days with hotter temperatures can increase risks of fires, impact vegetation, and lead to human health concerns in socially vulnerable communities (Grecni et al., 2021).

Table 9. Observed and Predicted Climate Change Indicators (Grecni et al., 2021)

Indicator	Current Change	Future Change
Hotter Days	↑	↑
Cold Nights	↓	↓
Average Air Temp	↑	↑
Avg Rainfall	↔	↓
Extreme Rainfall Days	↔	↑
Drought Frequency	↔	↑
Storm Frequency	↔	↓
Storm Intensity	↔	↑
Sea Level	↑	↑
Tidal Flood Frequency	↑	↑
Sea Surface Temp	↑	↑
Degree Heating Week (heat stress)	↑	↑
Ocean Acidification	↑	↑

For stormwater management purposes on Saipan, NOAA Atlas 14 precipitation frequencies are summarized in **Table 10**. Some engineers are designing to the upper 90% confidence limit to account for more rainfall and higher intensities.

Based on CNMI stormwater management criteria, recharge of 1.5" of precipitation is required in limestone areas and 0.80"- 0.10" is required in volcanic areas (depending on soil HSG). Water quality treatment of 1.5" or 0.80" of rain are required in areas draining to high (Class AA) and moderate (Class A) quality marine waters, respectively. Most of Achugao's coastal plain of is subject to 1.5" recharge and 0.80" water quality targets (**Figure 8**).

Table 10. Rainfall Frequencies (NOAA Atlas 14, Volume 5, Version 3)

Duration	Average Recurrence Interval					
24-hr	1-YR	2-YR	5-YR	10-YR	25-YR	100-YR
Capitol Hill						
Inches	4.29	5.72	7.73	9.34	11.6	15.4
+ range	5.57	7.43	10.1	12.2	15.3	20.5
Saipan Intl Airport						
Inches	3.98	5.41	7.42	9.03	11.3	15.0
+ range	5.05	6.87	9.45	11.5	14.5	19.6

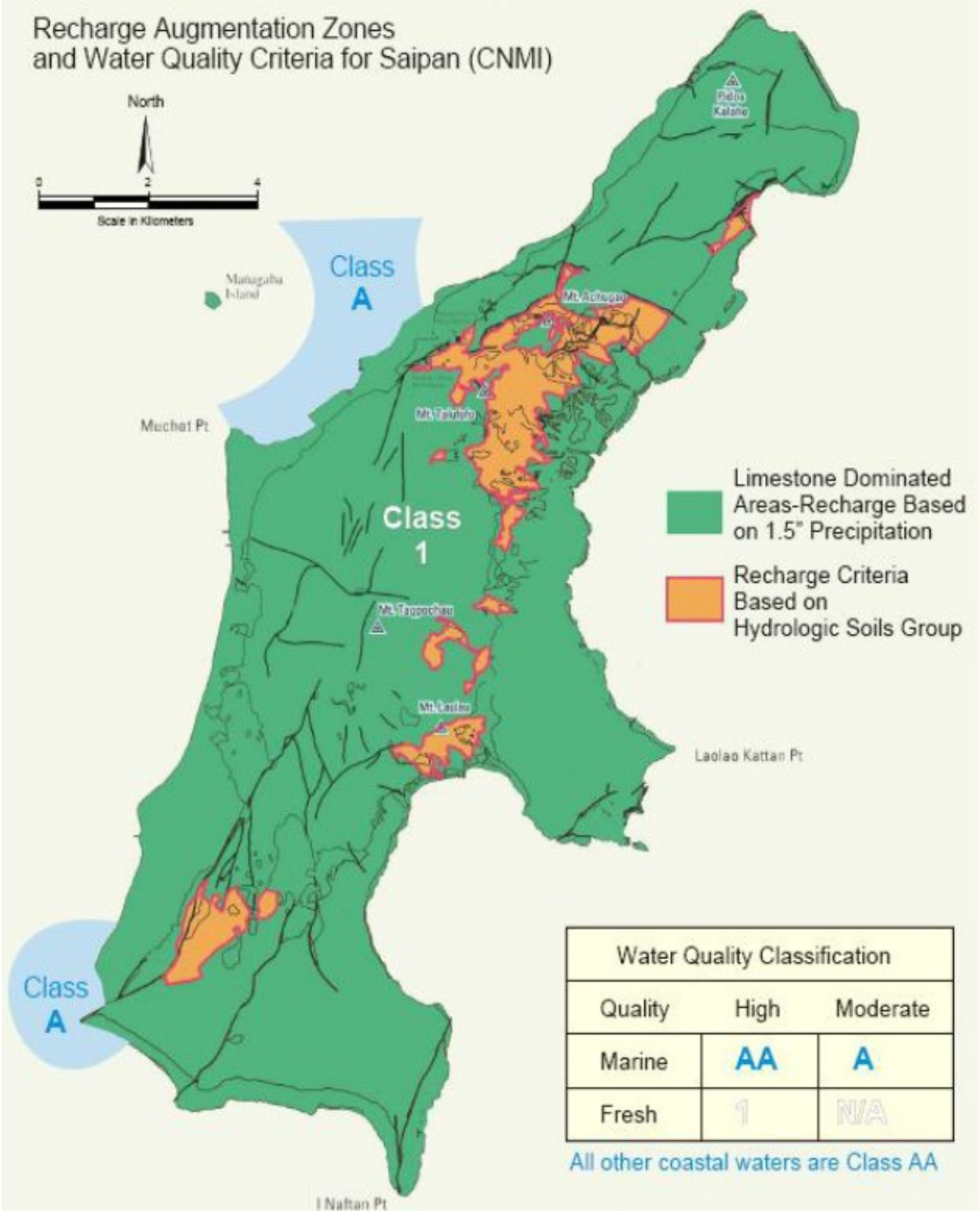


Figure 8. Recharge and Water Quality Treatment Criteria

Geology, Soils, & Groundwater

Per the USGS soil classification hydrologic soil groups (HSGs), most of the watershed is HSG C and D soils (low infiltration capacity and high runoff potential), with a HSG A and B soils (higher infiltration capacity and lower runoff potential) along the coastal plain (**Table 11**). **Map 9** shows the location of hydrologic soil groups across the watershed. Soil erosion potential based on NRCS SSURGO data indicates low to medium levels of erosion in the watershed, with higher potential in the steeper slopes in the upper watershed (**Figure 9**). Patches of high activity clays (fertile, absorb water) and a range of soil pH (controls the availability of essential plant nutrients) are found in the watershed. Optimal pH range for plants to uptake nutrients is 6-6.5.

Table 11. Soils Information for Achugao (from NRCS)

Parameter	As Agatan	Dogas	Achugao	San Roque
HSG	22% A 2% B 10% B/D 29% C 37% D	10% A 8% B 60% C 21% D	3% A 17% B 36% C 43% D	9% A 16% B 2% B/D 10% C 63% D
Depth to groundwater*	12% <3 ft; 16% 3-5f; 72% >5 ft	2% <3 ft; 8% 3-5ft; 90% >5 ft	2% <3 ft; 8% 3-5ft; 90% >5 ft	4% <3 ft; 6% 3-5ft; 90% >5 ft

**Based on NRCS soil depth to groundwater estimates with an adjustment of 2% for shoreline and up to 8% for transition zones*

The geology of Saipan consists of limestone over older volcanic rock. Almost 90% of the exposed rock surfaces in Saipan are limestone or calcium deposits. In the Achugao Watershed, limestone is found in the western coastal plain, particularly in the southwestern portion of the watershed (**Map 10**). Volcanic rocks become more with prominent in the central uplands and the headwaters of the watershed (**Figure 10** and **Figure 11**). Soils formed on top of the rock overtime due to chemical weathering processes, the addition of organic matter, and potentially by the deposition of dust from Central Asia.

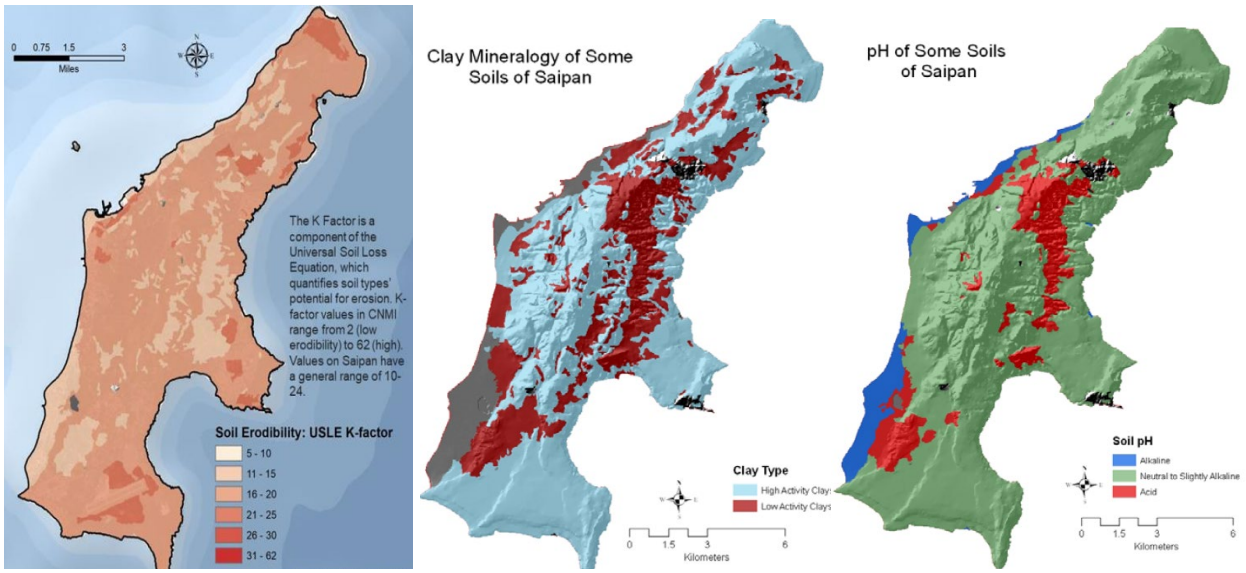


Figure 9. Soil Erodibility, Clay Mineralogy, and Soil pH of Saipan (from NRCS)

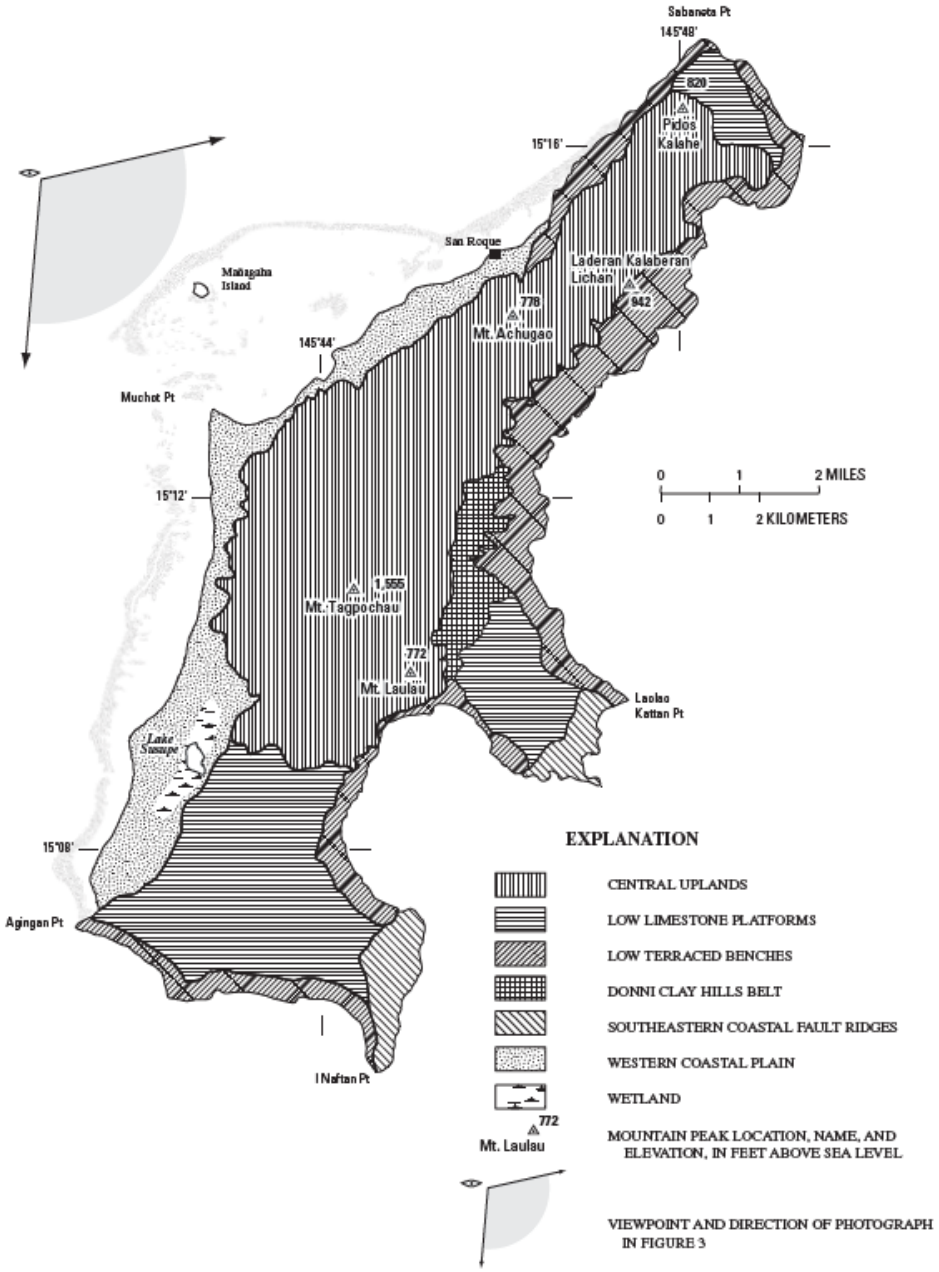


Figure 10. Geological formations of Saipan (from Carruth 2003)

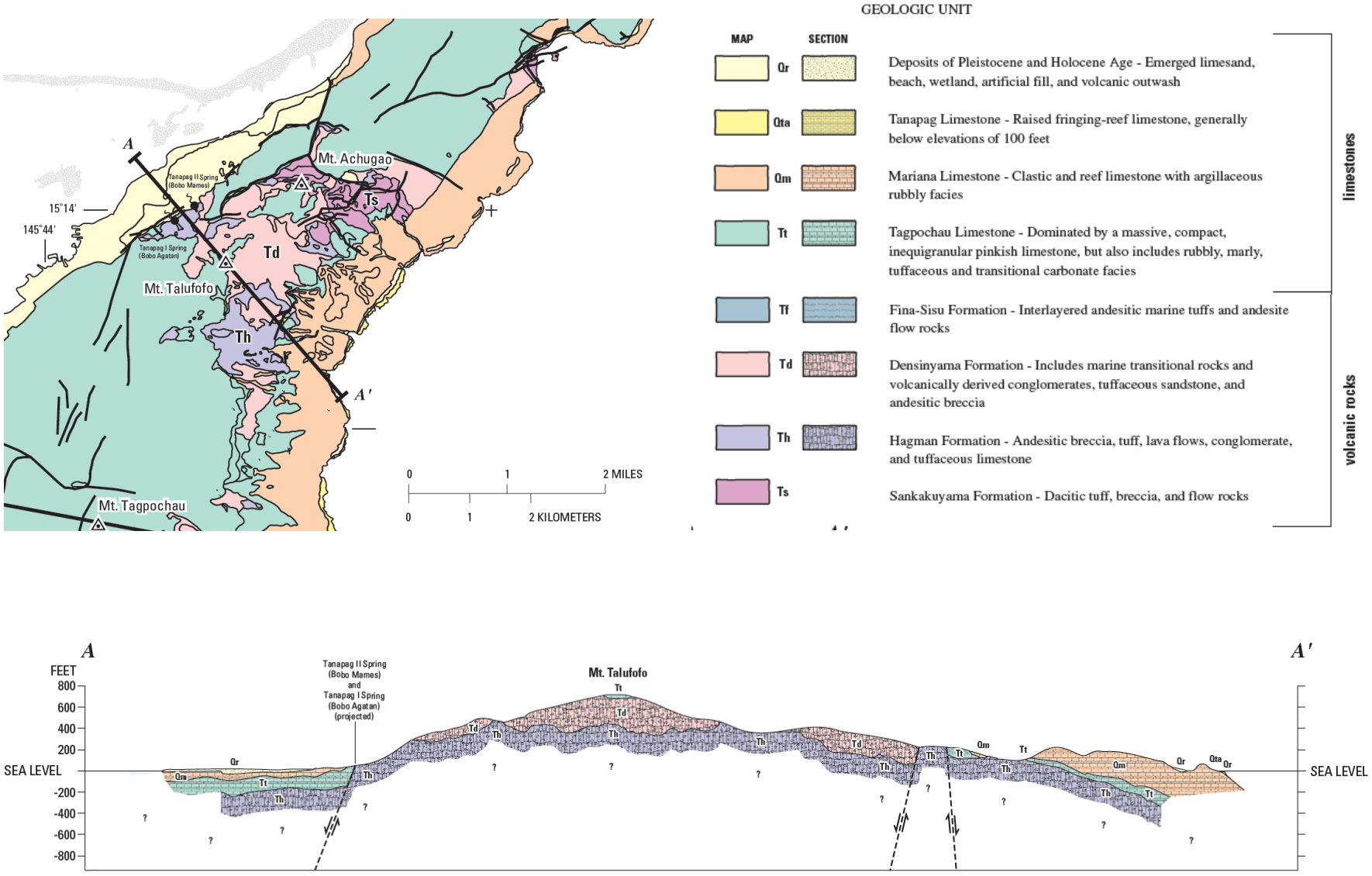
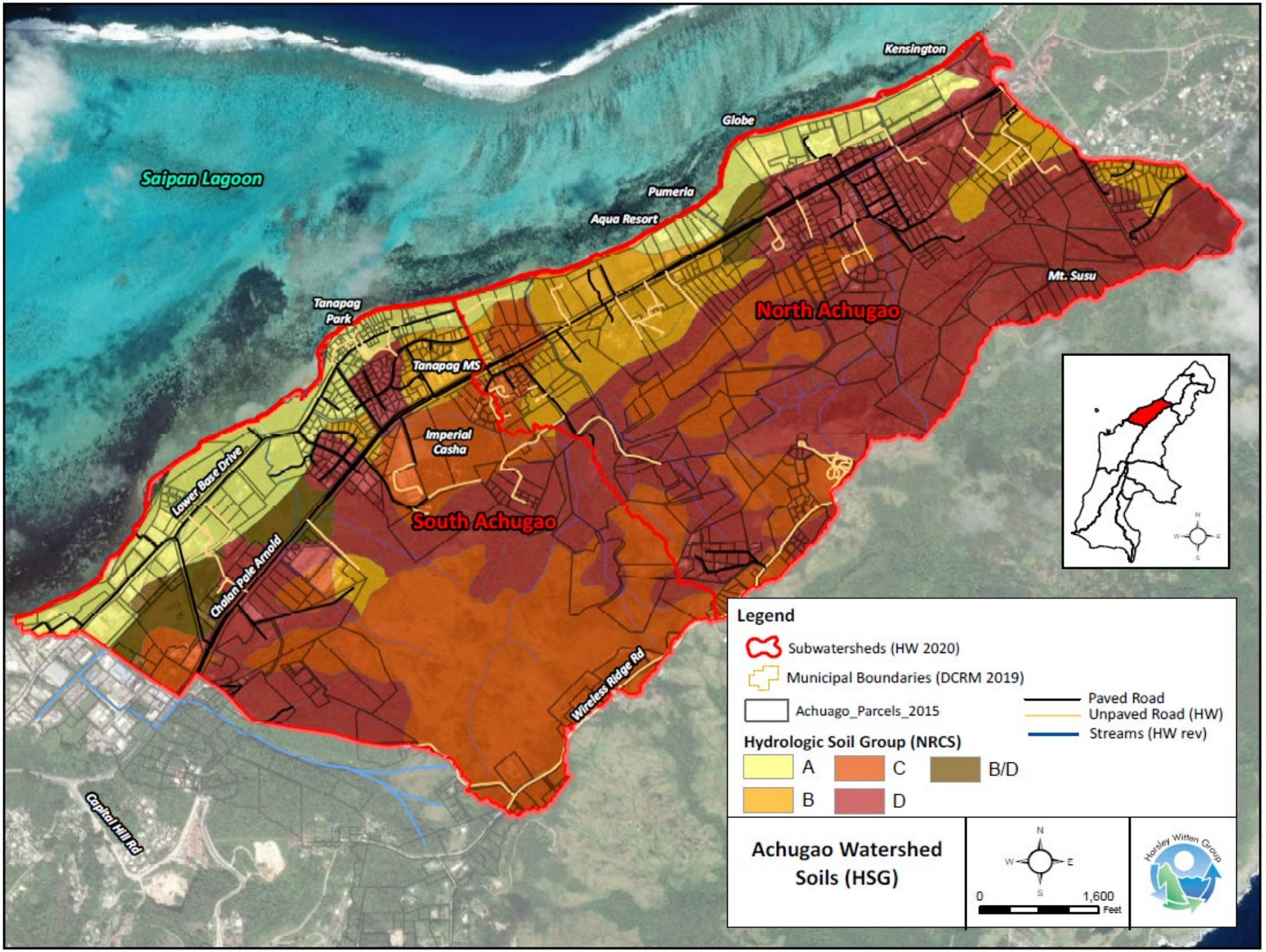
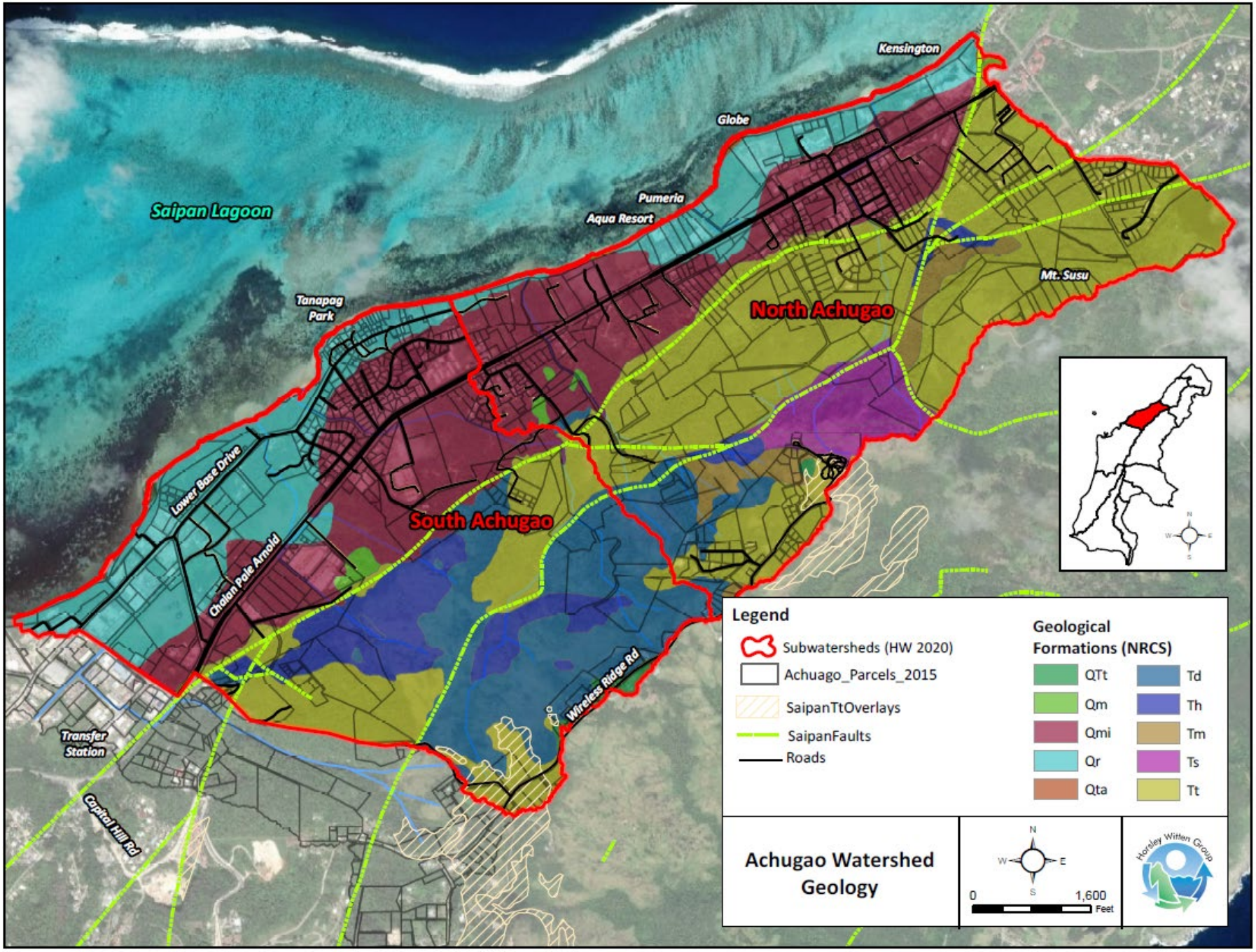


Figure 11. Geological units and representative cross-section (Carruth 2003)



Map 9. Achugao hydrologic soil groups (NRCS, 2019)



Map 10. Achugao geological formations and faults (NRCS, 2019)

There are several low-discharge springs and seeps in the central uplands of the watershed, that partially drain high-level aquifers. Carruth (2003) documents that an average of 0.22 Mgal/day were contributed to the municipal water supply from Tanapag I and II Springs and Achugao Spring. Water level in the high-level aquifers (and flow from springs) fluctuates seasonally and is sensitive to periods of low rainfall.

Figure 12 and **Figure 13** show groundwater management zones, location of water wells, water table and groundwater flow direction, and municipal supply spring locations.

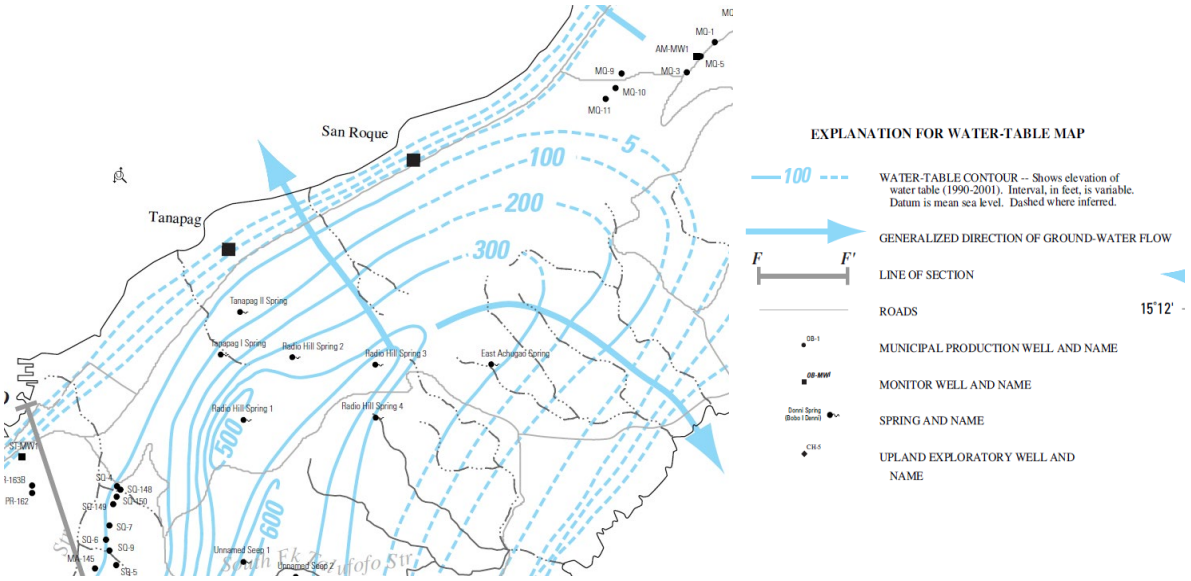


Figure 12. Water table contour and flow map (Carruth, 2003)

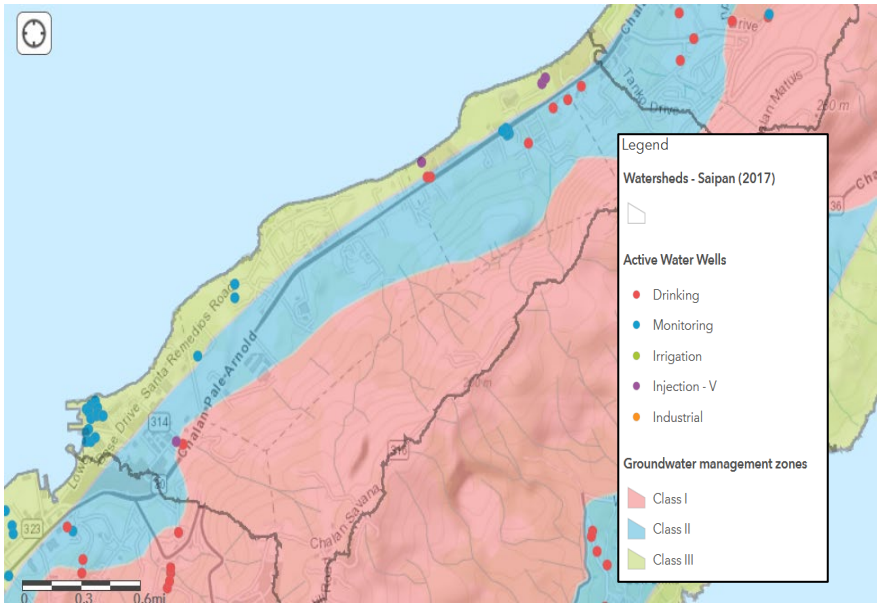


Figure 13. Groundwater management zones and wells from CRMOGIS (BECQ, 2017)

Hydrodynamics

The Tanapag Lagoon is relatively shallow, with an average depth of approximately 4 m—2 m or less nearshore in Tanapag and San Roque (**Figure 14**). There is a barrier reef to the north and a shipping channel to the west. Two hydrodynamic studies (Damlamian and Kruger, 2010 and SEA Engineering, 2019) describe predominant wave-driven flows over the northern reef, into the lagoon, and out the shipping channel or further south into the lagoon depending on tides (**Figure 15**).

Incoming ocean currents from the shipping channel can create a large eddy off Tanapag when the wave and wind pattern is predominantly from the east. This can create lower wave stress on the northern reef, slower southward currents in the lagoon, and increased in-flow from the shipping channel. Waves breaking on the northern barrier reef meet incoming oceanic waters creating anti-clockwise eddies and northward flows (**Figure 16**). During either winter or summer scenario, there are slow currents along the shoreline which may influence dispersal patterns and accumulation rates of land-based pollution from stream outlets and outfall pipe discharges. Die tracing studies by Sea Engineering (2019) show not much movement along the shoreline.

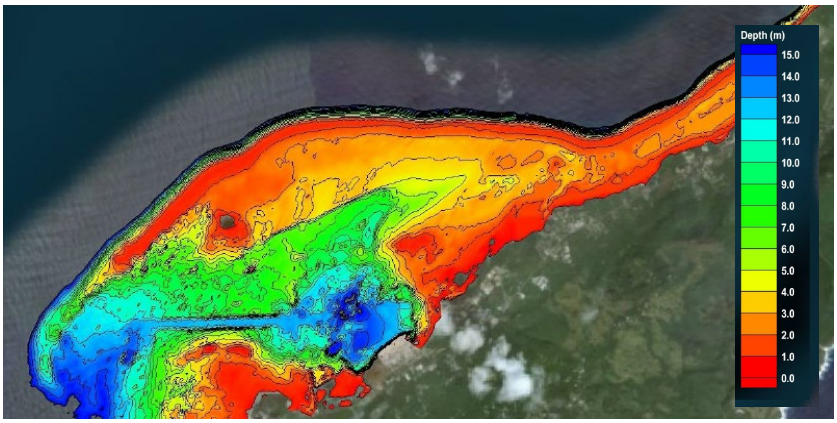


Figure 14. Bathymetery of Tanapag Lagoon (Sea Engineering, 2019)

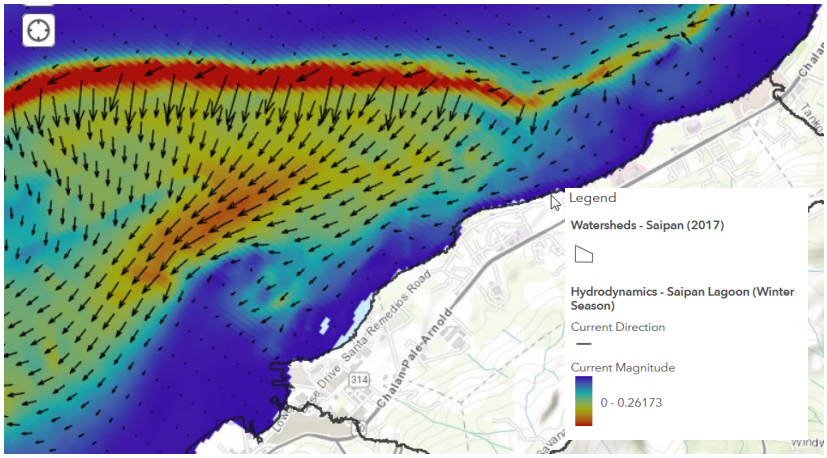


Figure 15. Predominant winter tradewind currents (from CRMOS, 2020, data from SEA Engineering, 2019)

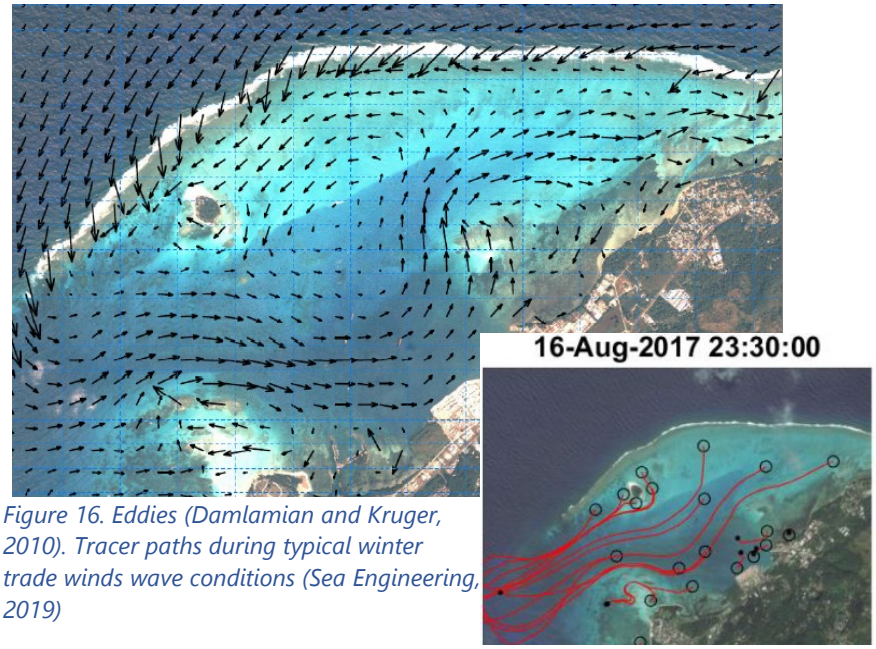


Figure 16. Eddies (Damlamian and Kruger, 2010). Tracer paths during typical winter trade winds wave conditions (Sea Engineering, 2019)

ECOLOGICAL RESOURCES

Marine Benthic Ecology

In 2017, NOAA updated the shallow water benthic habitat maps for Saipan Lagoon to reflect changes in coverage and habitat distribution due to previous bleaching events and tropical storms (Kendall, et al 2017). This mapping effort used a combination of remote sensing, underwater video, and photos to produce high-resolution mapping of substrate and cover types to characterize habitat diversity, including sea grass beds and coral cover (living and dead) (**Map 11**). The benthic maps show important seagrass and coral resources in the northern part of the Lagoon, including live Acropora. Significant loss in sea grass beds near Lower Base, as well as nearshore sand distribution was observed (**Figure 17**). This decline was also documented in detail by Camacho (2016) in a study on the spatial and temporal changes in seagrass and macroalgal assemblages. He suggests watershed management resources should focus on areas recently trending towards increased macroalgal cover, which include the Tanapag area, and suggests that restoration efforts in these regions could result in more ecological benefits for less cost and with less social conflict.

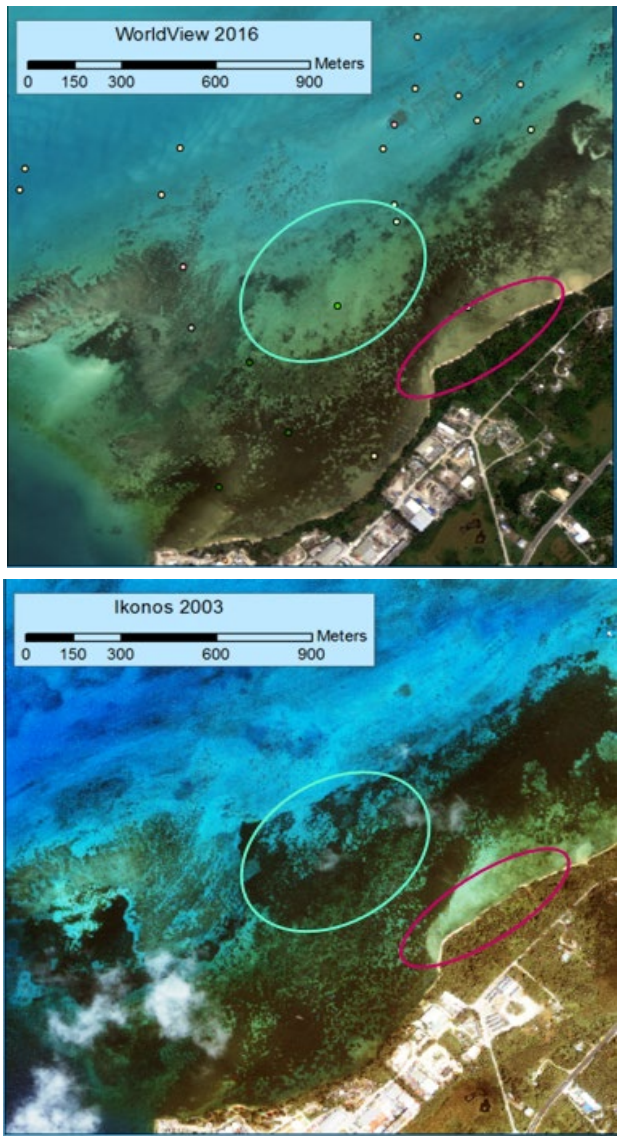
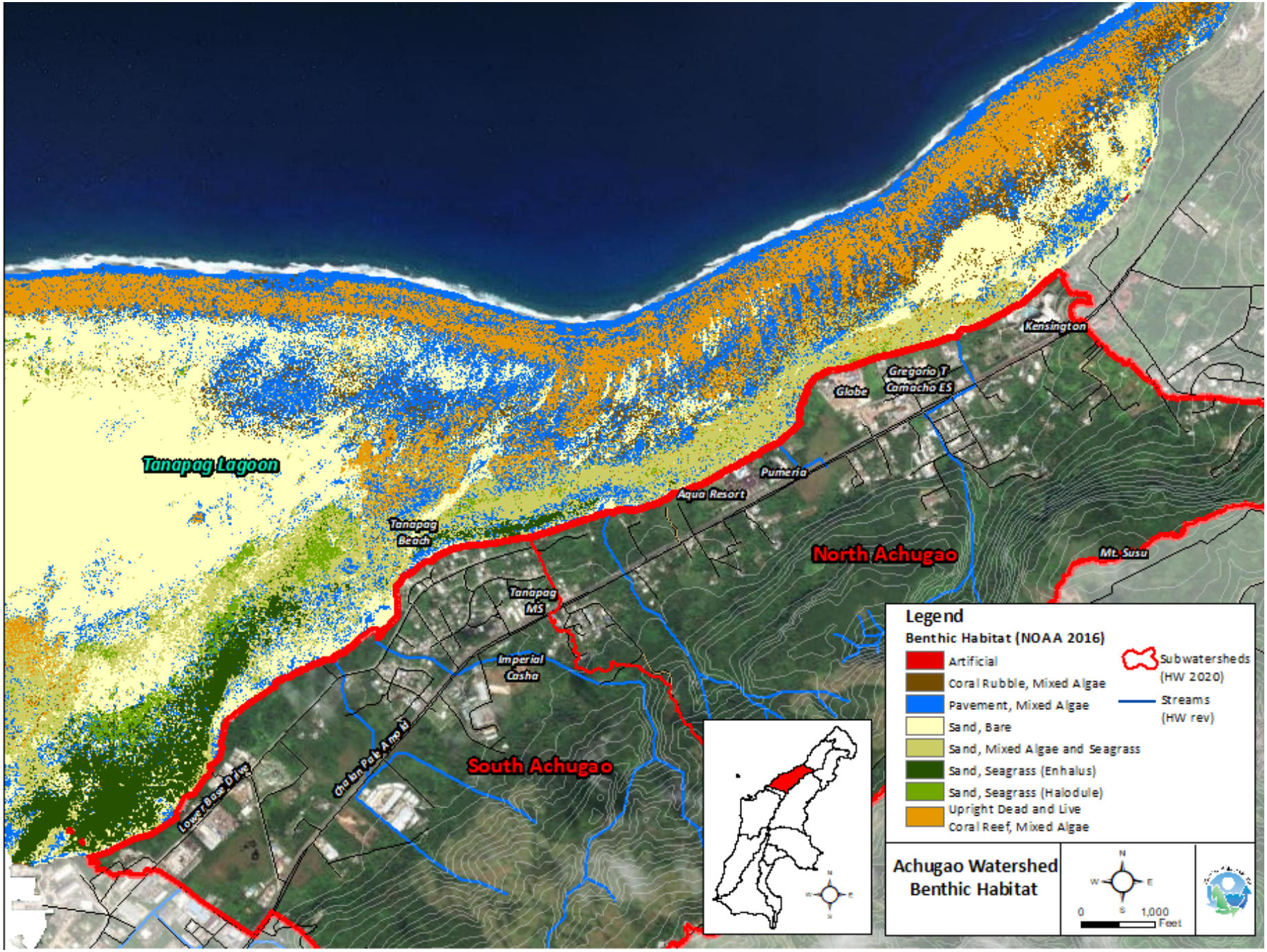


Figure 17. Comparison of seagrass coverage (blue) and shoreline extent (pink) between 2003 and 2016 imagery (presented by Steve McKagan, 2017).

Preliminary results from 25 long-term, marine habitat monitoring sites in Saipan Lagoon from 2015-2016 were presented at a watershed meeting in 2017. **Figure 18** shows the cover and habitat diversity scoring for seagrass and coral at these sites. The seagrass beds (without consideration of invertebrates) rate fair to good in quality. Coral condition generally ranks poor, with better quality (some of the best in the lagoon) seen near PauPau Beach.

Sea surface temperatures, the frequency and intensity of heat stress, and ocean acidification have been increasing and this trend is expected to continue (Grecni et al., 2021). High heating alert levels that can lead to bleaching events were observed in the CNMI in 2013, 2014, 2016, and 2017. 90% of *Acropora* and 70% of *Pocilloporus* were killed off in the 2017 bleaching event.



Map 11. Benthic Habitat in northern Saipan Lagoon (NOAA 2016)

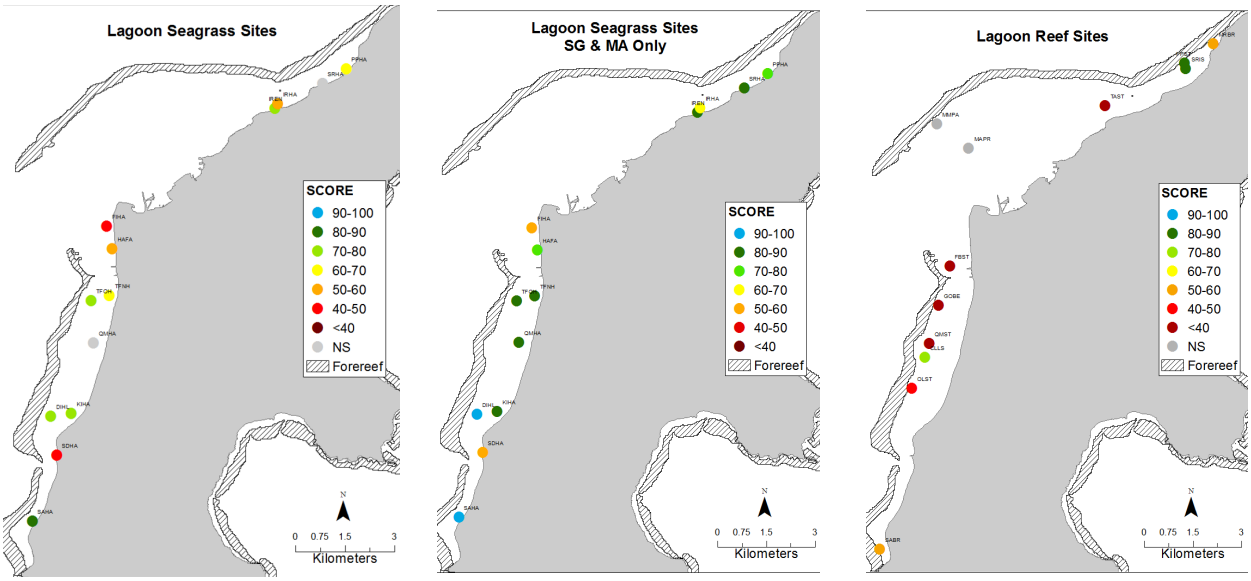


Figure 18. Status of seagrass and coral habitats in Saipan Lagoon 2015-2016 (Johnston presentation, 2017), where a) is seagrass habitat scores including invertebrate assemblage parameter; b) is seagrass habitat looking at seagrass and macroalgae cover and diversity only; and c) is reef habitat (coral abundance, richness, etc.).

Between 2012 and 2018, over 67% coral cover decline was observed across 35 monitoring sites across the CNMI (Maynard et al., 2019). **Figure 19** shows the relative change in coral cover during this timeframe. The relative impact of land-based sources of pollution on sites around Achugao was assessed as medium, based on the sources and the number of water quality exceedances (**Figure 20**).

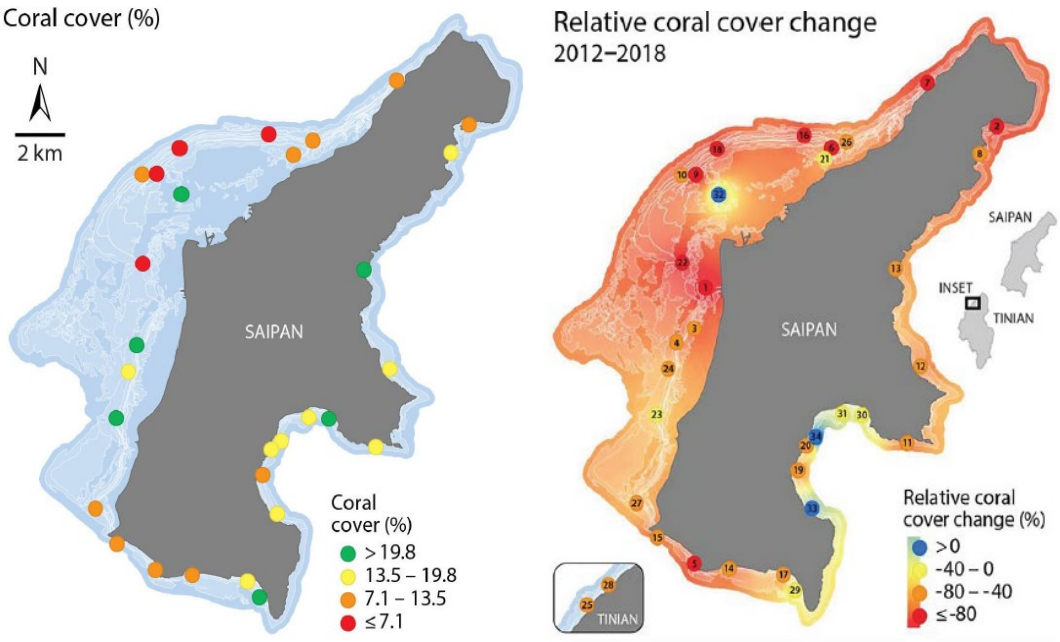


Figure 19. % Coral cover in 2018 (Maynard et.al, 2018) and change in coral cover between 2012-2018 (Maynard et al., 2019)

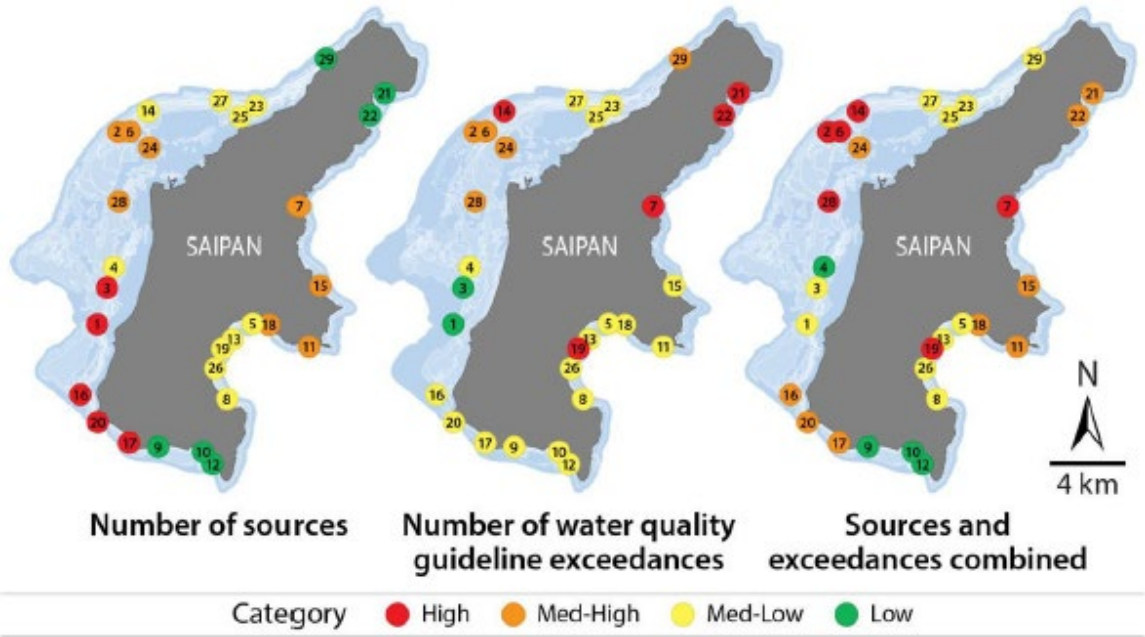


Figure 20. Relative impact of watershed pollution (Maynard et al, 2018).

USGRCP (2018) modeled the onset year of severe annual bleaching conditions for the CNMI under a high warming scenario. Estimates show these conditions could be met within the next 10 years in Achugao **(Figure 21**).

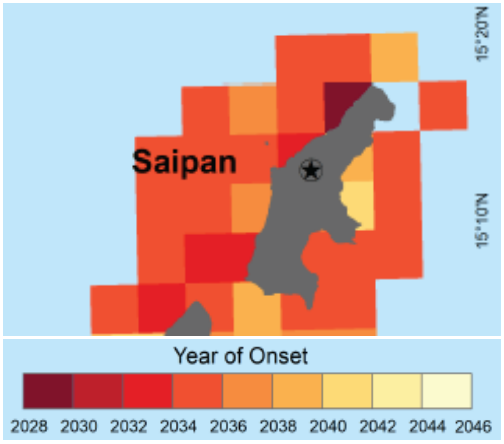


Figure 21. High warming scenario modeling of onset of severe annual bleaching conditions (from Grenci et al. 2021)

A coral economic valuation study for the CNMI estimated that across several ecosystem services, coral reefs in the CNMI generated over $104.5M annually (ERG, 2019). The reefs in Saipan lagoon contribute to infrastructure protection, tourism, recreation, fishing, and biodiversity revenue. Economic value is increased when reefs are close to shore and accessible. The reefs and seagrasses in the Achugao watershed are within 100m to shore and protect significant infrastructure (villages, roads, hotels, sewer lines, etc.).

An evaluation of marine habitat services was conducted as part of a resiliency analysis by Dobson et al. (2020) that identified the most important habitats for coastal protection and aquatic organisms. **Figure 22** shows high value reefs and seagrass off Achugao.

Figure 22. Marine habitat index (Dobson et al., 2020)

Terrestrial Ecology

A study of forest quality across Micronesia found that the CNMI had the smallest trees, lowest basal area, highest stem density, lowest average canopy cover, and highest levels of disturbance and invasive species coverage compared to other islands (Dendy et al. 2020).

Less than 20 hectares of mangrove remains in the CNMI. The only mangrove forest in the CNMI is between Memorial Park and Tanapag (Wildlife Action Plan 2015-2025) and at the mouth of some streams in Achugao. A recent valuation study in the CNMI estimates the value of local mangroves at over $100,000 per hectare per year. The 2016 vegetative cover mapping identifies no native limestone or ravine forests in the watershed. In a 2005 mapping analysis by NOAA, 40 acres of limestone forest were identified along the Achugao stream corridor (**Figure 23**). It is uncertain if this loss of native forest is simply due to classification discrepancies of a highly fragmented forest, or if it represents an actual decline in native species. A "Native limestone forest" is defined as forests of varying ages present on a limestone substrate, with a canopy dominated by native tree species, such as *Elaeocarpus joga* (joga), *Pisonia grandis (umumu or umomo)*, *Hernandia labyrinthica* (oschal), *Hernandia Sonora* (nonak or nonag), *Ficus prolixa* (nunu), *Macaranga thompsonii* (pengua), and *Intsia bijuga* (ifit). Dominant canopy species vary by each island, and in some cases by region of an island.

The Wildlife Action Plan for the CNMI 2015-2025 doesn't specify critical habitats or species in the Achugao watershed, but does include some relevant recommendations, including: establishing a vine management program; prioritizing areas for habitat conservation for species of concern (Micronesian megapode, golden white-eye, Mariana common moorhen, and nightingale reed-warbler); and reducing disturbance at swiftlet caves.

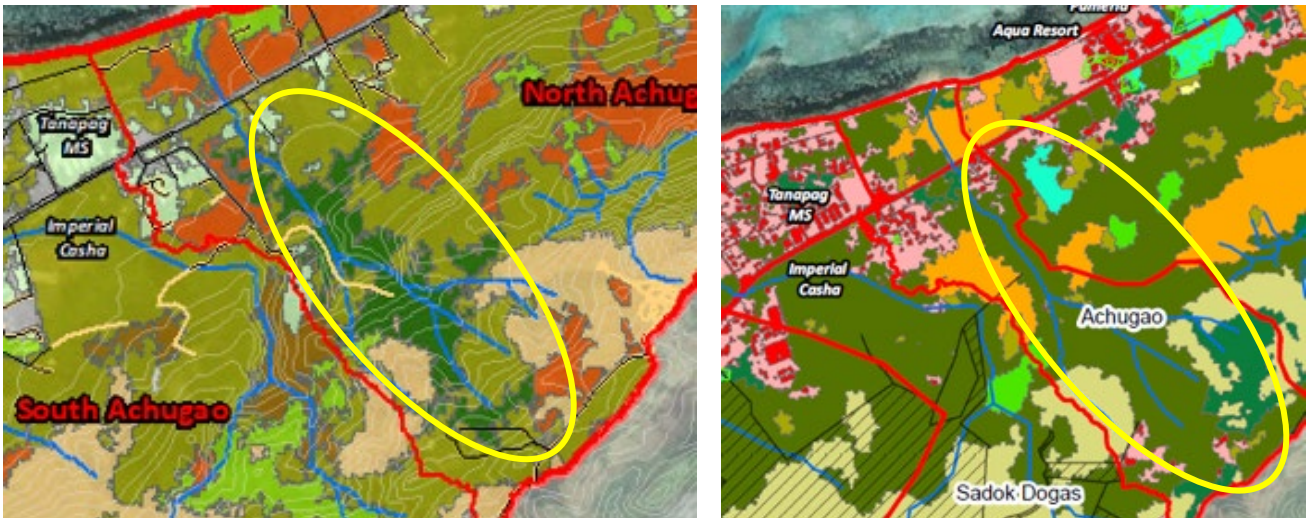


Figure 23. (Left) Native limestone forest (dark green) along Achugao stream in 2005. (Right) Same area in 2016 shown as mixed introduced forest (dark green).

The 2020-2030 CNMI Forest Action Plan reports that 15% of native plants in CNMI are listed as threatened or endangered and that invasive species have significantly and permanently altered the terrestrial habitats and reduced the value of ecosystem services across the Marianas. Common invasives include: Scarlet gourd (*Coccinia grandis*), chain-of-love (*Antigonon leptopus*), alalaga/paper rose (*Operculina ventricosa*), bitter vine (*Mikania micranthra*), bitter gourd (*Momordica charantia*) wood rose *(Merremia tuberosa*), Water hyacinth (*Eichhornia crassipes*), and Lantana (*Lantana camara*). Within the Forest Inventory & Analysis plots, 29 invasive plants/trees were found; >90% of the plots had some level of invasive plants/trees; and the average % cover by invasive plants/trees was 56% (Forest Action Plan 2020-2030).

An evaluation of upland habitats was conducted as part of a resiliency analysis by Dobson et al. (2020) to identify the areas most suitable for species of concern by IUCN. **Figure 24** shows relatively med-high value areas in Achugao. PCRP 2022 also conducted a spatial analysis for the updated Forest Action Plan to identify priority forest stewardship areas. Of the 140 acres identified as priorities on Saipan, approximately 115 acres are located in the Achugao watershed (**Figure 25**).

Major storms can damage trees and cause delays in fruiting/flowering that affects pollinators. Longer or more intense droughts may increase wildfire risk, hinder revegetation efforts, and increase native tree susceptibility to pests and diseases. Fragmentation increases vulnerability to pests and diseases. Coastal wetlands and mangroves may be sensitive to changes in sea level, salinity, and sedimentation exacerbated by climate change (Greene and Skeele 2014).

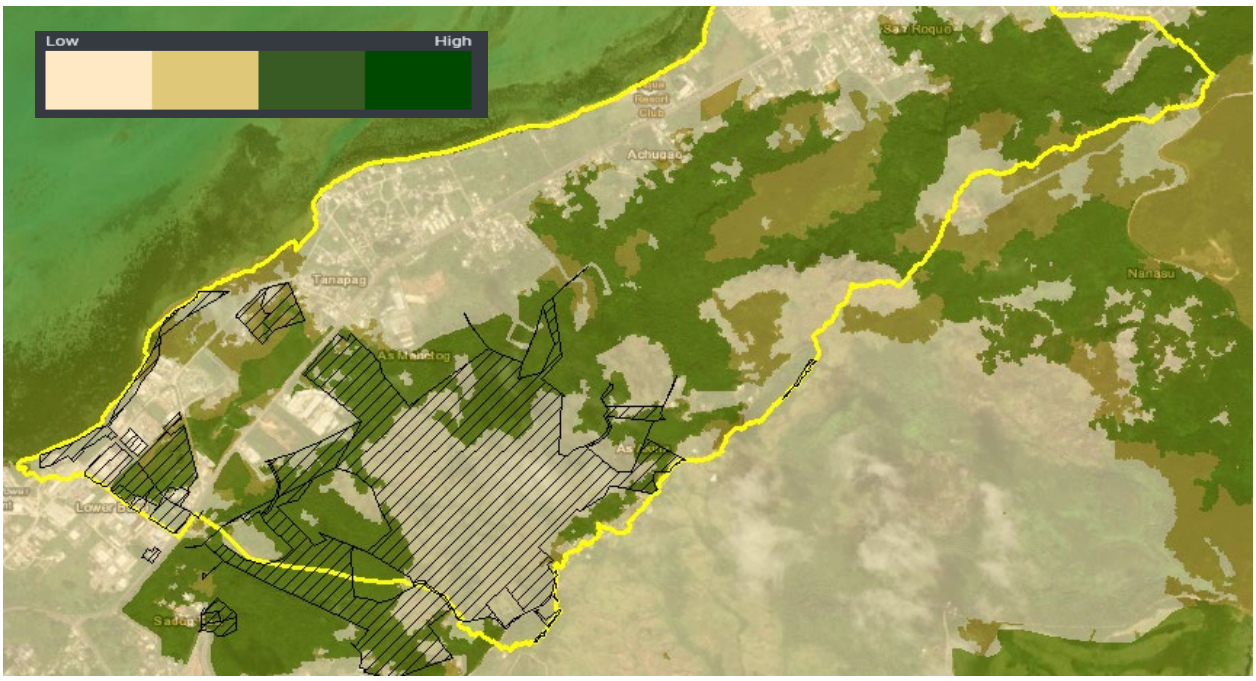


Figure 24. Terrestrial habitat index (Dobson et al. 2020) and undeveloped public lands (hatched).

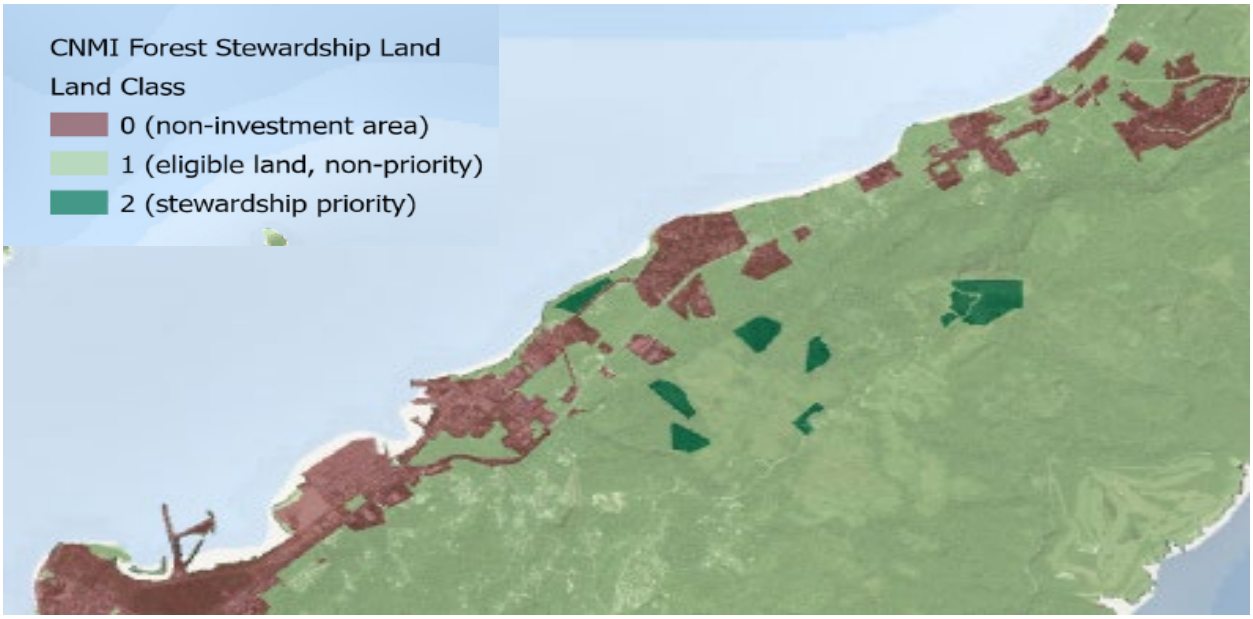


Figure 25. Priority Forestry Stewardship Lands (dark green) in Achugao Watershed (PCRP, 2022)

Streams

The CNMI has few streams that are wet most of the year and none have measurable flow volumes year-round through their entire length. The four major stream systems in the watershed include (mapped steam miles): As Agatan (1.4 mi), Saddok Dogas (2.5 mi), Achugao (1.7 mi), and San Roque (2.2). There are perennial freshwater pools located in the headwaters and Agatan Stream is deep enough near the mouth to maintain standing water. Visual stream assessments were conducted by BECQ in 2020 for the Agatan, Dogas, and Achugao streams using the new CNMI SVAP method. **Figure 26** shows overall rating of stream quality for the streams that were assessed, as well as scores for embeddedness, bank stability, and riparian habitat.

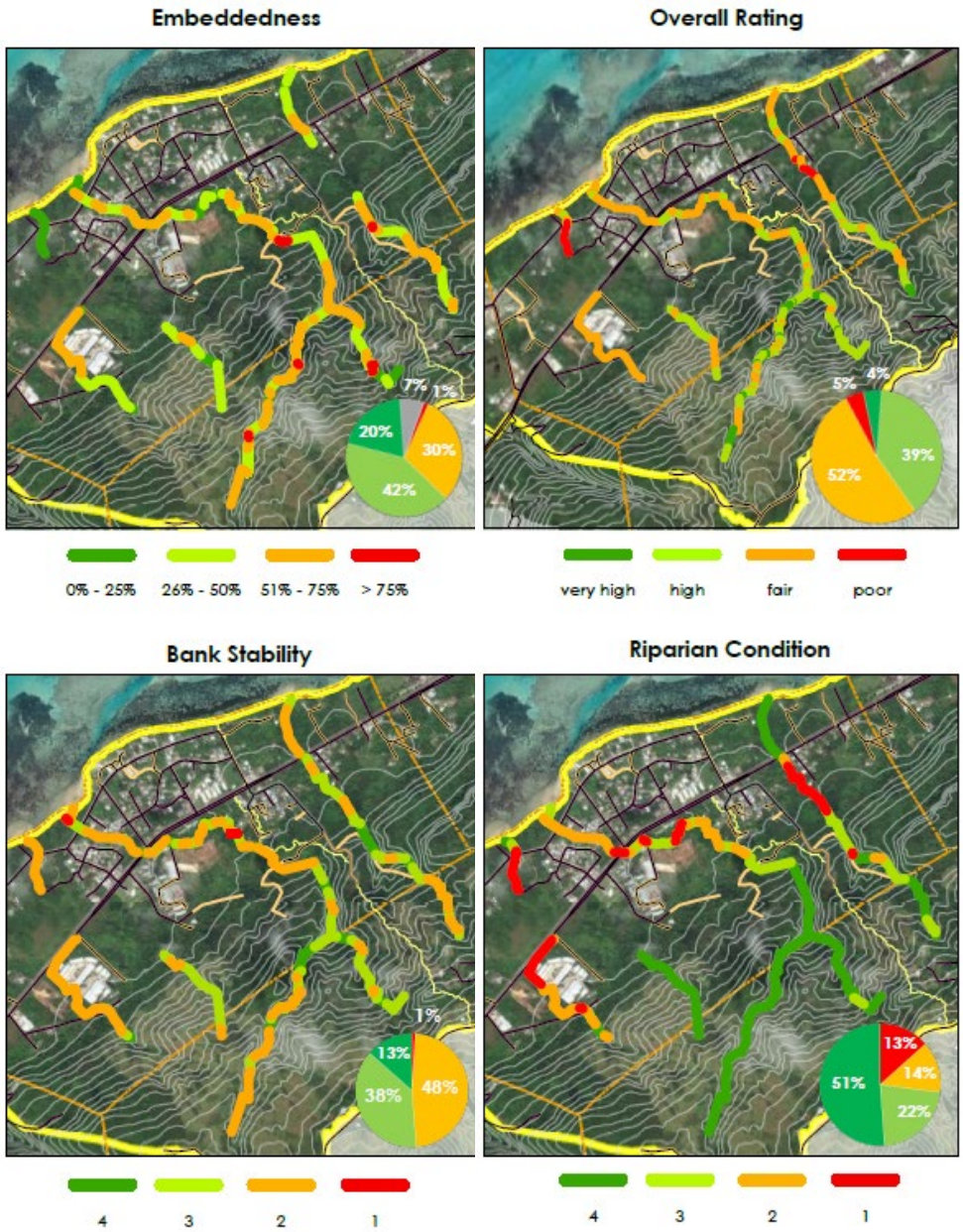


Figure 26. DEQ's 2020 Stream Visual Assessment overall stream quality rating and % segment embeddedness, riparian condition score, and bank stability score.

The 2020 Integrated Waters Report states that shrimp and eel were observed in mid and upper reaches of Agatan and Dogas streams above Middle Rd. WWII dumpsites were confirmed in the mid to upper reaches of Dogas.

Freshwater Wetlands

There are over 56 acres of freshwater wetlands in the Achugao watershed, mostly located seaward of Middle Rd. There are three large wetland complexes: the Falig Wetland mitigation site in Lower Base, a similarly sized and connected complex in the As Agatan drainage system, and an area spanning both sides of Middle Rd. between the Plumeria Hotel and the Saipan Globe construction site in San Roque.

These natural systems likely provide water quality, flood attenuation, and habitat services unique to Saipan despite significant physical and hydrologic alterations (past and present). The two active construction sites at Saipan Globe and Imperial Casha offer examples of active buffer encroachment and wetland alteration/loss. Comprehensive wetland habitat and functional assessments of these systems has not been conducted recently.

A RAM wetland assessment was conducted by DCRM in 2020 for six depressional, palustrine wetlands (**Figure 27**). While many stressors were noted (localized disturbance, sedimentation, invasive plants and animals), most of these wetlands ranked "high" for total scores and wetland function, except for SA04TA01 and SA04TA02 **(Table 12**). Both of these wetlands had landscape-wide disturbance, water pollution, and hydrologic alterations. Common invasive plant species in the wetland buffer included *Mikania scandens,* Bamboo *sp., Coccinia grandis, Leuceana leucocephala, Pluchea indica, and Antigonon leptopus*.

Table 12. RAM Wetland Ranking

Metric/Index	B05	B06	B08	B09	A01	A02
TOTAL RAM	HIGH	HIGH	HIGH	HIGH	HIGH	MED
HYRDOLOGY	HIGH	HIGH	HIGH	HIGH	MED	MED
WATER QUALITY	HIGH	HIGH	HIGH	HIGH	MED	MED
HABITAT	HIGH	HIGH	HIGH	HIGH	HIGH	MED

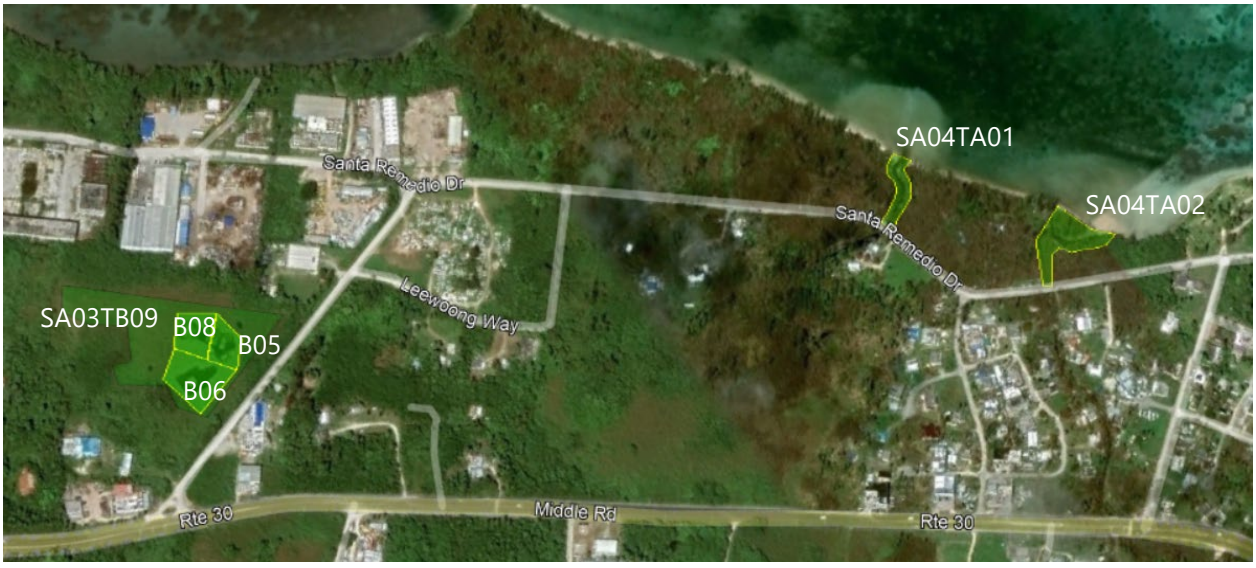


Figure 27. Location of RAM Wetland Assessment Sites in the Achugao Watershed

WATER QUALITY

Impaired Waters

All coastal waters in Achugao are class AA, with the exception of the Class A industrial waters off of Lower Base, which span from the Agatan stream outlet southward to Smiling Cove Marina. The draft 2020 305(b) and 303(d) Integrated Waters Report identifies several impairments for Achugao waters, including poor habitat, low dissolved oxygen, high enterococcus bacteria counts, lead (Pb) in bivalves, and elevated orthophosphate. summarizes the 2020 listings for each assessment unit in the watershed.

Table 13. 303(d) Impairment listings excerpt from the draft 2020 Integrated Report (Enterococci not listed due to completion of 2017 TMDL)

Seg ID	Segment Name	Size	Cause Name	Source	Cycle First Listed
20 A	Achugao (North)	1.9 miles	DO% (205)	Roads, Infrastructure New Construction	2010
			Phosphate (340)	Source Unknown	2020
20 B	Achugao (South)	2.4 miles	DO% (205)	Grazing in Riparian or Shoreline zones	2010
				On-site Treatment Systems Septic	2010
				Sanitary Sewer Overflows	2010
				Urban Runoff/Storm Sewers	2010
			lead (267)	NPS Pollution from Military (Other than	2018
20STRB	Achugao (South) Stream	6.5 miles	lead (267)	NPS Pollution from Military (Other than	2018
			Enterococci (215)	Grazing in Riparian or Shoreline zones	2018
				On-site Treatment Systems Septic	2018
				Sanitary Sewer Overflows	2018
				Urban Runoff/Storm Sewers	2018

Map 12 shows the assessment units and monitoring locations in the Achugao watershed. Achugao South has three BEACH monitoring sites (two in the industrial Class A waters—the sea plane ramp and central repair shop—and one near the Tanapag Meeting House). The 2020 Integrate Report includes four long term BEACH monitoring sites at the hotels (Aqua, Plumeria, Saipan Globe/San Roque School, and Kensington). Not shown are the two stations at Aqua Resort and Plumeria nor the sea plane ramp site south of the watershed boundary. SWQAMP monitoring sites were identified at locations within the stream systems; however, it is not clear if these monitoring stations are active. Stream water quality sampling was conducted in Achugao in 2014 and 2020 on three stream systems that were impaired—Achugao, Dogas and Agatan. Sanitary assessments of the streams revealed illicit discharges of kitchen greywater, waste from animal pens, and failing sewer lines and connections. No specific locations of severe stream erosion, buffer encroachment, culvert replacement or other restoration opportunities were explicitly identified.

Table 14 summarizes attainment status for each designated use category. While Enterococci is listed less frequently, this is because of the completion of the 2017 TMDL for bacteria rather than an actual decrease in WQS violations. There has been an increase in impaired listings for heavy metals. Studies by Denton, et.al. (2010, 2014, and 2018) indicate that heavy metals are transported into sediment and biota from nearby WWII debris dumpsites. Coastal waters in South Achugao do not support fish and shellfish consumption due to elevated heavy metals.

Table 14. Designated Use Summary (2018 Integrated Waters Report)

Designated Use	20 (B) Achugao South			20 (A) Achugao North		
	Coastal WB9-7	Streams ACH03-02	Wetland	Coastal WB6-3	Stream ACH01	Wetland
Aquatic Life	Poor habitat, DO% low	Native habitat, visual field good	NA	Fair habitat, low DO%, Ortho-phosphate exceeded	Native habitat, visual field good	NA
Fish Consump-tion	Lead in bivalves	HG, Pb in bivalves	--	Fully Supports	Insufficient information	--
Recreation	Entero-coccus Exceeded*	Entero-coccus Exceeded*	--	Entero-coccus Exceeded*	Insufficient information	--
Aesthetic enjoyment	Fully Supports	Fully Supports	--	Fully Supports	Fully Supports	--

Table 15 shows bacteria violations and dissolved oxygen (DO) exceedances in Achugao. North Achugao bacteria impairments in 2016 were reportedly due to sanitary sewer overflows and increased sewage flows during hotel renovations. Sewer upgrades and pump replacements since then have been credited with improved water quality. Similarly, Achugao South experienced multiple sewage overflows and system

Table 15. Percentage of annual bacteria and dissolved oxygen exceedances (draft 2020 Integrated Report) South (bottom) subwatersheds (2017 Bacteria TMDL fact sheet).

Enterococci % Violations																		
Sample Station ID	Sampling Station Name	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Segment Class
	SEGMENT 20A: ACHUGAO (NORTH)																	
WB 03	Kensington Hotel (Nikko Hotel)	21	8	6	19	4	6	0	10	8	8	7	16	0	0	6	0	AA
WB 04	San Roque School	35	14	13	17	14	10	4	8	6	10	18	14	4	2	4	2	AA
WB 05	Plumeria Hotel	10	12	6	13	4	0	4	19	4	2	18	12	4	6	8	4	AA
WB 06	Aqua Resort Hotel	8	14	12	13	2	4	6	8	2	4	28	12	2	4	7	4	AA
	SEGMENT 20B: ACHUGAO (SOUTH)																	
WB 07	Tanapag Meeting Hall	44	35	50	32	36	38	37	35	26	40	44	42	15	31	20	20	AA
WB 08	Central Repair Shop	33	35	35	34	34	56	23	38	39	37	26	39	6	23	29	35	A
WB 09	Sea Plane Ramp	0	4	2	15	0	0	0	2	2	2	3	2	4	6	8	2	A

% DO Exceedences														
Sampling Station ID	Sampling Station Name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Segment Class
	SEGMENT 20A: ACHUGAO (NORTH)													
WB 03	Kensington Hotel (Nikko Hotel)	2	12	2	4	12	4	8	4	19	21	6	9	AA
WB 04	San Roque School Beach	2	6	8	4	10	2	6	2	13	8	9	0	AA
WB 05	Plumeria Hotel	10	8	6	2	6	0	0	4	4	4	7	0	AA
WB 06	Aqua Resort Hotel	2	6	4	4	8	0	0	2	4	8	7	0	AA
	SEGMENT 20B: ACHUGAO (SOUTH)													
WB 07	Tanapag Meeting Hall	2	8	8	10	6	0	4	8	15	10	9	5	AA
WB 08	Central Repair Shop	4	16	13	21	19	16	10	16	16	27	13	7	A
WB 09	Sea Plane Ramp	2	8	6	4	4	0	3	2	4	0	2	5	A

failures associated with worker barracks. Several instances of raw sewage overflow into wetlands were reported in 2017.

In addition, piggeries at homesteads in the upper watershed have been cited as bacteria sources. Stormwater runoff and feral animals have also been identified as likely sources of bacteria; however dry weather flows (at least in Achugao south) seemed to be the predominant issue at the time (**Figure 28**). This may have since changed with wastewater infrastructure maintenance and upgrades.

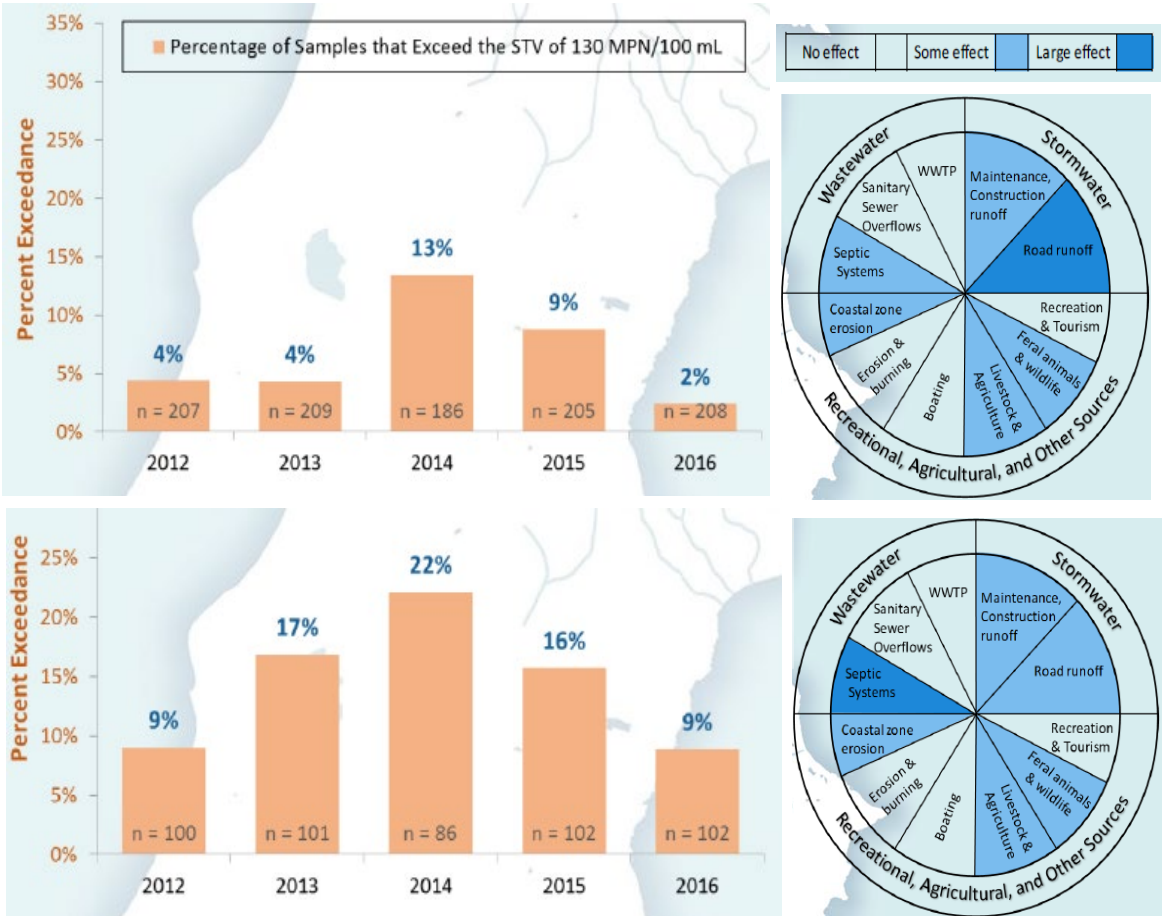


Figure 28. STV exceedances for Enterococcus between 2012-2016 and presumed sources in Achugao North (top) and South (bottom) subwatersheds (2017 Bacteria TMDL fact sheet).

Bacteria Total Maximum Daily Load (TMDL)

A coastal waters bacteria TMDL was completed in 2017 by Paradigm Environmental establishing several reduction targets for Achugao based on rainfall season and duration curves (**Table 16**). Watershed recommendations (presuming wastewater infrastructure improvements have been completed) include managing road runoff, construction activities, and septic systems. The TMDL recommends EPA focus on supporting small-scale water quality projects, site reviews of local piggeries and other local farm sites; continued outreach to farmers on accessing NRCS funds for best management practices, and watershed revegetation efforts to reduce impacts of fires.

Table 16. Summary of Enterococcus TMDL load reduction targets

	% Reduction Duration Curve Zone				
	Dry (0 - 10%)	Low - Mid (10 - 40 %)	Mid (40 -60 %)	Mid - High (60 - 90 %)	High (90 - 100%)
Achugao North (Segment 20A)					
STV	0%	0%	0%	0% / 38%	71% / 0%
Geomean	0%	0%	0%	0%	0% / 2%
Achugao South (Segment 20B)					
STV	40% / 0%	0%	0% / 38%	40% / 63%	85% / 77%
Geomean	2% / 0%	0% / 38%	4% / 20%	8% / 88%	52% / 72%

Reductions shown for dry season / wet season

Microbial Source Tracing

Enterococci monitoring can be useful for identifying water quality "hot spots," but doesn't necessarily inform managers of where microbial contamination is generated. In 2018, molecular microbial source tracking for fecal indicating bacteria (FIB) was conducted at over 60 sites around Saipan to determine if sources were human, pig, cow, seabird, or dog (**Figure 29**). Several of these sites were within or near the Achugao watershed: WB07 (Tanapag Meeting House), WB08 (Central Repair Shop), and shoreline samples S04-S10.

Sinigalliano et al. (2020) reports that high levels of dog FIB were found at the Tanapag Meeting House (WB07) and S09 stations. Most shoreline samples returned insignificant counts of human FIB, with the exception of S09 in March 2018 and WB07 in July 2018. These findings indicate that dog waste may be the primary source of bacteria. Sinigalliano recommends BECQ gain a better understanding of temporal and spatial dog waste contributions regionally as well as additional investigation into stormwater runoff contamination in Tanapag.

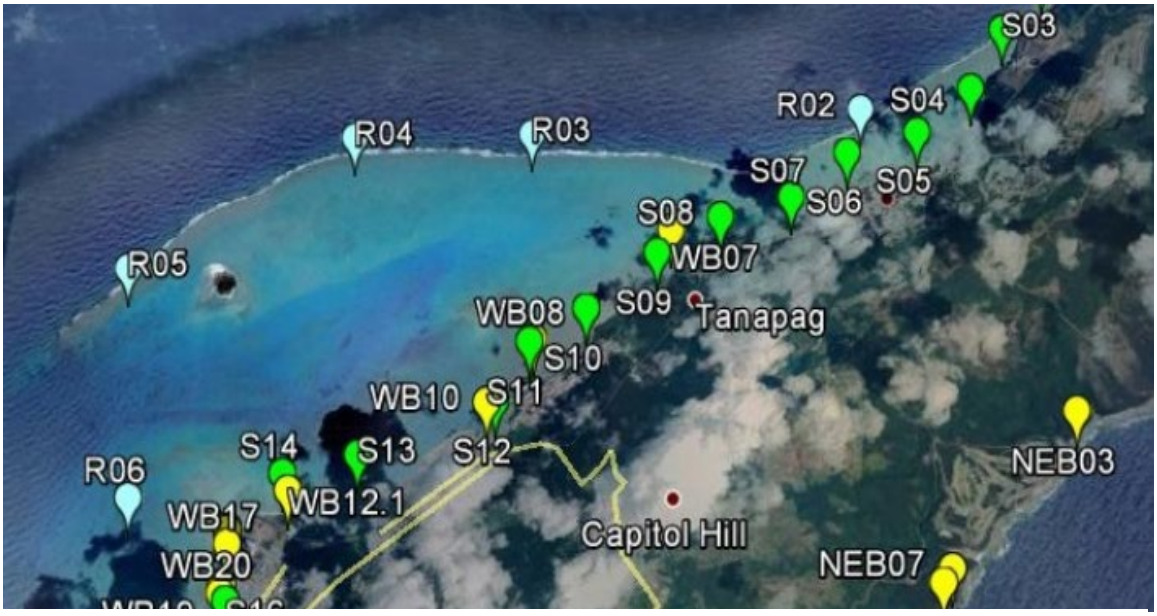


Figure 29. MST and nutrient study sites in and around Achugao (Sinigalliano et al 2020 and Kim, 2019)

Groundwater Nutrients

Nutrient contributions from groundwater are a concern in the CNMI. Research on Guam has been conducted looking at nitrogen isotopes in seagrass to evaluate the impact of anthropogenic sources of nutrient loading (Pinkerton et. al 2015). This effort has expanded into recent studies by Dr. Kiho Kim and others to understand the source of nutrients and the spatial and temporal variations of nutrient-enriched groundwater discharges into the Saipan Lagoon. They collected benthic algae and seagrasses for isotope analysis as well as water quality samples for nutrient and radon analysis at several monitoring stations used for the microbial study. Stations S04-S10 are in the Achugao watershed.

Findings indicate that: 1) shoreline station S08 in Achugao is one of three nitrogen "hotspots" from sewage-derived nitrogen; 2) groundwater nitrogen concentrations are an order of magnitude higher than surface waters; and 3) wastewater system improvements may go further to improve nutrient dynamics than stormwater retrofitting.

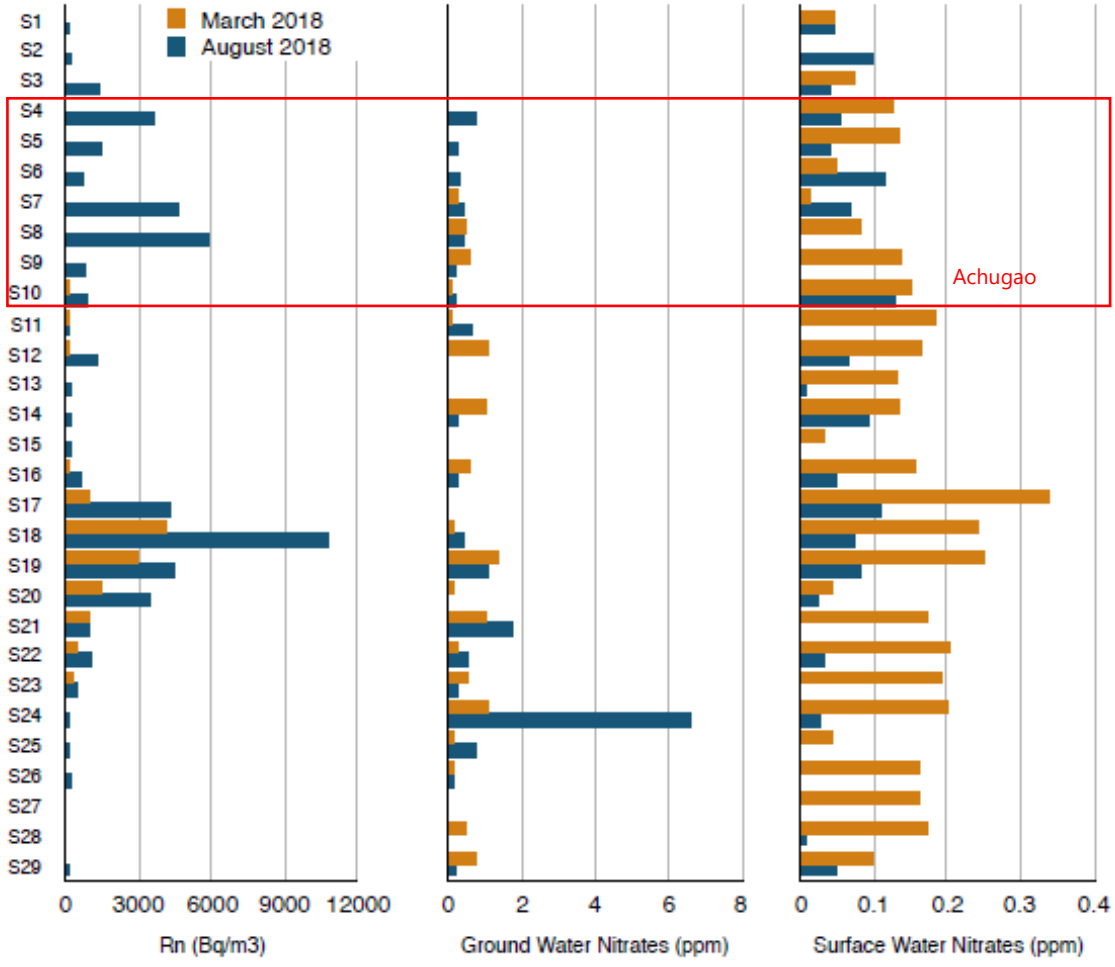
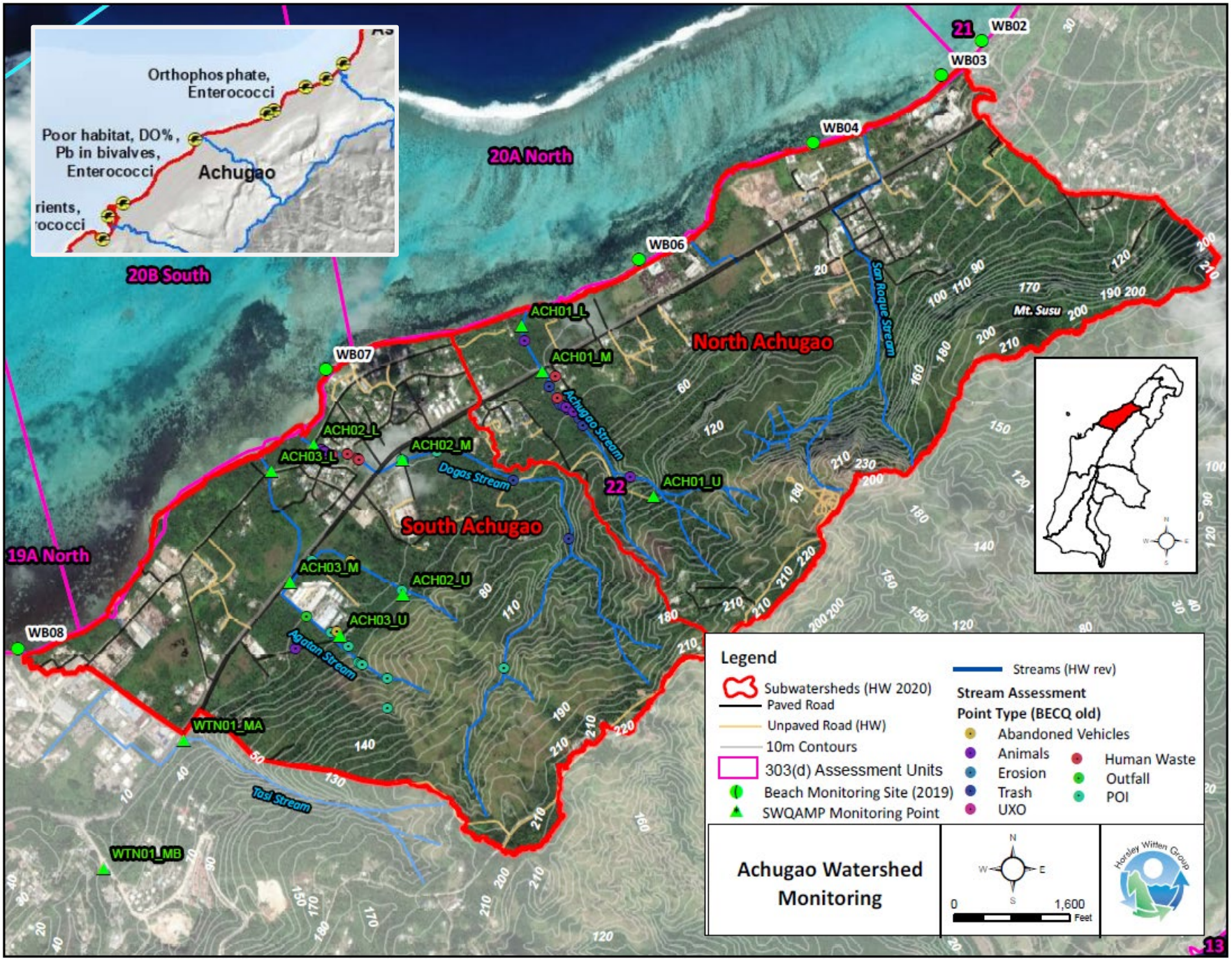


Figure 30. Nutrient concentrations in ground and surface waters (Kim 2019)



Map 12. DEQ Monitoring locations and 303(d) assessment units

Watershed Services

Watershed workshop to solicit input on agency initiatives and management objectives related to Achugao, Garapan, and Laolao watersheds.

In January 2020, over 40 stakeholders from CNMI government agencies and NGOs came together to discuss watershed management objectives for Achugao. Part of these discussions involved identifying natural watershed services and specific activities that are negatively impacting those services. Participants identified ways the Achugao watershed benefits the community, wildlife, and the local economy. The services listed below were ranked by stakeholders into the top three:

1. Freshwater—there are several springs and wells that directly benefit the community (19 votes)
2. Habitat (19 votes)—seagrass provides fish habitat and 2nd strongest flowing streams provide habitat for eels and shrimp
3. Erosion prevention and maintenance of soil fertility—forest cover and other natural vegetation protects slopes and shorelines from erosion (18 votes). Mangroves stabilize shorelines and provide habitat.
4. Water purification and waste treatment (11 votes)—lovely diverse wetlands that protect lagoon and beach water quality and provide habitat
5. Food (8 votes)
6. Spiritual, Religious, Cultural Value (3 votes)—presence of medicinal plants affords opportunity to pass on cultural knowledge
7. Aesthetic Value (2 votes)
8. Carbon Sequestration (1 vote)
9. Nutrient cycling (1 vote)
10. Recreation (0 votes)—there is a great community center and activism in protecting resources for fishing, boating, etc. Parks bring people together.
11. Raw materials (0 votes)
12. Aquaculture (0 votes)

Negative impacts on watershed services were attributed to several activities, including wildfires, new development, invasive species, and land-based sources of pollution.

Table 17 summarizes the discussion of root causes and potential strategies for addressing these threats.

Table 17. Threats to Watershed Services and Potential Solutions

Root Causes/Threats /Drivers	Strategies
Wildfires • Climate change—drier/warmer weather • Agricultural clearing (time of year) • Trash burning and green waste→ lack of transport to dump • Hunting	a) Have advisory signs and targeted education to rebrand "wildfires" to ensure people know that it's human caused; what to do/not to do (in dry conditions); b) Improve understanding of what plants can help with restoration, etc. (Ilan working on this) c) Implement air quality regulation/permitting for agricultural burning d) Revegetate burned areas with fire risk in mind e) Improve interagency cooperation with fire department
New Development • Increase in tourism investments → Chinese visa waiver program & MVA encouragement • Foreign investors → cultural differences not used to cheap land and no infrastructure • Zoning unclear and vague • Lack of long-term planning • Relaxed permitting • Failure to follow through with permit violations	a) Improve consistency in development planning and permitting with foreign investors ; think infrastructure first in pre-permit process; address language barrier/interpreters; develop a flow chart of different agency permits. b) Explore changes to how leasing occurs. Limit the number of years with no activity before lease is lost. Consider how to protect landowners from abandoned construction/degraded lands. c) Find ways to increase community involvement in decision making on development d) Update zoning to protect wetlands and include small scale/boutique tourism zoning. Show economic value of watershed services to decision makers and landowners. e) Increase enforcement by hiring more staff and restructuring fines so they outweigh cost of compliance. f) Develop a new MOU for one-start permitting; Build compensatory mitigation into permit process (In progress); More review of zoning waiver requests/checklist of review agencies; Specify waiver criteria and exclusions g) Update technical design manuals for stormwater & wastewater h) Make redevelopment projects improve existing environmental conditions i) Follow through on permitting incentives for better buildings (In progress at CRM)
Invasive Species • Don't know management methods • Typhoon knocking down trees, • Import of materials	No strategies identified
Land Based Sources of Pollution • Poor land development practices • Dogs- bacteria • FUD sites/cemetery leaching • Solid Waste (trash/illegal dumping) • Agriculture fertilizer/pigs • Septic systems and sewer overflows • Sedimentation from fires and construction activity	a) Renewal of MS4 permits – cover public roads and outfalls. Pair with SW/WW manual b) Build new ASPA facility; education on microbial tracing study and proper waste disposal to dog owners c) Provide more trash services for low income and more community clean up events; Behavior change campaign; Adopt-A-Stream d) NRCS outreach and capacity building for sustainable practices for the on the ground workers (not just land owners. Piggeries → lower priority e) Reduce flooding that contributes to SSOs; Raise/replace sewer manholes; program for septic inspections before rainy season; get ahead of buildout by upgrading sewer line at Imperial Casha f) Follow through with enforcement actions for violations during construction; collect performance bonds
Shoreline Erosion Climate change and storms	a) Seagrass restoration → provides nursery and cc adaptation b) Protect/enhance living shoreline c) Identify areas for wetland migration to maintain for the future; community engagement for managed retreat and open dialogue with community about the low lying cemetery

WATERSHED VULNERABILITY

Coastal Hazards

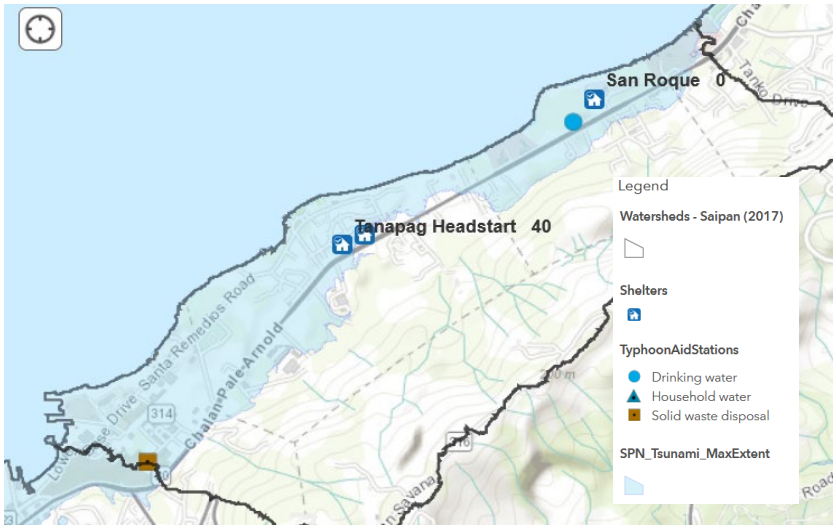


Figure 31. Tsunami maximum extent predictions (CRMOGIS, 2020)

Since 2015, the CNMI has had three tropical cyclones triggering federal disaster declarations. The fringing reef provides some measure of shoreline protection from storm damage. However, there are critical facilities (school, fire station) and extensive infrastructure (coastal roads, utilities, etc.) in low-lying areas of the Achugao watershed (**Figure 32**), much of which is vulnerable to coastal flooding from sea level rise, storm surge, and impervious cover. The Lower Base, portions of Tanapag and San Roque, several resorts, and utilities along Middle Rd. are within FEMA flood hazard areas (**Map 13**) and vulnerable to sea level rise impacts (**Map 14**). The 100-year flood could affect up to 0.3 miles inland, which is the most populated area of the watershed.

Sea level rise is anticipated to be slightly greater in the CNMI than the global average (1.2 ft vs 1 ft global average, for example). Increased sea levels translate into more high-water days, more frequent and longer duration inundation events, and saltwater intrusion into groundwater (Grecni et al., 2021).
Maximum Tsunami impacts are predicted to have a strong influence in the watershed (**Figure 31**). Designated shelters appear to be within the predicted impact zone. PCRP is currently under contract with HSEM to map tsunami flood and evacuation zones. Preliminary maps should be completed by the end of October, with a project completion expected in May 2023.

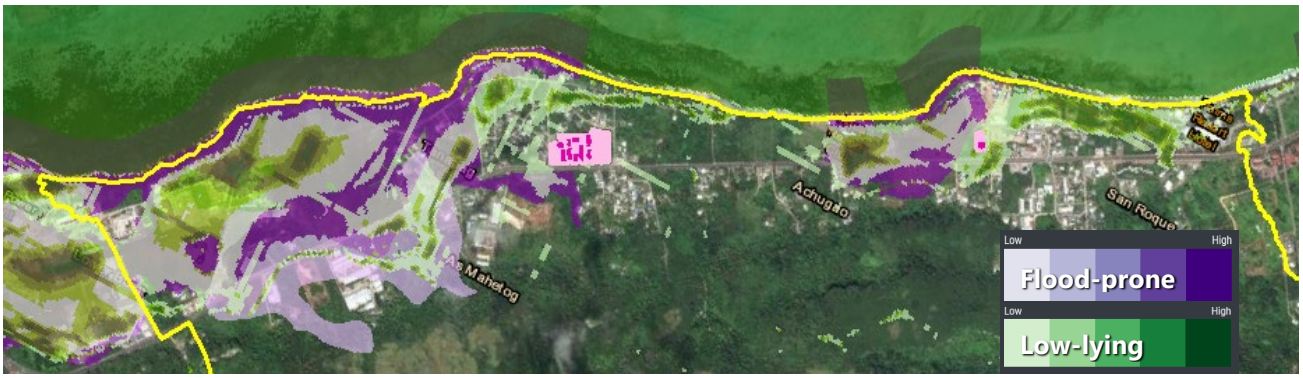
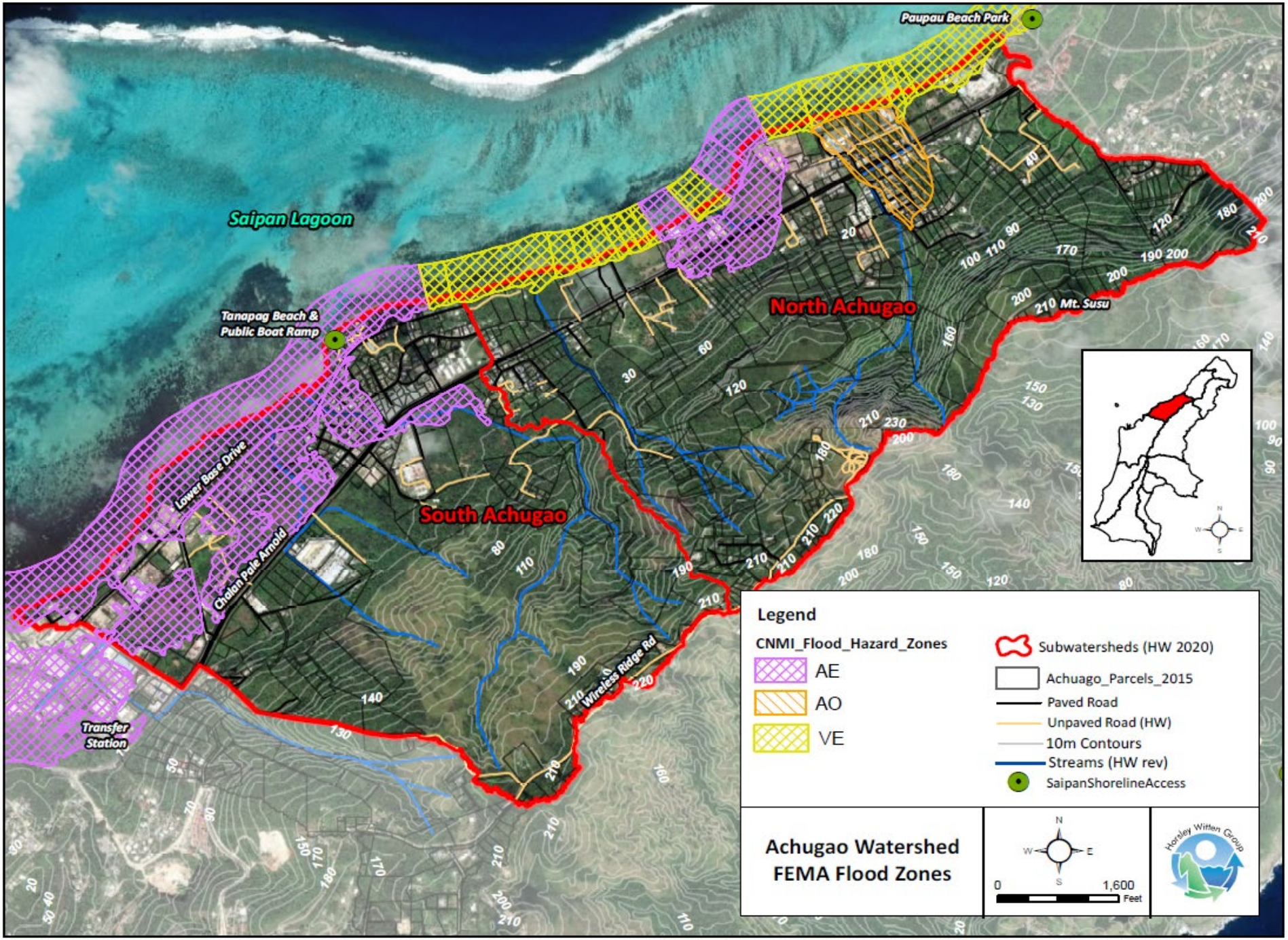
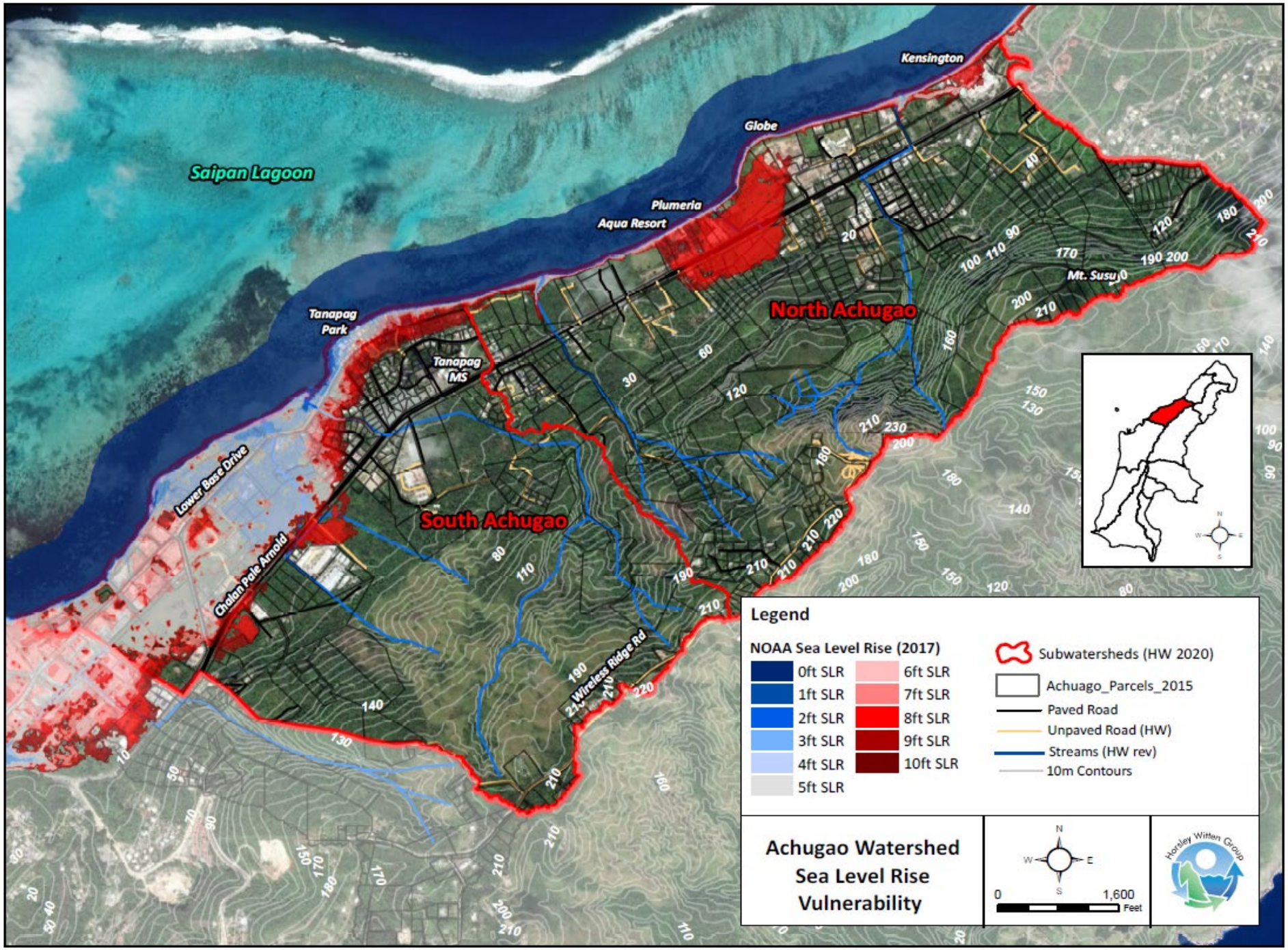


Figure 32. Achugao areas prone to flooding (100-500 yr storms) and low-lying areas likely to retain water with critical facilities in pink (CREST, 2020).



Map 13. FEMA Flood Hazard Zones



Map 14. Sea Level Rise estimates predict significant inland inundation (NOAA 2017)

Social Vulnerability

The social vulnerability index completed by Greene and Skeele (2014) as part of a NOAA-funded Climate Change Vulnerability Assessment indicates a medium to med-high vulnerability for the communities in the Achugao watershed (**Map 15**). The vulnerability index values range from 26 (dark green) to 72 (red) with higher values equating to greater vulnerability.

Dobson et al. (2020) estimated lower values of social vulnerability based on 2010 Census data on household income and EPA's Environmental Justice screening methodology (**Figure 33**).

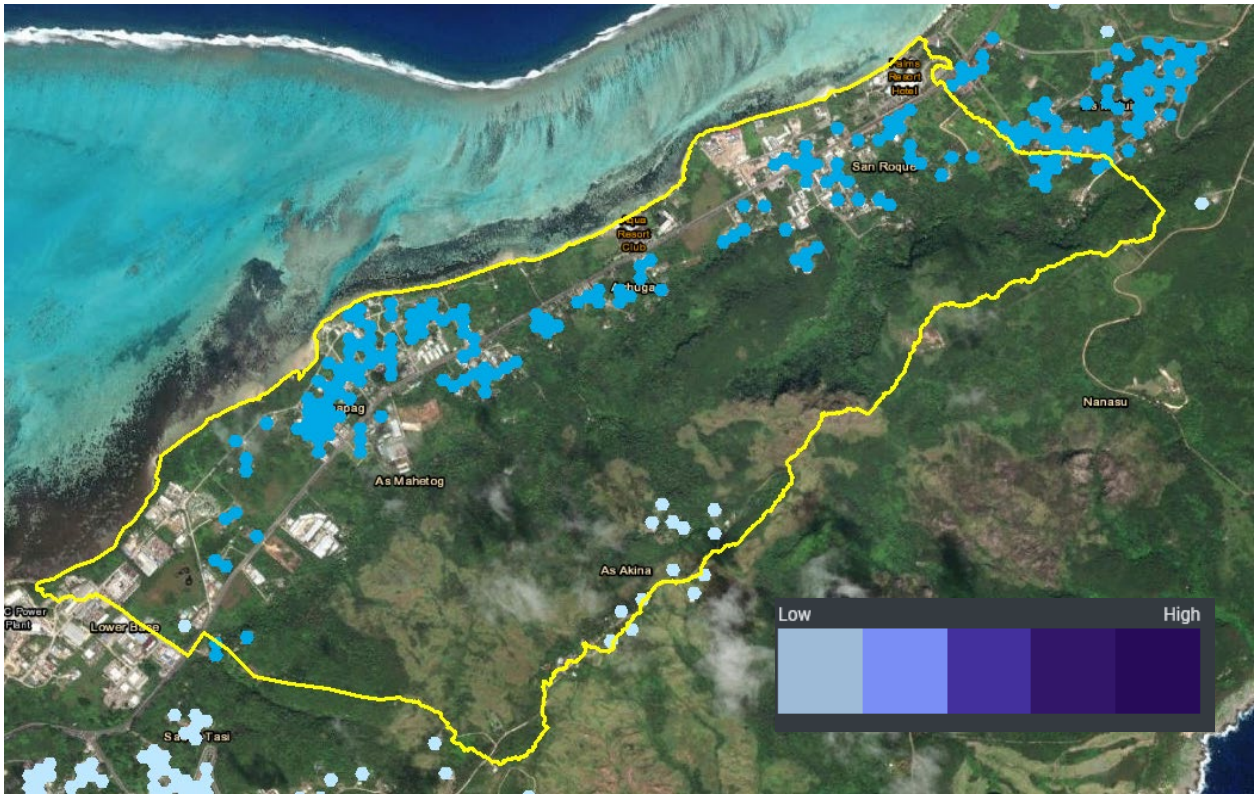


Figure 33. Social vulnerability of populations in the Achugao watershed (Dobson et al., 2020).

Resilience

A GIS-based resilience analysis was conducted by Dobson et al. (2020) looking at land use, protected areas, human community assets, areas subject to flooding, and terrestrial and marine ecology to identify Resilience Hubs. These hubs are priority natural areas to target for restoration or protection measures in order to improve resilience. In Achugao, the analysis highlights the shoreline and coastal waters near Lower Base as the highest priority for improving resilience (**Figure 34**).

Hubs are identified and prioritized based on a combination of four indices (**Figure 35)**:

1. Community Assets—considers population density, critical facilities (schools, fire station, shelters), critical infrastructure (roads, utilities, etc.), and social vulnerability.
2. Threats—indicators of flood-related factors such as impervious cover and soils, low-lying areas, sea level rise, storm surge, and soil erodibility.
3. Community Exposure—the product of assets and threats which indicates where essential assets are most at risk of flooding.
4. Fish and Wildlife—indicates high value habitats for marine and terrestrial species.

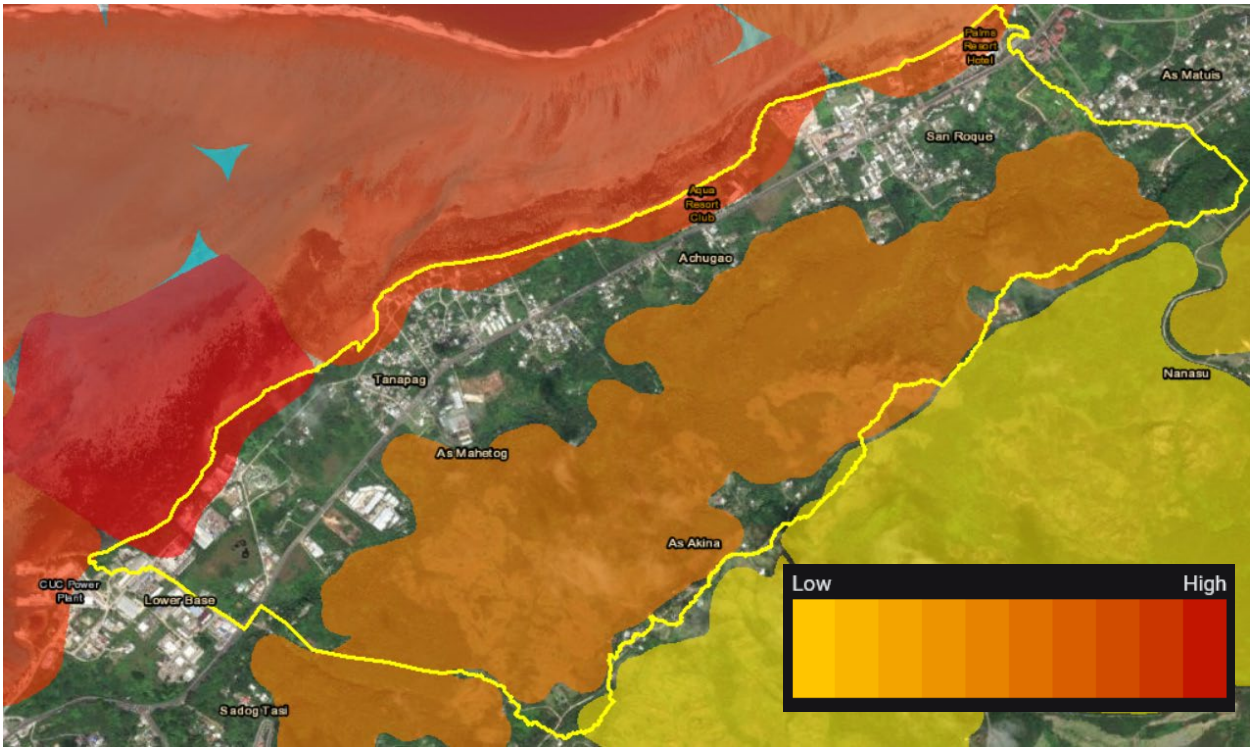
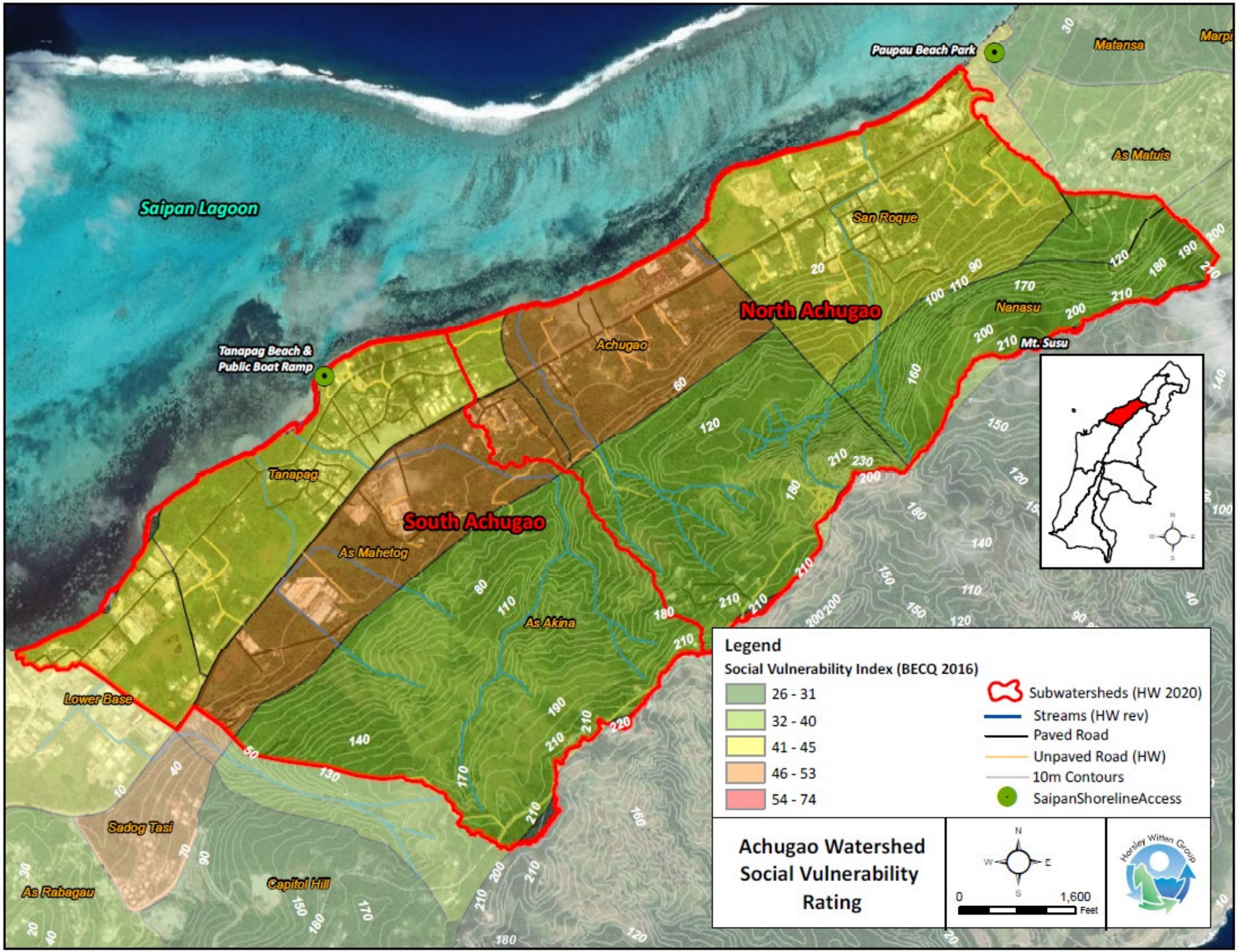
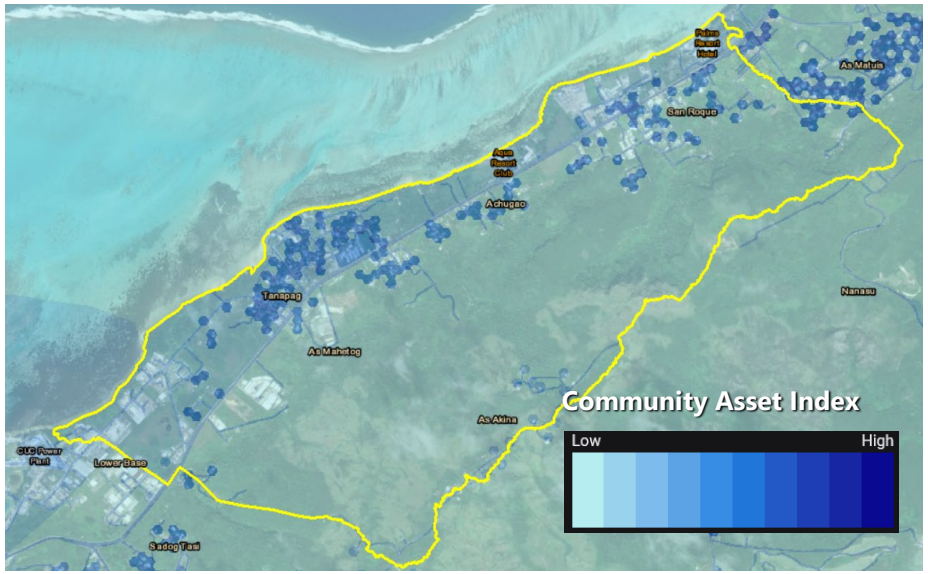
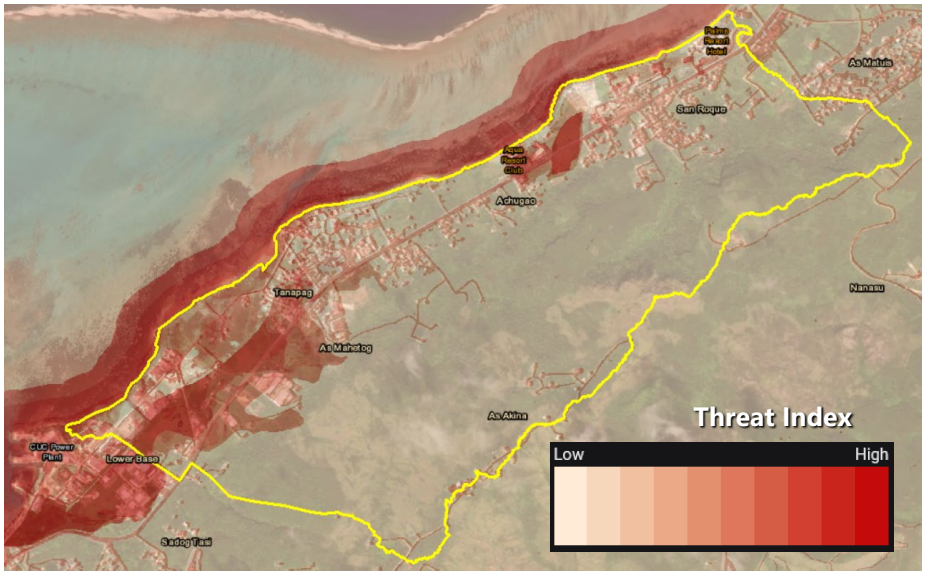


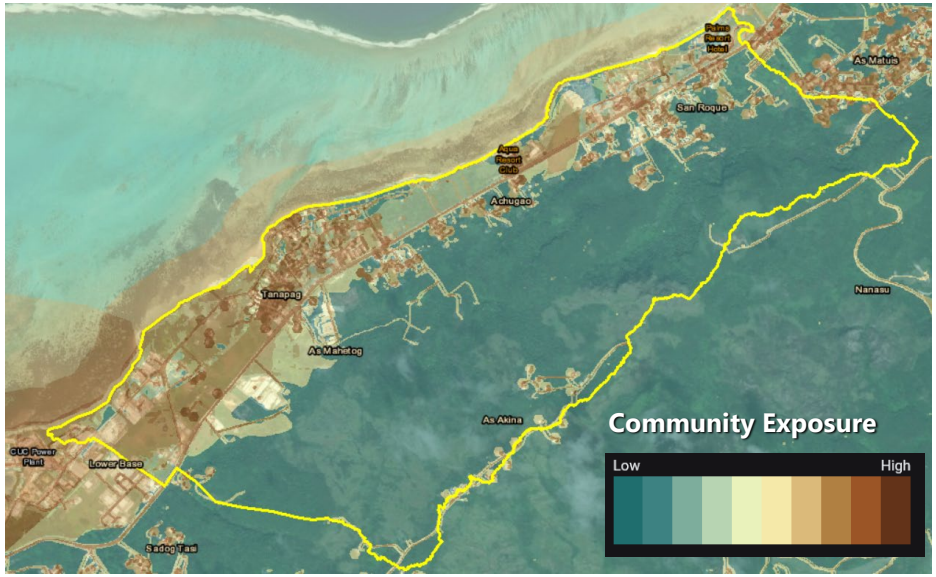
Figure 34. Resiliency Hubs in the Achugao Watershed (Dobson et al., 2020)



Map 15. 2016 Climate vulnerability rating in Achugao (Greene and Skeele, 2014)







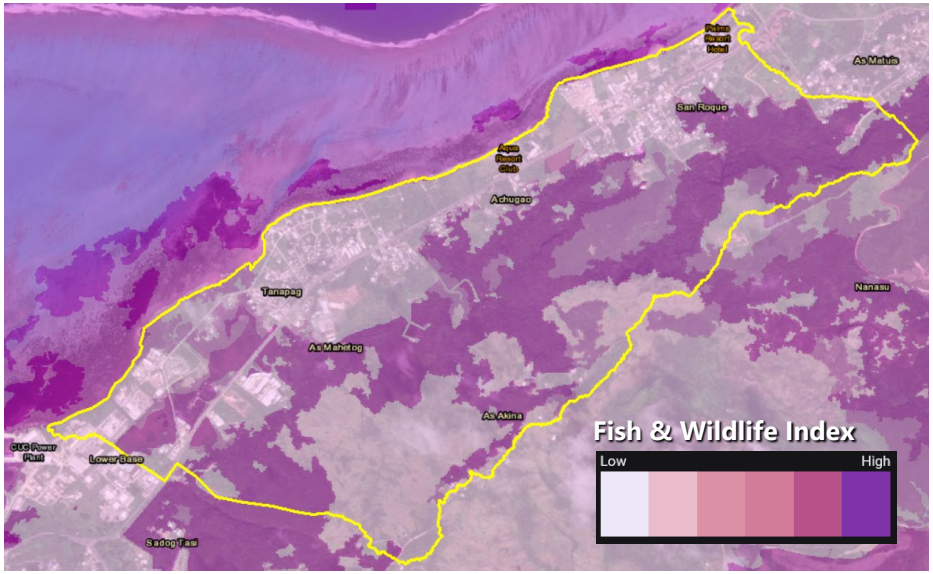


Figure 35. Spatial Analysis of Resiliency Indices in the Achugao Watershed (https://resilientcoasts.org)

Restoration Potential

Watershed Inventory

HW, KOA Consulting, BECQ, and NOAA conducted a rapid watershed assessment in January 2020 to map drainage infrastructure, identify problem areas (pollution sources, flooding, damage, etc.), and identify potential restoration project opportunities. **Table 18** provides a generalized list of the types of restoration opportunities looked for and the watershed benefits they offer.

Field teams look for opportunities to improve water quality, reducing flooding, enhance habitat, and increase community resilience.

More than 35 potential projects were identified by field teams at sites in North and South Achugao, in addition to several projects in the Tasi catchment (**Map 16** and **Map 17**). **Table 19** provides a short concept description and initial feasibility ranking for each project. In addition to these sites, project partners and local agencies have also identified a list of potential restoration projects. While not included in Table 13, these projects are integrated into the overall watershed recommendations and implementation strategy.

Appendix C contains the field sheets from each potential site, including concept sketches, where applicable.

Table 18. Inventory of Watershed Opportunities

Project type	Opportunities Considered
Drainage Infrastructure Repair	Reduced flooding; Public health & safety; Infrastructure protection; Improved resiliency; Reduced erosion or resource impacts; Water quality improvement; Fish/aquatic insect passage; Report issues
Stormwater Retrofits	Improve water quality or flood control; Encourage green infrastructure; Add trees or provide other co-benefits; Education opportunity
Unpaved Road Stabilization	Diversions, Cross drains, Water bars, Dips, Turnouts, Sediment Traps, Slope stabilization, Resurfacing
Shoreline Stabilization	Living shoreline; Mangrove Restoration; Infrastructure protection; Hard structure or combo; Repair existing feature; Retreat
Stream/Wetland Restoration	Habitat restoration; Infrastructure protection; Reduced erosion, Bank stabilization; Link to upland volume controls; Improve buffer; Invasives removal; Replant vs natural revegetation; Reconnect to floodplain
Upland Revegetation	Revegetation of previously burned areas; Invasive species management; Replant vs natural revegetation; Education
Wastewater improvement	WQ improvement; Health and safety; SSO or pump repair; Upgrade or repair OSDS; IDDE and monitoring; Behavior change/education (dumping wash water); Connect to sewer; WWTP upgrade or package system; Report illicit discharges
Construction Sites	Inspect erosion control; Propose BMP installation or maintenance recommendations; Report violations

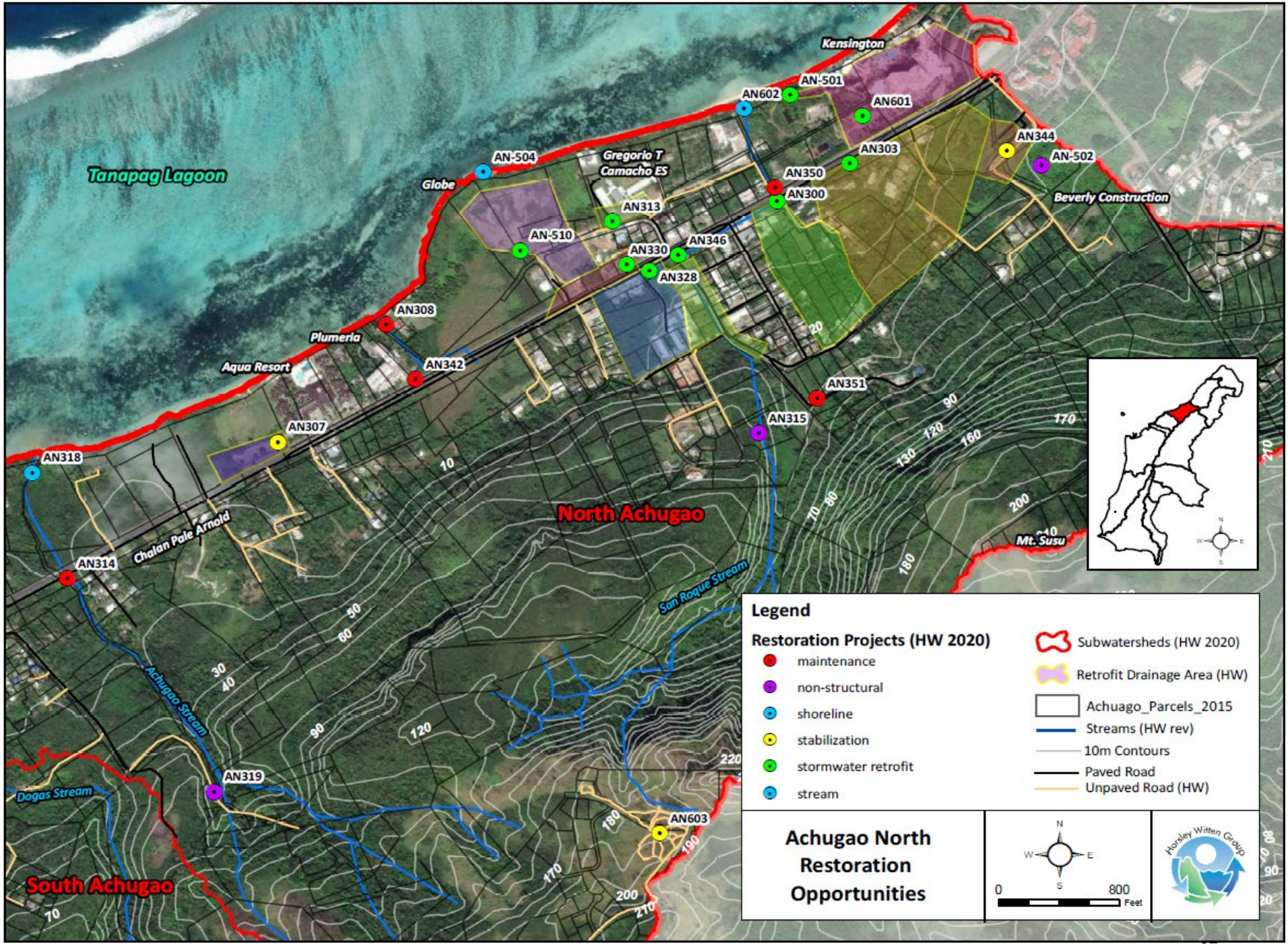
Project type	Opportunities Considered
Pollution Prevention/site remediation (commercial, industrial, livestock hotspots)	Structural and non-structural; Monitoring; Trash cleanups/Dumpster cover; Spill prevention; Outdoor material storage; Landscaping; Vehicle maintenance/wash water-dedicated areas; Animal waste/piggeries; Buffer encroachment/restoration
Residential Stewardship	Lawn care; Pet waste; Connect to sewer; Downspouts or driveway disconnection; Buffer enhancement; Vehicle maintenance; Trash management; Common space management
Watershed Education/Signage	Improve watershed awareness; Wildfire prevention; Build community support; Watershed warriors programming
Land Conservation	Habitat protection; Preserving hydrologic functions; Improved resiliency

General Observations

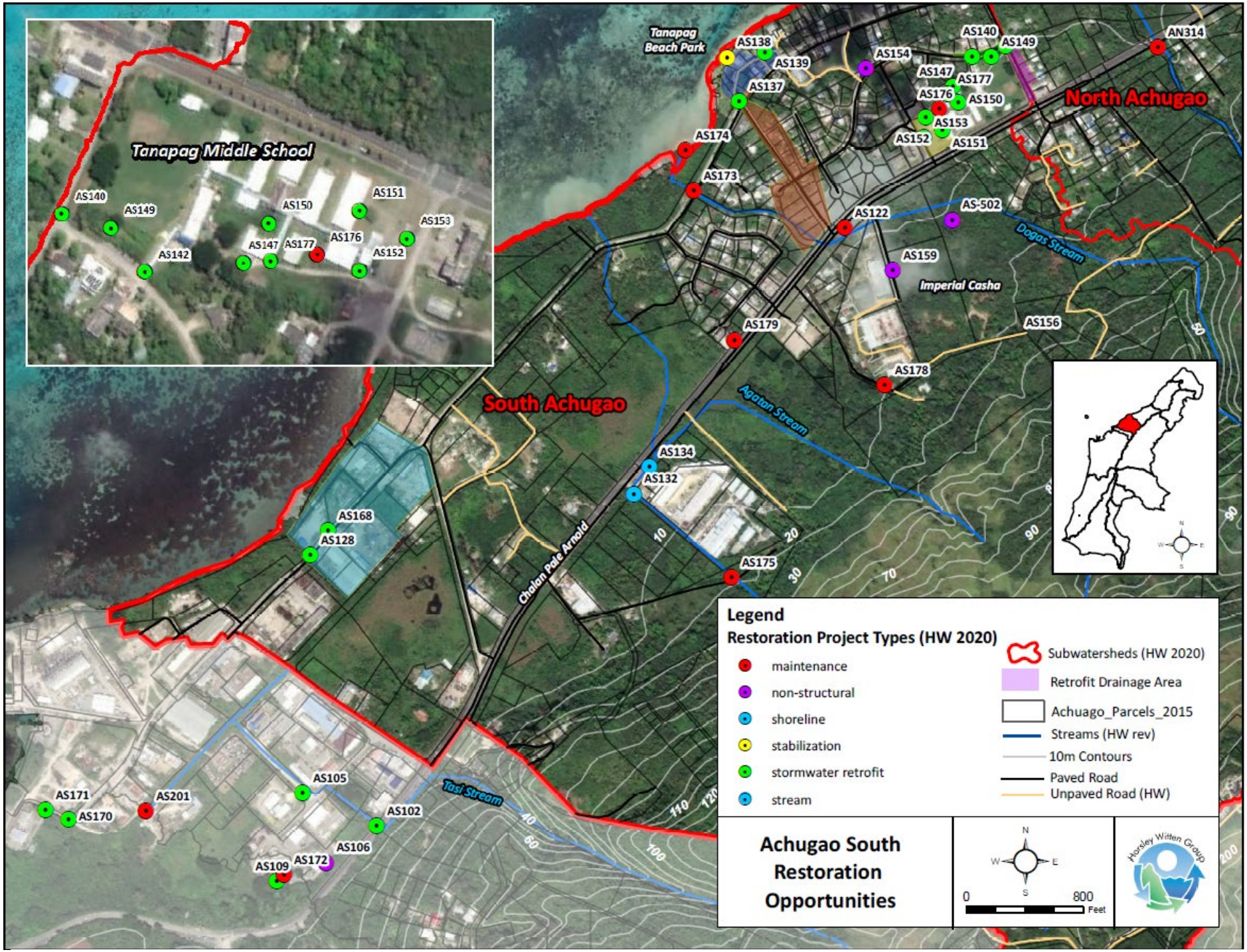
General observations of the Achugao watershed include the following:

1. There is significant infrastructure along the shoreline that is vulnerable to coastal flooding (roads, electric/water/sewer, large hotels, schools, businesses in Lower Base, etc.). This is confirmed by SLR and FEMA mapping and the coastal resilience analysis. It was reported that there are many homesteads given out along the Dogas stream without consideration of FEMA flood zone mapping. Flooding at the recycling/transfer station occurs regularly. Heavy metals and post-typhoon debris are vulnerable to seepage and or washing away.
2. Tanapag Lagoon is partially protected from polluted watershed runoff by the freshwater wetland complexes spanning the coastal plain. These wetlands have been impacted from past hydrologic alterations, water level fluctuation and pollution due to unmanaged stormwater runoff, and habitat degradation from buffer encroachment and invasive species. Man-made drainage ditches connect wetland pockets and complicate watershed delineations.
3. The low-lying commercial/industrial area in Lower Base is an obvious sediment source and lacks adequate pollution prevention and runoff controls. Road shoulders and private properties offer numerous opportunities to treat stormwater.
4. Two large construction sites (Imperial Casha and the Globe) offer insight into the extent of expected growth in Achugao, as well as the lack of environmental care afforded during the construction process. Both sites impacted streams/wetlands and exposed soils at the Imperial Casha property (>5 years) has impacted public drainage infrastructure, lagoon ecosystems, and the community.
5. Economic activities include proposed tourism expansion, hotel development, and extension of power/CUC service to the north of the island. There is a strong community “sense of place” and this conflicts with land use plans. They want growth, but not like Garapan. There are large areas of public land in the upper watershed.
6. Fires in the upper watershed are reportedly a big issue, exposing soils to erosion, contributing to declines in native vegetation and habitat diversity, and supporting the spread of invasive species.
7. The watershed includes historic sites, several cemeteries, a fishing community, hunting, and medicinal plant gathering in the upper watershed. Small-scale agriculture, including piggeries, have been identified along the offshoot road neighborhoods east of Route 30.

8. Achugao (South) –Dense development is nearly continuous on the west (seaward) side of Middle Road. The east side of the road is more lightly developed along the road, including an abandoned garment factory. The terrain west of Route 30 is low-lying and extremely flat. The road design is curb and gutter with concrete culvert crossings under Route 30. A drainage divide between North and South Achugao exists at the Tanapag Middle School. Ample open space and flat conditions provide an opportunity for green stormwater infrastructure. Tanapag Park, boat ramp, and meeting hall within the neighborhoods behind the Elementary School is a notable public asset. Any management plan needs to incorporate an activity here to engage the community.
9. Achugao (North) –North of the Mobil gas station, the road design changes to concrete shoulder-channels and uncontrolled, open drainage. Minimal development exists along the seaward (West side) of Route 30 for about a mile heading north and development shifts to the east side. The road remains flat to San Roque village, where the drainage collection system changes to curb/gutter and closed pipes with little stormwater treatment. Large, concrete box culverts in San Roque carry substantial runoff volumes. Four hotel/resorts include: Aqua and Kensington (open), Plumeria (abandoned), and the Globe (under construction). The watershed terminates at the abandoned Mall site. Numerous infill and redevelopment opportunities exist near the Kensington Hotel.
10. An extensive wetland system exists just north of Aqua Resort, it is bisected by Route 30, and abuts the Saipan Globe development. A 10'-wide culvert crossing connects the two eco-systems. The beach is most pristine towards the northern extends of Achugao North.



Map 16. Potential restoration opportunities in Achugao North



Map 17. Potential restoration opportunities in Achugao South

Table 19. Potential Project Opportunities Identified in Achugao

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Achugao North										
AN300	Grassed area along road shoulder between unpaved driveway and gravel parking lot @ Latte Stone. Loose aggregate driveways contributing sediment to street. High visibility opportunity to provide water quality treatment and reduce sedimentation onto public road. Existing infrastructure in road make overflow connection relatively easy. *Divert drainage into forebay; 15'W x 100' long between sidewalk and UT poles. Divert parking lot and two driveways' runoff into rain garden with sediment forebays on either side. Overflow into inlet in the road. Unpaved driveways may need stabilization.*	2	H	$	●		●			
AN303	Edge of road between sidewalk and utility poles approximately 25'Wx1000' owned by municipality. Dual box culverts as outlet. Improve aesthetics and performance of existing swale with plantings. Extend detention time with check dams and reshaping. Simple depression no more than 12" to maintain invert elevations for flow. Trash rack and sediment forebay are optional. Significant amount of road runoff - thermal pollution and trash.	3	H	$$	●				●	●
Aqua Resort AN307	Aqua Resort overflow grass/gravel lot - access lane could be stabilized with grass pave (or similar) to improve runoff quality and reduce volume. Maintain/improve porosity and reduce channelized flow. Help to meet Sustainable Hotel objectives.	2	M	$$$	●				●	●
San Roque Elementary School AN313	Existing trench drain at school drains to infiltration basin and overflow backs up/ponds at access road and discharges into deep wooded basin. *Educational opportunity at school for bioretention. Overgrowth could be thinned, invasive species removed, and native species planted. Highly visible educational opportunity. Same capacity with more appreciation.*	4	M	$	●	●				●
AN315	Natural channel turns to concrete channel on Diablo. Path on the side of the road leads to a gorge, which is a stream during the wet season. *Investigate further to determine if bank stabilization/stream restoration is warranted or if this is an opportunity for land conservation.*	3	M	?				●	●	
Achugao Stream AN318	Channel width 17' at outlet on shoreline. Channel showing hairline root exposure/erosion. Mild sheen on open water pockets - minimal trash. *Restoration and bank stabilization. Investigate opportunities upstream for volume reduction from developed lands.*	3	M	$		●		●		
AN319	Tank leaking through hole. Looks like it hasn't been used in a while. Standing water around tank. *Fix leak*	1	L	$					●	

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
San Roque Market AN328	Runoff from parking lot goes to concrete swale at edge of Route 30. Minimal pitch in either direction. Sediment accumulation observed in channel along road. Vacant/wooded lot to north offers *potential location for stormwater practice, such as a sand filter*. Gas station also in the contributing drainage area, so could be an opportunity to remove PAHs from runoff.	3	M	$$	●					
AN330	Across from shell gas station near new condo construction, sediment accumulates on street because it is so flat. Direct road runoff to *vegetated bioretention or bioswale in ROW*.	3	L	$	●					
Magazine Drive (La Fiesta Mall) AN344	Where unpaved road turns and meets back of the mall (Magazine Drive). Gulling and wash out/sediment accumulation observed at the low point. Road also seems much wider than needed. *Road stabilization recommended, including paving section to top of turn/construction site, installing water bars or cross drains, and adding drainage swale with check dams and turnout.*	4	M	$			●			
AN346	Large residential drainage area to single inlet and culvert that is clogged and broken. Natural stream is channelized into concrete channel. *Clean out leaves and repair concrete structure. Reduce existing road widths within San Roque and install linear bioswales to collect and treat road runoff. This would be a great place to design "CNMI Green Streets" for water quality and impervious reduction.*	2	M	$$$	●					●
AN350	Channel and culvert full of trash, overgrown vegetation, and stagnant water. Neighbors report having problems with trash and mosquitoes and complained about needing to clean up. Flood issues in past. Open channel is fenced off on drive entrance to school. Poor visibility due to vegetation. *Need to clean out vegetation and remove trash. Reevaluate channel to determine if stream/buffer restoration is appropriate. Important to re-establish positive drainage at this site to avoid mosquito breeding conditions. Could be opportunity to beautify area and provide education for school on drainage. Look for upstream retrofits.*	4	H	$-$$$		●			●	●
Kensington AN501, AN601	Pond system draining hotel. Clean out algae/jellyfish/organic debris at outlet structure, possibly retrofit ponds to improve water quality treatment by creating more wetland features (micro topography, floating wetland treatment cells, etc.). Need to confirm drainage at hotel, review plans. Opportunity to educate visitors and meet water quality objectives of CNMI Sustainable Hotels. In addition, runoff from the parking lot goes either to an existing wetland or is discharged to pond system. If it is going to the wetland, it would be good to treat runoff first using green infrastructure techniques. More investigation needed to confirm existing flow paths.	4	H	$-$$$	●	●			●	●

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Beverly Cnst. AN502	New construction site and clearing; hard to see if perimeter controls have been properly installed. *Needs to get out for inspection.*	2	M	$					●	
Global Saipan AN504, AN510	Walled off section of existing wetland to be used as stormwater practice for resort and convention center. Does not appear to be sized to manage full site. *Revisit permit to ensure compliance with stormwater standards. Require mitigation or make them restore wetland and redesign stormwater plan.* Zachary identified Bonsai Mangrove growing in shoreline karst (potentially). *This should be confirmed and, if present, be protected. There may be pending applications for boardwalk or bringing in sand to provide access for resort. Need to review beach access plans to ensure protection of mangrove.*	4	H	$	●				●	
San Roque Stream outlet AN602	Channel outlet appears to have been recently reopened with heavy equipment. Gabion baskets being undermined and there is trash and debris. *Investigate drainage paths further and consider options for habitat restoration and bank stabilization in channel, removal or repair of gabions.*	3	M	?		●		●	●	
Achugao South Subwatershed										
Lower base AS128 and AS168	Concrete swale along road. Collapsed culvert. Old WWII era tidal gate. Swales full of sediment. Industrial areas don't control their sed runoff. *Formalize inlet and add sediment forebay. For industrial businesses nearby-- implement individual BMPs to control sediment. Replace culvert & restore side slopes. Clean swale. Require BMPs in contributing industrial area at each site. May be opportunities to install BMPs to control sediment in the ROW.*	5	H	$$	●				●	
AS132 & AS134	Agatan Stream has base flow and has been rerouted as part of development. Stream runs freely across the road and then along gutter line into wetland. Constant flow to another channel through clogged culvert. *PRIORITY PROJECT. Restore and reestablish stream to reduce flow of water and erosion of road edge. Fix culvert (AS133). Restore stream along Middle Road.*	5	H	$$	●		●			●
Tanapag Park AS137 (entrance)	Paved roads drain to unpaved road in park. Road runoff appears to pond and scour. Add waterbar or cross drain to direct runoff from Tanapag Ave (paved) to forebay and bio/rain garden in park. May have to be a wet swale. Education opportunity in park.	3	H	$$	●		●			●
Tanapag Park AS138	Boat ramp and several roads with unorganized vehicular traffic causing minor erosion and sedimentation. Overall, park is in good condition except lots of trash. *Eliminate some roads by reorganizing circulation and re-vegetating. Add signage for litter.*	2	L	$			●		●	●

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Tanapag Park AS139	Roof runoff discharges directly to park through downpipes. Rain garden to capture runoff from building roof, eliminate access road. (See AS138)	2	H	$	●					●
Tanapag MS AS140	Road has little/no drainage infrastructure, so runoff goes into grass. Stormwater practice in grass area (NW corner of school).	1	M	$	●					
Tanapag MS AS142	Paved parking lot drains to swale and weep holes in school wall drain to infiltration trench with pipe overflow. Water from paved swale discharges to lawn w/ erosion and then crosses road. *Drainage/vegetated swale along road and tie into infiltration trench overflow near the school yard wall. Possible combination with AS140.*	1	M	$	●					●
Tanapag MS AS147	Informal swale draining runoff from end of dirt road and school yard that discharges off site. Eroded swale. Runoff goes between tanks and pump house. *Fix dirt road grades and direct to basin (AS149) on site.*	2	L	$$	●		●			
Tanapag MS AS149	Large basin in the NW corner of school site. Takes roof, walkway and field runoff. Vegetation is overgrown and should be cleared/cut and maintained. Standing water observed. Water overtops in the SW corner of basin and contributes to drainage issues at AS142. Basin is 4-6' deep, varies in width; up to 20'. *Clean basin. Explore possibility of expanding capacity and address overflow issue?*	3	H	$$$	●				●	●
Tanapag MS AS150	Roof runoff and overland flow uncontrolled in courtyard at school. Does not appear to be a problem but could be an opportunity to integrate stormwater into curriculum. Spoke with principal, who thought students and faculty would like that. *Stormwater BMP to manage roof runoff. Great possible outreach (cool project) but not big impact.*	1	H	$	●					●
Tanapag MS AS151	Existing planters at school with downspouts directed to them. Downspouts may not actually discharge into planters (may go underneath). No plants. Spoke to principal: they have tried to grow plants but have issues with watering. *Convert planters into stormwater planters. Low hanging fruit and great education opportunity!*	2	H	$	●				●	●
Tanapag MS AS152	Wet/mushy soils./Determine cause-- leaking pipe? Stormwater? other?	3	M	?					●	

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Tanapag MS AS153	Parking lot drainage directed to existing swale. Two inlets and one outlet. Inlets clogged- too small. Runoff may not actually be entering swale. Drainage area is parking lot of school and runoff overflow via concrete swales. *Add inlets to allow for better drainage/more inflow. Fix existing inverts and outlets to ensure flow. Clean swale and replant.*	2	M	$	●					●
Tanapag MS AS176	Clogged inlet of rain garden at Tanapag Middle School (see AS145). May contribute to flooding of building. *Clean inlet. Widen and clean outlet spillway. Maintain positive drainage from outlet to road.*	5	H	$	●					●
Tanapag MS AS177	Existing culvert clogged and unclear where it goes (off school property?). *Unclog culvert and consider a stormwater BMP at the downstream inlet.*	3	M	$	●					●
AS154	Water on road. Confirm water source. Eliminate water from road.	2	M	?	●					
Imperial Casha AS159, AS502	Gravel drive to main road. Runoff from inactive site discharges to road at construction entrance without erosion controls. *Erosion control on site at entrance. Stabilize site if construction is inactive, owner must enforce.*	4	H	$	●		●			
	Site to be stabilized with vegetation, mulch, or other cover— it's been left exposed for >2 yrs. Significant stream buffer encroachment; sedimentation is evident in stream bed. Existing sediment basins in need of maintenance and removal of accumulated sediment. Site is in clear violation of regulations. *Site stabilization and restoration/protection of stream. Use money from fines or bond to intervene on behalf of delinquent owner. Start with replanting vegetation in the buffer; add a perimeter berm to divert flows away from stream into additional sediment traps; clean out existing sediment basins; hydroseed remaining site. Confirm condition of small, isolated wetland on site. Remove billboards to increase visibility.*	5	H	$$$ (funded from fines)	●				●	
Dogas Stream Outlet AS174	LOTS of trash, including human waste (diapers). Remove trash and discourage future dumping (signs, community education). Focus location for MINA	5	H	$					●	●
Mt Susu AN603	Informal dirt bike recreational area. Erosion issues. Develop a plan for formalizing and stabilizing trail system, possibly as part of outdoor recreational grant opportunity. Needs better sediment collection system and could be good location for vegetative management and native species planting. Great spot for watershed education signage given the view.	2	L	$$		●	●			●

ID	Description of Condition & Potential Solution	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Tasi Stream Catchment										
AS102	Ditch on uphill side of road, crosses road in 90 deg culvert to headwall. Maintenance: clean. Repair trash rack, increase swale and pipe size. Reduce angles of 90 degree turn, add sediment forebay.	2	M	$	●					
AS105	Catch basin & inlet to dry swale. Flow goes through culvert to drainage ditch with standing water (recently cleared by DPW Roads & Grounds). *Install a sediment forebay at inlet to wet swale for enhanced water quality treatment and reduced maintenance. Possibility for educational signage.*	2	H	$	●					●
Municipal transfer station. AS106, 109	Two leaking water main bubbling up in road, picking up trash and dumpster juice. Discharging to historic wetland. May be for fire suppressant. *Fix water line leaks.* Transfer station drainage network clogged. Unclear where runoff is discharged. *Build swale along landscape strip between wetland, fence, and roadway.*	5	H	$-$$	●				●	
AS170	Concrete swale with sump box is clogged with sediment. Culvert discharges to wetland. Sedimentation observed in wetland. Evidence of past cleaning and removal of sediment from wetland. *Clean box sump. Unclog pipe. Remove sediment from wetland. BMPs needed for all the sites in this area to manage disturbed surfaces with no stabilization. Make box sump easier to clean.*	4	H	$$	●	●			●	
AS171	Open space in front of DFW building. Appears that road runoff drains there now. Great spot for a bioretention facility near DFW sign to treat small amount of road runoff from crowned road. Small drainage area but highly visible. Would like to get DFW involved as educational/public opportunity.	2	M	$$	●					●

[1] Relative severity (or condition) indicates how critical it is to address this site, based on professional judgement on a scale of 0-5, where 5 is high.

[2] Implementation Priority (preliminary) is based on professional judgement of importance, feasibility, visibility, etc. H=high, M=medium, and L=Low. This has not gone through a formal ranking or stakeholder input process.

[3] Relative cost is a placeholder for additional development, where $$$>$50,000, $$=$25-50k, $<$25k. Don't hold us to this.

● Indicates type of project.

KEY PROJECTS

Potential restoration projects were initially ranked as high, medium, or low based on a preliminary assessment by the project team of the feasibility, severity of problem, and anticipated watershed benefit. Once additional factors such as project complexity and constructability, site ownership, pollutant removal, climate resiliency, community benefit, and cost were considered, 12 projects rose to the top (**Table 20**). These include projects that were identified and are actively underway by project partners (i.e., upland reforestation and wildfire prevention efforts, mangrove restoration, and educational programming).

Appendix B provides a more detailed description of each key project.

Table 20. Summary of Key Projects

Site	Project Description	Planning Level $*
As Agatan Stream & Wetland Restoration & Infrastructure Protection (AS-132)	Eliminate flows on Middle Rd. by redirecting through culvert under access drive; recreating a floodplain wetland to handle larger storms; providing treatment for runoff from impervious cover using green stormwater infrastructure; and improving habitat through invasive species removal and restoration of native buffers.	$250,000-$350,000
Tanapag Beach Park (AS-137)	Community-led resiliency design to design living shoreline, stormwater management system, recreational usage, and educational moments for park users.	$170,000-$250,000
Improving Stormwater Infrastructure at Tanapag Middle School (AS-153)	Reduce runoff volume at Tanapag Middle School by expanding capacity of onsite practices, installing additional practices, and fixing runoff bypass issues on Middle Rd. that are contributing to school flooding. Consider developing master drainage plans to meet coastal resiliency objectives for both schools.	$75,000-$100,000
Imperial Casha Site Stabilization (AS-502)	Address erosion and sedimentation from >10 acre clearing at stalled construction site. Involves replanting vegetated riparian buffers, hydroseeding exposed soils, and excavating existing sediment basins to restore capacity	$25-$50,000
Lower Base Pollution Prevention (AS-128 & AS-168)	Remove accumulated sediment in concrete swales and drainage structures along road; install sediment forebays and swales in the road right-of-way; identify structural and non-structural practices and prepare stormwater pollution prevention plans for each property to reduce off site contributions of pollutants.	$50,000-$150,000
San Roque Green Streets (AN-300 & 301)	Utilize road median and right-of-way to incorporate street trees, stormwater management, and pedestrian/bike safety. There is also potential for additional stream and wetland restoration seaward of Middle Rd.	$400,000-$500,000
Kensington Hotel Sustainable Green Infrastructure (AN-501 & 601)	Improve pollutant removal performance and aesthetics of hotel's stormwater infrastructure with wetland vegetation in the central pond system and parking lot improvements.	$250,000-$350,000
Aqua Resort Overflow Parking (AN-307)	Implement sustainable hotel stormwater practices with drainage improvements at unpaved overflow parking using permeable pavers, swales, and bioretention facility.	$25,000-$100,000
Upland Reforestation	Reforestation of areas at the upper ridges of Achugao, converting fire-vulnerable grasslands back into native forest.	$ 30,000
Wildfire Outreach & Prevention	Island-wide environmental awareness campaign targeting one source of land-based sources of pollution (LBSP): wildfire and resulting erosion and sedimentation.	$ 30,000
Watershed Warriors Program	Environmental education programming targeting 4th grade students at Gregorio T. Camacho Elementary School in San Roque village.	$ 15,000
Mangrove Nursery	Establish *in situ* mangrove nursery to propagate existing and extirpated mangrove species for reforestation efforts along Saipan Lagoon.	$ 12,000

**Planning level construction costs do not include engineering, design, permitting, or land acquisition costs*

Restoration Benefits

There are several benefits that can be achieved through the implementation of key watershed projects (e.g., reduced nuisance flooding, better water quality, habitat improvement, and community engagement). One element of EPA's watershed planning criteria is to estimate existing and future watershed pollutant loads to help prioritize management actions. To this end, we used the Watershed Treatment Model (WTM), Version 3.0 (Caraco, 2013)--a public-domain, Microsoft Excel-based spreadsheet model used to estimate annual watershed pollutant loads for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), fecal coliform bacteria (FC), and runoff volume within each of the four drainage catchments. While the WTM can be used to generate qualitative annual loads, it is better used to compare relative contributions between subwatersheds and changes between existing conditions and future management scenarios.

Table 21 summarizes model results for existing conditions, future management options/watershed treatment, and with future development. It summarizes potential reductions ranging from 10-42% with the implementation of BMPs, depending on the location, pollutant, and type of BMP. The quantification of annual pollutant loads and runoff volume, while useful, is highly dependent on specific data inputs, such as runoff concentrations, impervious cover, number of pigs, volume of sewer overflows, etc. We don't recommend putting much stock in these numbers unless a more rigorous effort to refine inputs and validation with water quality is conducted. For the purposes of the Achugao WMP, it is the relative change in value between existing and future conditions, all data input assumptions being equal, that is the most relevant.

A more detailed summary of modeling assumptions and results can be found in **Appendix C.** Some general takeaways related to restoration potential can be garnered:

Table 21. Initial WTM Results

Catchment Condition	TN	TP	TSS	Fecal Coliform	Runoff Volume
	(lb/year)			(billion/yr)	(acre-ft/yr)
As Agatan					
existing	4,078	570	423,319	435,813	591
w future BMPs	3,680	506	372,620	334,401	552
% reduction	**10%**	**11%**	**12%**	**23%**	7%
w future development	3,829	549	380,312	344,627	599
Dogas					
existing	2,228	383	474,018	410,702	421
w future BMPs	1,904	323	377,866	300,199	409
% reduction	**15%**	**16%**	**20%**	**27%**	3%
w future development	2,287	447	393,973	326,527	532
Achugao					
existing	786	132	156,244	74,738	126
w future BMPs	760	126	156,034	58,890	126
% reduction	3%	5%	0%	**21%**	0%
w future development	843	142	161,457	62,989	142
San Roque					
existing	4,675	863	791,397	818,292	835
w future BMPs	3,902	707	660,234	472,362	789
% reduction	**17%**	**18%**	**17%**	**42%**	6%
w future development	4,088	769	666,986	485,791	853

Shaded cells indicate increases over existing conditions under a future development scenario based on active permits

1. The model identifies San Roque as the largest total contributor of annual pollutants of the four catchments, due primarily to relative size and urban. The smaller As Agatan catchment generates a similar level of nutrients perhaps due to the heavily developed Lower Base and issues with onsite wastewater systems.
2. To reduce TSS, stormwater retrofits (including unpaved road improvements), stream restoration, and better construction site management are likely to have the most impact (**Figure 36**). Reforestation would arguably be a significant activity as well, but the model currently doesn't distinguish between forest, grassland, and previously burned areas. As such, Sadok Dogas construction sites and upland burned areas may contribute more sediment load than the model currently estimates.

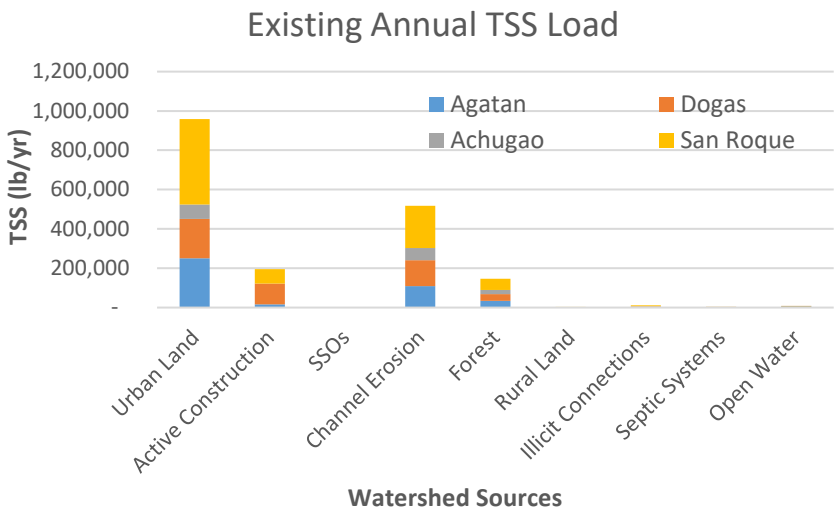


Figure 36. Modeled sources and catchment contributions of sediment

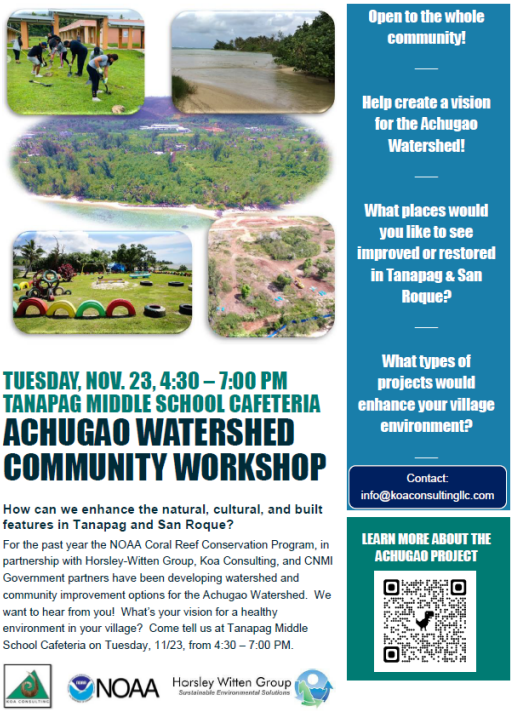
3. Under the treatment scenarios modeled, the most effective restoration options to reduce nutrients in the watershed are wastewater improvements and illicit discharge removal, stormwater retrofitting, riparian buffer improvements, and erosion control. Understanding the influence of illicit discharges will be critical to refining a management approach.
4. Initial results for bacteria load reductions ranging from 21%-42% are encouraging. The 2017 bacteria TMDL establishes a wet weather geomean reduction range of 20-88%. The largest reductions are gained through illicit discharge disconnections, retrofits, SSO repairs, and enhanced riparian buffers. MST data shows that most of bacteria in water quality samples are from dogs. More information is needed to model livestock and dogs on watershed loads and better evaluate the real influence of sanitary overflows and illicit connections on the system.
5. There is a lot of room to achieve load reduction in the watershed, even if sanitary sewer improvements have mostly been completed. There is currently very little area being captured by stormwater management practices and enforcement of erosion control at construction sites could be improved.
6. Future development could quickly undue any water quality or runoff volume reduction gains earned through retrofitting and other watershed restoration actions. Anticipated development in Dogas and Achugao catchments, for example, show a 3-17% increase in loads under the actively pending development projects.

Keep in mind that a model is only as good as the data that goes into it. To further utilize the WTM in Achugao, consider incorporating reforestation, education, and better maintenance and enforcement into the model. Land use and assigned pollutant concentrations matter, so updating impervious cover, accounting for construction, and separating out forest, grassland, and previously burned areas may prove significant. In addition, better assumptions related to streambank erosion could be made based on a review of the stream assessment data. Most importantly, wastewater inputs (e.g., dogs, SSO's, and illicit discharge) should be researched given their influence on results and subsequent management guidance.

Management Approach

VISION

As part of development of the CNMI Sustainable Comprehensive Development Plan (OPD, 2021), public surveys were conducted island-wide to solicit input. Respondents were asked to identify core values that they believed should drive development planning. Results show the top two values were environmental stewardship and economic opportunity (**Figure 37**). This response was consistent with results from a watershed survey conducted in 2022 specifically asking respondents what Achugao should look like in the next decade (**Figure 38**). Most respondents (n=20) identified "natural," "local," and "small-scale tourism" as the words best representing their vision for the area.



This public meeting was derailed due to COVID-19 and an online survey was distributed instead.

Similarly, attendees at a watershed workshop in January 2020 discussed how they envisioned the watershed in the future:

- Land and water preservation
- Sustainability and education
- Continued community-based fishing
- Tourism (controlled, small-scale)
- Hotel/resort revitalization and infrastructure improvements rather than expansion
- More green infrastructure
- Better water quality
- Fire resistant vegetation
- Improved corals and fisheries
- Less impacts from flooding
- Climate change adaptation
- Aquaculture and farming opportunities for better food security
- Healthy relationship between residents and investors

Therefore, the vision guiding watershed management for Achugao over the next 10 years is of a watershed that reflects:

1. Controlled developed in keeping with the current sense of place (focused on small-scale tourism and redevelopment);
2. Sustainability and climate resilience (flood and fire resistance); and
3. Healthy natural resources (fishing, water quality, corals, etc.).

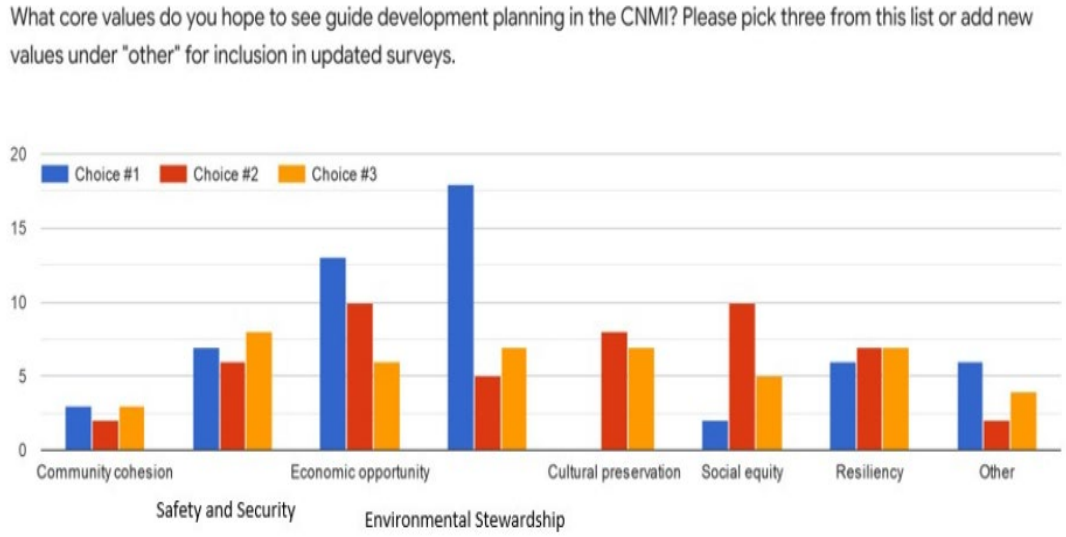


Figure 37. Core Values (OPD, 2021)

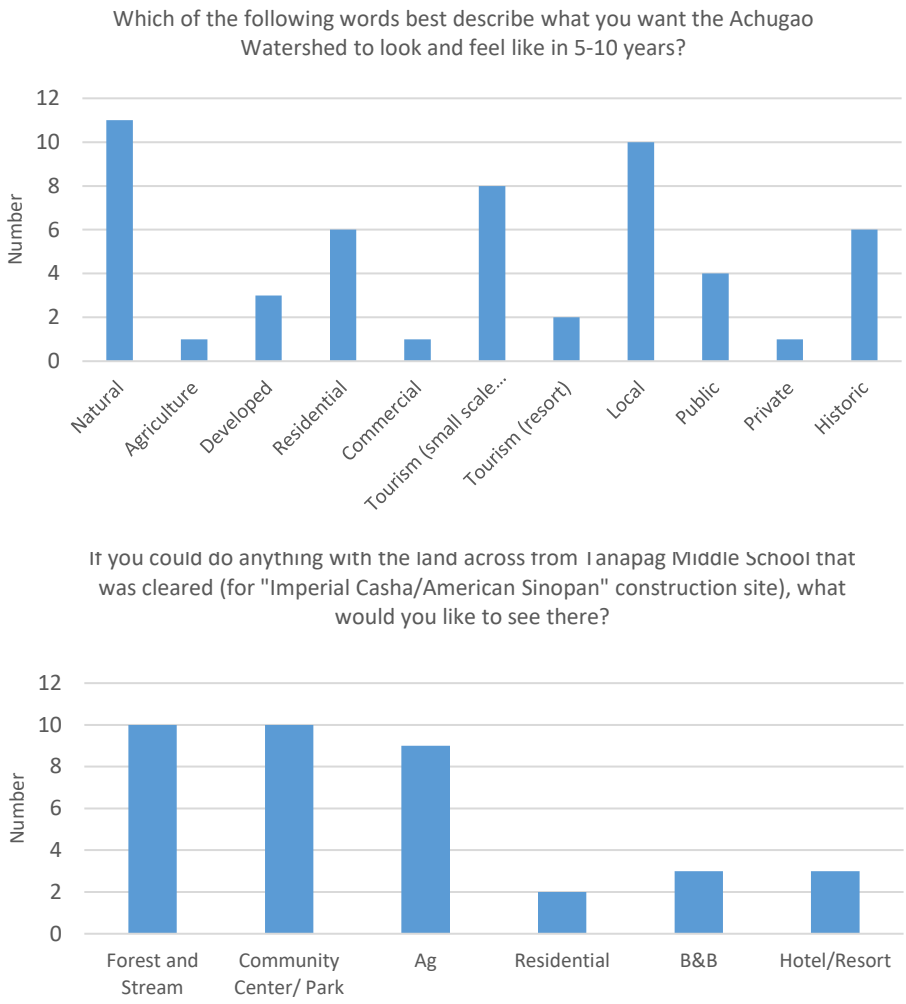


Figure 38. Visions from the 2022 Achugao Watershed Survey

Watershed Goals

Through 2030, management of the Achugao watershed will target four main goals: water quality, coastal hazard mitigation, habitat restoration, and community engagement. These goals were established to reflect the input and vision of stakeholders and to integrate with other overlapping CNMI planning initiatives for 2020-2030 (e.g., the Sustainable Comprehensive Development Plan, Micronesian Challenge, Smart Growth Guidance, Forest Action Plan).

1. Reduce urban pollutant loads to Tanapag Lagoon by managing 30+ acres of existing impervious cover, applying better land use controls on new development, and maintaining infrastructure. Of the 150 impervious acres in the watershed, less than 20 acres appear to be managed by stormwater facilities that control flooding, remove pollutants, infiltrate, or provide storage for rainwater reuse. Opportunities to retrofit an additional 60 impervious acres were identified during field assessments. Priority sites include public schools, beach parks, hotel parking lots, and Middle and Lower Base roads. Using green stormwater infrastructure can help provide additional co-benefits (e.g.,habitat improvement and resiliency). To avoid worsening water quality issues and to achieve CNMI sustainable development objectives, all future development must manage runoff appropriately. The CNMI should capitalize on redevelopment and road improvements to help restore hydrologic function, provide more consistent maintenance of drainage infrastructure, and continue to invest in wastewater treatment system upgrades and repairs.

Goal 2. Adopt predicted rainfall amounts, sea level rise estimates, groundwater elevations, and storm surge levels for the 30-yr planning horizon (year 2050), at a minimum, for development and infrastructure planning. Much of the Lower Base, coastal Tanapag, and portions of San Roque are low-lying and prone to flooding. This makes roads and utilities, buildings, and shorelines more susceptible to storms. CNMI's Smart Growth Guidance recommends development planning and other coastal hazard mitigation efforts plan using 2050 predictions.

3. Protect or restore 30% of the terrestrial and wetland habitats in the watershed through invasive species management, native reforestation, and land conservation. The recent renewal of the Micronesian Challenge increased regional habitat protection and restoration targets to 30%. To help achieve this goal, a similar target is set for Achugao. Achugao has fragmented limestone forests, small patches of remaining mangroves, impacted stream and wetland buffers, expansive *Tangantangan*, and ample opportunity for reforestation. Invasive vine management has been highlighted under several iterations of the CNMI's forest action plans and there are 120 acres identified as Forest stewardship priorities concentrated in Achugao. The biggest challenge to achieving this goal will be in setting feasible targets based on habitat types and defining a baseline from which to measure progress.

4. Empower community-based watershed stewardship by conducting at least 30 engagement, advocacy, and educational outreach activities. There is already a strong community awareness in Achugao connecting watershed health with fisheries and other natural services. Residents previously voiced concerns over proposed developments, conducted trash cleanups, and participated in DCRM's Stream Team Village Assistance Forum (e.g., sewer hookup, energy efficiency, piggeries). Hotels have shown interest in enhancing the sustainability of their operations and schools participate in the Watershed Warriors program. To ensure the community remains active in watershed decision making, residents and businesses should be offered technical assistance for pollution prevention, hands-on activities, education, and more opportunities to provide input in development and hazard planning.

Implementation Actions

To achieve these goals, specific objectives and implementation actions are recommended (**Table 22**). The table includes an anticipated schedule, planning level cost estimate, and potential agency/organization lead, as well as proposed metric(s) for measuring progress.

Table 22. Summary of Achugao Implementation Actions

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
Goal 1: By 2030, reduce urban pollutant loads to Tanapag Lagoon by managing 30+ acres of existing impervious cover, applying better land use controls on new development, and maintaining infrastructure.				
1.1 Retrofit existing development with green stormwater infrastructure (e.g., schools, hotels, industrial area, and roads). *Identify priority projects to advance to design, permitting, and construction (see Tables 19 and 20). Public sites such as the Tanapag Beach Park, one or both schools, and As Agatan flood control/wetlands should be on the initial list. PCRP, DCRM, and CUC have already applied for grant funds from federal agencies (NOAA, DOI, NFWF). Consider Land and Water Conservation Fund grant application for Tanapag Beach Park (Appendix B).*	In progress $250,000 design and permitting $1.5M in construction	$250,000 design and permitting $1.5M in construction	DCRM (PCRP, CUC, DPW)	• Impervious acres managed • Total drainage acres managed • Estimated pollutant load and volume reductions
1.2 Aggressively enforce erosion and sediment control at construction sites and ensure remediation actions occurs. *Violations in federal and territorial NPDES requirements for construction activities were observed at several sites. Increase enforcement by hiring more staff and restructuring fines so they outweigh cost of compliance. Work with Achugao elected representatives to educate politicians on impacts and options for ways to incentivize compliance. Complete site remediation for delinquent owners using performance bonds or levied fines. Stabilize the Imperial Casha site.*	$25,000/yr to support additional staff position (island-wide) $25,000-$50,000 to fix *Imperial Casha*	$25,000/yr to support additional staff position (island-wide)	BECQ (island-wide)	• # and type of violations, enforcement actions, and remediation actions annually • $ collected in fines
1.3 Update technical design manuals for stormwater & wastewater technologies to address climate adaptation and to apply standards to redevelopment, large renovations, and road improvements to address existing problems. *The manuals are >10 years old and due for an update to account for lessons learned from agencies and engineers on design methods and technologies. The MS4 permit is also up for renewal and may have elements that should be incorporated into an*	$250,000	$150,000	BECQ (DPW, CUC)	• Completion of manuals Summary of new design provisions and applicability standards

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
updated manual. New performance innovations and s design factors related to sea level rise, changing precipitation patterns, and redevelopment criteria should be included.				
1.4 Find opportunities to promote sustainable and locally appropriate development by addressing inconsistencies, gaps, and barriers in land development procedures (e.g., permitting, land lease, and zoning). *Issues arising from foreign investors and a lack of long-term planning are on display in Achugao and have led to a general stakeholder preference for small-scale boutique hotels rather than resorts. Specific actions include:* *a) limit number of years of inactivity allowable and options for handling abandoned/degraded lands in the land leasing process;* *b) clarify permit requirements and infrastructure needs with foreign investors in their native languages during pre-permitting;* *c) update zoning for wetland protection and establish boutique tourism zone;* *d) increase review on zoning changes and specify waiver criteria and exclusions;* *e) develop a new MOU for one-start permitting and build compensatory mitigation into permit process (in progress); and* *f) follow through on permitting incentives for better buildings (in progress).*	In progress $30,000	$20,000	OPD (DCRM, DPL)	Checklist of programmatic and regulatory changes made
1.5 Increase maintenance capacity for drainage system by developing an inspection and maintenance schedule, purchasing new equipment (e.g., remote cameras, vactor trucks), and hiring/training more staff on maintenance of green infrastructure and MS4 program requirements. *CUC's lift station repairs and sewer line replacements have made a big difference in the watershed. Drainage infrastructure does not get as much attention unless it contributes to flooding. Over 60% of the drainage structures inventoried required maintenance or repair and it is not always clear who is responsible for maintenance. Establish an inspection and maintenance schedule that prioritizes areas of higher frequency. Landscaping and sediment removal for green infrastructure practices may not be familiar to staff and additional training may be required.*	$500,000	$250,000	CUC/DPW (Mayors Office)	• % of structures inspected • Miles of pipe

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
Goal 2. Adopt predicted rainfall amounts, sea level rise estimates, groundwater elevations, and storm surge levels for the 30-yr planning horizon (year 2050), at a minimum, for development and infrastructure planning.				
2.1. Update environmental permitting requirements to reflect climate-forward calculation requirements.	$10,000	--	OPD (DCRM, DPW)	# changes adopted
2.2. Reduce wastewater system vulnerability by raising/replacing sewer manholes subject to flooding, get ahead of buildout by upgrading sewer line at Imperial Casha and implementing a subsidy program for septic inspections and hookups. *Much of lower base, Tanapag, and portions of San Roque are low lying and flood prone, which increases the likelihood of septic system failure and inflow & infiltration into the sewer system. Increased force main capacity will be needed to accommodate future development. CUC*	$1M	$1.5M	CUC	• # of structures replaced • # of OSDS inspected or connected to sewer
2.3. Use a living shoreline approach where erosion exists or is expected to worsen, and where conditions are favorable for short-term success. *The only place where shoreline restoration was identified during field assessments was at Tanapag Beach Park. The existing offshore reef and seagrass beds offer ideal conditions for a more natural approach to shoreline protection.*	$25,000	$50,000	DCRM	• Linear feet of restoration • # of plants • # of volunteers
2.4. Expand stream monitoring efforts to establish flow and peak discharge rates for the four major tributaries. *The water quality monitoring program is outstanding. Because each of the major streams in the watershed is accessible at road crossings and has flow for much of the year, these areas might be good candidates for flow gauging and additional wet weather monitoring. This information can help to better predict overbank flooding and quantify annual sediment loads.*	--	$50,000	BECQ-Monitoring (Univ of Guam, USGS)	• # of monitoring sites • # of baseflow and wet weather sample collection days • # of stage/ discharge curves established
2.5. Begin to engage the community in discussions related to managed retreat and initiate an open dialogue about the low-lying cemetery, wetland migration areas, and the most vulnerable homes and businesses. *Retreat is not popular, and this is a sensitive subject, but it is worth exploring options during workshops and community discussions. Take a closer look at Lower Base, Tanapag, and San Roque.*	$10,000	--	DCRM	# of participants

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
Goal 3: Protect or restore 30% of the terrestrial and wetland habitats in the watershed through invasive species management, native reforestation, and land conservation by 2030.				
3.1. Conduct on-site surveys of terrestrial and wetland habitats to determine the status of health and to identify potential needs and approach to management. *Achugao has extensive public lands that overlap with degraded habitats, there is (potentially) a fragmented native limestone forest along the Achugao stream corridor, small patches of mangroves, previously burned areas, degraded urban vegetation, and several areas identified as forest stewardship priorities. An inventory should be conducted by local ecologists to prioritize locations where reforestation and invasives management can be targeted: around native forests, forest fragments, urban canopy, wetland buffers, burn areas or where erosion delivery is high. High quality sites should be identified for conservation. Some wetlands have been assessed and previously burned areas have been mapped. Identify which savannah areas are desirable to maintain. Classify forest types by fragment size, targeting the largest fragments, or clusters of forest fragments that are relatively close to one another. Establish forest and habitat health baseline conditions to inform future management actions.*	In progress $25,000	$55,000	Forestry/ DFW (DCRM)	• Mapped acres of each habitat type inventoried • # of site specific restoration plans developed • Acres identified for conservation
3.2. Identify legal and financial mechanisms to conserve remaining undeveloped lands that are deemed critical for habitat or climate resiliency. *Develop a strategy for permanently protecting the highest priority lands from future development, keeping in mind agricultural needs and homesteading obligations.*	--	$25,000 (does not include land purchase)	OPD (DPL)	# of sites/acres with specific strategies identified
3.3 Review and update tree protection regulations to minimize further loss of native, large diameter trees, provide clear guidance for tree removal criteria on public lands, and incentivize urban canopy cover. *Urban greenspace requirements are not incorporated into any DPL leases, as well as all DEQ, DCRM, and zoning permits and regulations, or Qualifying Certificate requirements (Forest Action Plan 2020-2030)*	$5,000	--	OPD	• Review completed • Revisions adopted

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
3.4 Implement habitat restoration projects and invasive management program. a) *Support propagation efforts for native plants, including mangrove species. CNMI Forestry is supporting a native wetland and limestone forest plant nursery to propagate native plant species for site restoration and mitigation projects.* b) *Collaborate with partners and stakeholders to implement restoration projects and provide hands-on training on plant identification, invasives removal, and propagation and out planting techniques (e.g., direct, raised bed planting to avoid ground disturbance, seed dispersal, stump planting). Include mangrove, upland reforestation, and seagrass restoration (potentially).* c) *Implement invasive management program. Strategies include mechanical and chemical removal of invasive trees, vines, and other non-native plants. Consider number of treatments needed, biosecurity, and maintenance requirements. Stream and wetland restoration should be linked to flood protection projects near road crossings.*	In progress $300,000	$300,000	DLNR Forestry /DFW (OPD, DCRM)	• # of native seedlings propagated • Acres treated/restored • # & diversity of species planted/ removed • # of forest health and invasives trainings • # organizations or volunteers participating
3.5 Promote Forest Stewardship Program for restoration on private lands. *Of the 140 priority acres identified on Saipan, over 110 acres are in Achugao. Encourage private landowners to adopt conservation practices on their land by replacing non-native species with native plants by educating the public on the importance of protecting and expanding the surrounding forest on their lands, and by providing technical/financial assistance in developing and implementing stewardship plans.*	$100,000	$100,000	DLNR Forestry (DCRM)	• # of trees planted • Acres managed • # of landowners participating
Goal 4: Empower community-based watershed stewardship by conducting at least 30 engagement, advocacy, and educational outreach activities by 2030.				
4.1. Implement wildfire prevention education and outreach. *Drier/warmer weather, agricultural clearing, and trash burning, and hunting all contribute to increased risk of wildfire. Install advisory signs and implement targeted education to rebrand "wildfires" to ensure people know that it's human caused and to educate them on what to do/not to do during dry conditions. Improve*	In progress $30,000 per year	$15,000 per year	DCRM, Fire	• # signs • Frequency of advisories • # and acres of burns • # of educational materials distributed

Achugao Watershed Objective/Action	Implementation Schedule/Cost		Lead Agent (partners)	Metric
	2020-2025	2025-2030		
understanding of what plants can help with restoration, etc. (in progress). Other actions to consider include implement air quality regulation/permitting for agricultural burning and offering additional transportation to the landfill.				
4.2. Continue to engage schools and community groups in hands-on restoration projects (e.g., plantings, rain gardens, trash removal in streams, WQ monitoring) through the Watershed Warrior program.	In progress $30,000 per year	$30,000 per year	DCRM/Dept of Education	• # of engagements • # of students participating
4.3. Provide pollution prevention and sustainability technical services for local businesses. *Conduct free site visits with facilities managers in Lower Base to identify potential sources of pollution and offer potential solutions. Develop a site-specific pollution prevention plan (voluntary) to improve on site material storage, hazardous waste, drainage, etc. Work with interested hotels/resorts to complete sustainability index evaluation and identify site specific retrofit options.*	$25,000	$25,000	BECQ (OPD, HANMI)	• # of businesses participating • # of plans developed • # of projects implemented
4.4 Increase number of opportunities for public input in development permitting process, hazard vulnerability planning, restoration project designs, etc.	--	--	OPD	• # of public meetings • # attendance • # of comments received
4.5 Educate landowners, residents, and farm workers on sustainable practices related to pet and livestock waste management. *NRCS has outreach capacity for educating and financing related to sustainable practices. Provide specific education on microbial tracing study results and the importance of proper waste disposal to dog owners.*	$10,000	$10,000	NRCS/DEQ	• # of events • # of participants
4.6 Provide more trash collection services for lower income families and offer more community clean up events. *BECQ stream assessments identified several key sites for trash cleanup. CNMI has a enviable water quality monitoring program that could engage local schools while collecting more information within the stream network.*	$25,000	$25,000	DPW (Mayors Office)	• # of events • # of volunteers • Tons of trash removed • Miles of stream-adopted
4.7 Educate decision makers and landowners on the economic value of watershed services. *Without political will to support sustainability initiatives, improving conditions will be a challenge. Develop concise educational material outlining ecosystem services and their value specifically for the CNMI and Achugao communities.*	$5,000	--	DCRM/MINA (local law makers)	• # of presentations or materials distributed • # of decision makers reached

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