Draft Final

Wastewater Master Plan – Saipan, Commonwealth of the Northern Mariana Islands

Prepared for

Commonwealth Utilities Corporation

Prepared by

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Executive Summary

The Commonwealth Utilities Corporation (CUC) took over the management of the Commonwealth of the Northern Mariana Islands (CNMI) water and wastewater utilities from the Department of Public Works in the late 1980s. Since the time of the transfer of management responsibilities, utility staff have encountered extensive infrastructure problems, and annual capital and operational budgets have been insufficient to address the problems. The United States Environmental Protection Agency (EPA) and the CUC entered into Stipulated Order Number One for Injunctive Relief that required the development of a comprehensive, long-term water and wastewater Master Plans to identify specific issues and improvements to both the water and wastewater infrastructure on the islands of Saipan, Rota, and Tinian.

The most significant problems with the Saipan wastewater system were associated with:

- Unauthorized wastewater discharges, primarily associated with pipeline breaks and wastewater lift station failures.
- Failure to comply with National Pollution Elimination Discharge Standards (NPDES) water quality discharge requirements at the two wastewater treatment facilities and ocean outfalls.

The Saipan Wastewater Master Plan was the first step toward compliance with Stipulated Order No. 1 through the development of a roadmap consisting of new capital projects, replacement and repair of existing facilities, modification of operational procedures, and assessing current staffing levels and related policies.

The development of the Saipan Wastewater Master Plan consisted of the following processes to identify projects that were not only required to meet the Stipulated Order, but projects that would also provide a long-term benefit to CUC with regard to operations of CUC's wastewater infrastructure:

- Literature review
- Field data collection
- Documentation of findings in technical memorandums
- Analysis of the data
- Project identification and prioritization

Not all projects identified as part of the project identification process will be included in the Capital Improvements Plan (CIP) projects due to budget and scheduling restraints; it is not feasible to complete all projects that were identified and scored within the 20-year CIP implementation period specified by the Stipulated Order.

The Financial Plan is a companion document that discusses the capital and operating funding needs for the wastewater system and the rate impact on existing and future customers.

Goals for the Saipan Wastewater System Master Plan

Master Plans for the water and wastewater systems on Saipan, Rota, and Tinian have been developed to provide a roadmap for CUC to implement to meet the requirements of the Stipulated Order. The Wastewater Master Plan sets quantifiable milestones that the USEPA Region 9 staff can use to track compliance. CUC's overarching goal for these plans is to meet Stipulated Order requirements through a realistic implementation plan that also addresses real needs and promotes operational improvements. CUC's desired outcome for the Saipan wastewater system include the following:

- Assessment of the hydraulic capacity of wastewater collection system
- Pathway forward to reduce dry and wet weather overflows
- Assessment of the current condition of wastewater system assets
- Understand why specific NPDES discharge permit requirements are not being met and what is required to achieve compliance
- Develop a Capital Improvement Plan (CIP) prioritized project list to address public health and environmental issues in unsewered areas

The Saipan Wastewater Master Plan addresses these outcomes as described in the following sections.

Assessment of the Hydraulic Capacity of Wastewater Collection System

While determining the capability of the wastewater system to collect, convey, and treat peak dry-weather and peak wet-weather flows under current conditions as well as future population projections was a requirement of the Stipulated Order, CUC also wanted to collect this information to improve system effectiveness, especially with regard to reducing dry and wet weather overflows. The hydraulic capacity of the Saipan wastewater collection system was determined through the development of a collection system hydraulic model. This model was used to measure flow under dry and wet weather conditions, identify infiltration and inflow (I/I), provide data for a cost analysis of I/I control versus treating peak wet weather flows, and identify flow bottlenecks.

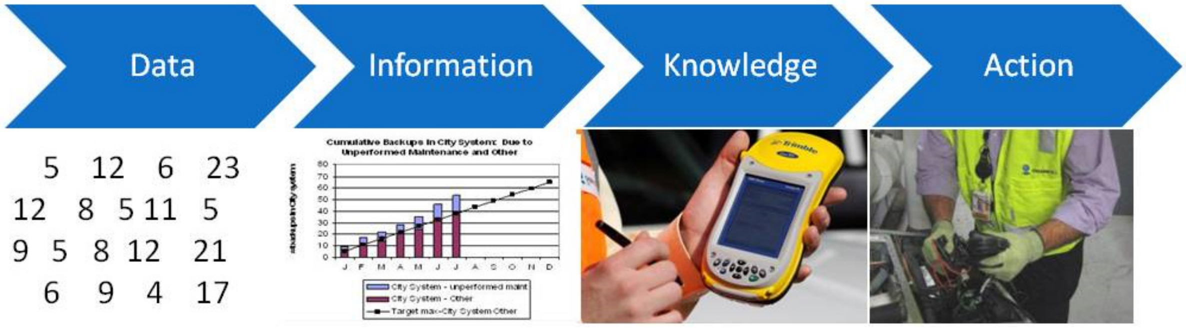
Innovyze H2OMap Sewer software was used to develop a hydraulic model of the Saipan wastewater collection system, and it was used to run extended period simulations and simulate unsteady flow conditions using the model. These simulations helped to estimate remaining system capacity, including that of lift station pumps and force mains; identify bottlenecks; analyze proposed system upgrades and modifications; and illustrate how the existing system operates as well as how it would operate in the future if proposed changes were implemented. As a result, short- and long-term solutions were identified and included in the list of recommended capital improvements.

Bottlenecks were identified in Sadog Tasi North, Sadog Tasi South (Garapan), Agingan West (San Jose and Chalan Kanoa), and solutions were recommended. Some of the solutions are included on the list of CIP projects for the Saipan wastewater system; the remaining solutions involve smaller projects that can be implemented as part of normal operations and maintenance efforts. CIP projects that will help to eliminate specific bottlenecks in the system include manhole upgrades, upgrade of the Lower Base collection system, and replacement of the As Perdido line.

Pathway Forward to Reduce Dry and Wet Weather Overflows

The wastewater collection system in Saipan does not include a Supervisory Control and Data Acquisition (SCADA) system, which restricts the level of data available from the field regarding real-time operations. The implementation of a SCADA system would provide the CUC Operations Team with real-time insight into specific operational problems and anomalies associated with dry and wet weather overflow events. Figure ES-1 illustrates the four activities that would improve the level of response and mitigation of dry and wet weather sewer overflows; a discussion of these activities follows the figure.

Figure ES-1. **Activities to Address Dry and Wet Weather Sewer Overflows**



Data. The lack of data generated at the edges of the collection system impacts the ability of CUC to react quickly to surcharging events. During Master Plan development, CUC has been evaluating new, advanced sensor technology to enable monitoring at the edge of the collection system through the collection and transmission of real-time data associated with dry and wet weather sewer overflows.

Information. Data collected in the field requires validation and anomaly detection to provide CUC with early warning of surcharge potentials through real-time alerts.

Knowledge. Blending the information from the asset through a visualization platform enables the operator to rapidly integrate his knowledge of the system with the information to clearly understand the criticality of the event.

Action. Knowledge created allows for rapid action to quickly stop the event and begin mitigation of both potential public health and environmental impacts.

During the development of the Saipan Wastewater System Master Plan, a number of critical actions were identified to improve the reliability of the system, lower the cost of operations, and reduce the impact to the environment that is associated with sewer overflow events during both dry and wet weather periods. Some key actions, which are a combination of capital projects and enhanced operations and maintenance activities, are presented below:

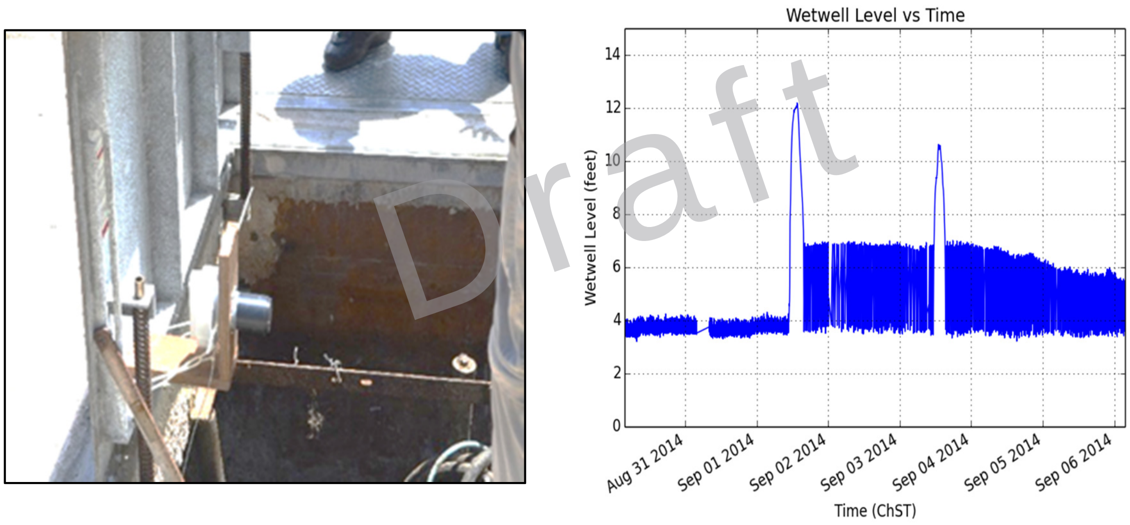
- **Replace asbestos-cement (AC) pipelines.** The AC pipelines in the wastewater collection system have the highest risk of failure due to excessive corrosion from hydrogen sulphide. A capital improvement project was identified to replace the 63,468 feet of AC pipe in the system; this project will span the initial 5-year capital improvement program (CIP). The replacement schedule will replace the segments at highest risk first. The CIP project for replacing these lines was the highest ranked project identified in this Master Plan.
- **Control fats, oils, and grease (FOG) inputs.** Illegal discharge of FOG into the collection system is a major cause of excessive lift station maintenance and sewer clogging, resulting in dry weather overflows. These overflows are preventable and CUC needs to improve its enforcement of grease trap permits and improve line and pump station maintenance in areas that are prone to FOG accumulation. A project to evaluate FOG control was rated number 9.
- **Implement a sewer cleaning program.** CUC needs to implement a routine sewer cleaning program to prevent the accumulation of FOG, disposable wipes, and other debris that clog the pipelines and cause sewer overflows. The sewer cleaning program should identify areas that are prone to clogging and place those areas on a more frequent cleaning schedule than other lines that have few problems. Additionally, using level remote ultrasonic sensing technology in manholes in problem areas can also provide early warning for clogging conditions. This approach is being used by other utilities under consent decrees in the United States.

- **Perform lift station Improvements.** Some key improvements identified for sewer lift stations are as follows:
  - Ensure pumps are properly sized.
  - Upgrade the controls at each lift station. A pilot SCADA project to evaluate and pilot enhanced controls for the lift stations was ranked fourth on the priority list.
  - Ensuring that all the lift stations have backup generators with a standard routine maintenance program. A project to repair and replace emergency generators was ranked third on the priority list.
  - Replace discharge piping with corrosion-resistant material.

  The capital project for upgrading lift stations was the fifth-ranked project and will be funded in the first 5-year CIP program.

An advanced evaluation on the use of machine-to-machine sensors for lift station monitoring was conducted during the master planning process. Figure ES-2 illustrates the information associated with a power outage at a lift station during a significant tropical storm in early 2015. Because the sensor was battery powered and used cellular communications, the data was able to be communicated to CUC in real time during the event.

Figure ES-2. **Condition of Wet Well (Left) and Corresponding Data Communicated by the Monitoring Sensor**



During 2015, CUC is implementing a large pilot SCADA system in a portion of its water system to evaluate technologies that can be applied to both water and wastewater systems. This will be followed with a pilot wastewater SCADA system in FY16.

In addition to implementing a data management strategy to manage overflows, the physical condition of the wastewater system from the sanitary sewers to the treatment plant will also be addressed. For example, identifying and installing the right-sized pumps in lift stations; upgrading controls; maintaining backup generators; installing corrosion-resistant discharge piping; replacing asbestos sewer lines; controlling fats, oils, and grease (FOG) inputs into the system; and implementing a sewer cleaning program—each of these will contribute to reducing bottlenecks and developing a wastewater system that works effectively and with few or no system overflows.

Current Assessment of the Condition of Wastewater System Assets

Accurate information and a complete understanding of any system is necessary to understand the useful life of the assets and identify practical, cost-effective improvements. CUC required a complete assessment of the wastewater system assets on Saipan to identify areas in the collection system that may benefit from improved operations, identify assets in poor condition, validate known issues in the collection system and treatment facilities, identify and evaluate alternatives to address those issues, and prepare a plan to implement the selected alternatives. The assessment included a review of existing data about Saipan's wastewater system, development of a hydraulic model for the collection system, and site visits to document physical condition of assets. Information gathered from these tasks was utilized to evaluate the overall condition and capacity of Saipan's wastewater collection and treatment facilities. The outcome of this was the development of a complete asset database

Reviewed Existing Data on Saipan's Wastewater System

To create a master plan for wastewater system improvements, a thorough understanding of the system is required. A literature review was conducted of nearly four dozen documents developed from 1988 through 2012 by CUC, CNMI Department of Environmental Quality (DEQ), water engineers, U.S. government agencies, industry groups, and others. Existing facility as-builts or original design drawings were reviewed to document asset locations, construction materials, and other pertinent data. Additionally, numerous meetings, workshops, and teleconferences were held to gather and confirm information, review Master Plan deliverables, approve and rank improvement projects, and communicate and make decisions regarding myriad project activities.

Evaluated Condition of Wastewater Collection and Treatment Facilities

For the purpose of this Master Plan, the sewer collection system was divided into two service areas corresponding to the wastewater treatment plants (WWTPs): Sadog Tasi and Agingan. Each service area was further divided into sewersheds. The Sadog Tasi service area contains 34 miles of sewer lines and 18 lift stations, while the Agingan service area is made up of 30 miles of sewer lines and 25 lift stations.

The condition of Saipan wastewater collection and treatment facilities was examined to add to the body of knowledge obtained through the literature review, workshops, and meetings. A field condition assessment of wastewater collection facilities was undertaken, which included appraisal of the sewer pipes using closed-circuit television (CCTV); lift stations, including their housing, electrical, controls, and appurtenances such as valves and flow meters; forcemains; screens; and generators. The Sadog Tasi and Agingan WWTPs were assessed with regard to treatment processes, updates and changes to the plant designs, permit requirements, and current performance. Assessment of underground assets (pipelines) were limited to CCTV inspections of high-risk pipeline areas identified by CUC and the project team.

Outcomes of the Assessment of Wastewater System Assets

Over 60 percent of the CUC wastewater collection system is constructed of polyvinyl chloride (PVC) pipe. Based on meetings with CUC operations and engineering staff, the PVC pipe is performing well, which is in line with common industry results for PVC pipe.

Approximately 20 percent, or 13 miles, of the CUC wastewater collection system is made up of asbestos-cement (AC) pipe. AC pipe is found in Garapan, San Jose, Susupe, Chalan Kanoa, and San Antonio, and along Chalan Monsignor Guerroro Road. The AC pipe has met its life expectancy and is a known major point of failure within the wastewater collection system. Areas in Garapan, San Jose, and along Chalan Monsignor Guerroro Road have all experienced a sewerline collapse in the last

10 years. Appendix A presents output from the geographic information system (GIS) database that shows the locations of the AC sewer lines.

The force mains were visually inspected at readily accessible areas such as valve pits and, in a few cases, points of termination (i.e., discharge manholes). The project team did not excavate to visually inspect any of the force mains. Information on the force mains was gained through visual assessment of the valve pits and reviewing the as-built drawings and design plan information. Interviews with CUC operations staff and engineering were conducted to determine past failures of the force mains. In addition, hydraulic modeling was conducted to evaluate force main operating conditions.

Check valves have posed operational problems for CUC. While most of the check valves were visually inspected, a few were located in a portion of a wet well that was obstructed from view. In the majority of cases the make and model of the check valves, isolation valves, pumps, and motors were not readily visible to the project team. In nearly all cases, the make and model information on these apparatus was painted over and/or the tags were removed. Information on size and make of each valve was ascertained by the project team based on the nameplate, configuration, and orientation of the valves. Information on the pumps and motors was ascertained through CUC records.

One large data gap was the limited information available on the lift stations' flow and head values. Data provided by CUC engineering and operations were incomplete and, in most cases, conflicting. This data gap required the development of theoretical estimates for the existing pump sizes to be used for the hydraulic model.

Understand Why Specific NPDES Permit Requirements are not being Met and What is Required to Achieve Compliance

Sections B1.51 and B1.52 of the Stipulated Order requires that the Master Plan identify conditions that cause or contribute to CUC's violations of its National Pollutant Discharge Elimination System (NPDES) permits and recommend improvements or modifications necessary to comply with the permits. NPDES discharge permit requirements that have been found to be in non-compliance include the following:

- Sadog Tasi Wastewater Treatment Plant (WWTP): biochemical oxygen demand (BOD), total suspended solids (TSS), *Enterococci*, pH, copper, and zinc
- Agingan WWTP: *Enterococci* and copper

Some of the non-compliant incidences were due to upset conditions occurring during plant upgrade construction periods and re-construction work at both Sadog Tasi and Agingan WWTPs. This non-compliance is generally no longer an issue since the upgrades were completed. *Enterococci* exceedances in effluent can be expected to continue, however, unless disinfection is added. Receiving water monitoring, however, indicates that bacteriological water quality criteria are usually met outside the zones of mixing, which were evaluated under this Master Plan and recommended for enlargement. This is currently being evaluated by EPA in the context of the renewal of the NPDES permits for both plants, the Stipulated Order, and a previous Administrative Order against the Sadog Tasi WWTP.

Recommendations to address the permit non-compliance are listed below:

- Sadog Tasi WWTP
    - Review and revise the water column monitoring frequency in the NPDES permit. Implement a quarterly water column monitoring frequency at Sadog Tasi WWTP, similar to that carried out at Agingan WWTP, to reduce logistical needs in light of the limited resources available.
    - Review and revise pH limits in NPDES permit. Widen the existing range of pH limit values (7.4 to 8.6) to be more consistent with that for Agingan WWTP, which has an allowable range of 6 to 9. A wider and more practical range of allowable pH values will more closely reflect receiving water pH levels.
    - Consider the use of a higher dilution factor to address *Enterococci* values. It has been observed from the available monitoring data that the receiving waters are not adversely impacted by the effluent.
    - Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone, as is the practice elsewhere, to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.
- Agingan WWTP
    - Review and revise the choice of WET test species in NPDES permit. Propose the use of *Hyalella azteca* as the only species for WET testing, as *Daphnia magna* is a freshwater species not suitable for a saline environment.
    - Consider the use of a higher dilution factor to address *Enterococci* values. It has been observed from the available monitoring data that the receiving waters are not adversely impacted by the effluent.
    - Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone, as is the practice elsewhere, to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.

Develop a Priority List to Address Public Health and Environmental Issues in Unsewered Areas

Section 58 of the Stipulated Order requires that the Master Plan include an assessment of and recommendations regarding unsewered areas. Unsewered areas are defined as areas that do not have sewer lines or are not currently connected to a sewer collection system, including areas with septic systems that may be able to be connected to existing, expanded, or new wastewater collection systems, as well as areas that may not be able to be connected to a centralized wastewater system.

The unsewered area analysis included the following:

- Review of nitrate contamination in groundwater, including potential sources and historical presence
- Review of wastewater collection and treatment in Saipan
- Review of previous studies related to unsewered areas and nitrates

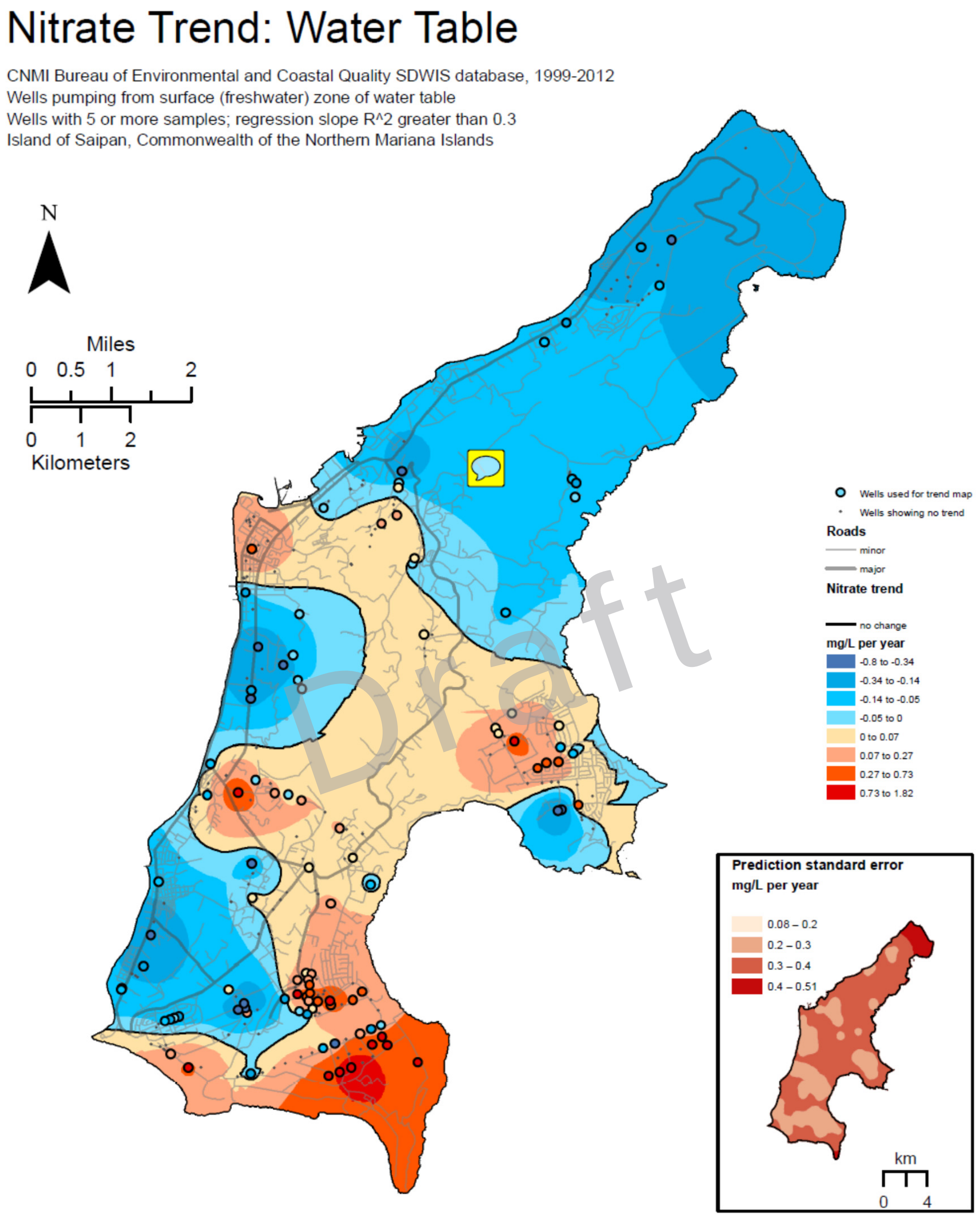
- Evaluation of water quality in each of the unsewered areas (Kagman; San Vicente, Dan Dan, and As Lito; Isley; and Obyan, Koblerville, Central, and Northern wellfields) and recommendations for addressing nitrates in those areas. Some of the key findings of this evaluation are as follows:
  - The well consolidation program has eliminated MCL violations through blending even though individual wells may exceed 10 mg/L of nitrate.
  - Elevated nitrate levels in groundwater is prevalent in many parts of Saipan due to historical land uses and septic systems. The nitrate concentration map (Figure ES-3) developed by Brian Bearden/CUC includes all well data in the DEQ database.
  - While the Kagman wellfield received the second highest prioritization score during the unsewered areas analysis (see Table ES-1), it would seem to be more logical to first connect Dan Dan and other areas in close proximity to the Agingan and Sadog Tasi WWTPs. Dan Dan and other areas in close proximity to Agingan and Sadog Tasi should be connected before any consideration for a costly Kagman sewer system should be raised in priority.

Table ES-1. **Unsewered Areas Analysis Scoring System**

Village	Septic Tank Suitability	Groundwater Protection Zone	Agriculture	Number of Times NO_3 > 10 mg/L	Number of Wells of Concern (Average NO_3 > 5 mg/L)	Prioritization Score
Kagman	5	3	2	1	10	**21**
San Vicente/ As Lito/ Dan Dan	5	3	2	0	2	**12**
Isley	5	3	1	84	23	**116**
Obyan	5	3	2	0	10	**20**
Koblerville	5	3	2	1	4	**15**
Central Well Fields	4	3	1	0	0	**8**
Northern Well Fields	3	2	1	0	0	**6**

  - Twenty CIP projects have been identified that would connect unsewered areas to the existing wastewater treatment plants. It is recommended that an in-depth evaluation of the unsewered areas be conducted to determine the source of potential groundwater contamination.
  - Recommendations include prioritization of unsewered areas, creation of a well blending program, specific recommendations for Kagman and the Isley wellfields, and general recommendations applicable to all unsewered areas on Saipan.

Figure ES-3. **Nitrate Concentrations, Saipan**
Source: Brian Bearden/CUC



Recommended Capital Improvement Program and Operations and Maintenance Projects

The project team and CUC identified many more capital projects that could be funded over the 20-year CIP horizon, which is not an unusual outcome when preparing a master plan. Additionally, operations and maintenance activities were identified during the site visits and interviews with CUC staff. Table ES-2 summarizes the number of projects identified for the CUC wastewater system for Saipan, Rota, and Tinian.

Table ES-2. **Projects Identified by the Master Plan**

Total Number of Capital Projects Identified	Number of Capital Projects in 20-year Plan	20-Year Capital Project Projected Costs	Number of O&M Projects
57	24	$48,270,000	104

Capital Improvement Projects

Based on Stipulated Order requirements, goals that CUC has for its wastewater system on Saipan, and information collected as part to the Master Plan development, the recommended CIP projects, listed in Table ES-3, were identified.

Table ES-3. **20-Year Wastewater CIP Capital Costs**

Project Location	Project #	Project Description[a]	1st 5 Year CIP (FY2016-2020)	2nd 5 Year CIP (FY2021-2025)	3rd 5 Year CIP (FY2026-2030)	4th 5 Year CIP(FY2031-2035)
Saipan	**1**	**Replacement of Existing Dilapidated Sewerlines**	**$ 3,630,000**			
Saipan	**2**	**Island-wide New Sewer Service Connections**	**$ 1,555,000**			
Saipan	**3**	**SCADA Phase I: Pilot Study**	**$ 521,000**			
Saipan	**4**	**Upgrade Generators**	**$ 432,000**			
Saipan	**5**	**Upgrades of Various Lift Stations**	**$ 4,366,000**			
Saipan	**6**	**SCADA Phase II: Design**	**$ 195,000**			
Saipan	**7**	**I&I Reduction**	**$ 1,859,000**			
Saipan	**8**	**Garapan Lift Station Elimination**	**$ 1,210,000**			
		5-Year Total	**$13,768,000**			
Saipan	**9**	**FOG Phase II: FOG Disposal Facility Design & Construction**		**$ 3,260,000**		
Saipan	**10**	**As Terlaje Sewerline Replacement & Lift Station Elimination**		**$ 3,461,000**		
Saipan	**11**	**S-3 Force Main Replacement**		**$ 378,000**		
Saipan	**12**	**Sadog Tasi Hygiene Facility**		**$ 303,000**		

Table ES-3. **20-Year Wastewater CIP Capital Costs**

Project Location	Project #	Project Description[a]	1st 5 Year CIP (FY2016-2020)	2nd 5 Year CIP (FY2021-2025)	3rd 5 Year CIP (FY2026-2030)	4th 5 Year CIP(FY2031-2035)
Saipan	**13**	**Lower Sadog Tasi Sewer Collection System**		**$ 863,000**		
Saipan	**14**	**Inventory Upgrades**		**$ 550,000**		
Saipan	**16**	**Lower Base Phase IIb: Southern Tanapag and Chalan Pale Arnold Sewer Collection System**		**$ 1,344,000**		
Rota	R1	Phase I: Wastewater System Needs Analysis - Song Song		$ 60,000		
Rota	R2	Phase I: Wastewater System Needs Analysis - Sinapalo		$ 60,000		
		5-Year Total		**$10,279,000**		
Saipan	**15**	**Isa Drive Sewer Realignment**			**$ 3,318,000**	
Saipan	**17**	**Afetna Sewer Collection System Upgrades & Expansion**			**$ 2,102,000**	
Saipan	**19**	**Wireless Road Phase I: Gravity Sewer System**			**$ 2,076,000**	
Saipan	**20**	**As Perdido Road Sewer Collection System**			**$ 441,000**	
Saipan	**21**	**Saipan Wastewater Equipment Maintenance Facility**			**$ 2,340,000**	
Tinian	T1	Phase I: Wastewater System Needs Analysis			$ 60,000	
		5-Year Total			**$10,337,000**	
Saipan	**18**	**Sludge Composting**				**$10,550,000**
		5-Year Total				**$10,550,000**
		Discretionary Project Funds	$ 602,000	$ 1,021,000	$ 963,000	$ 750,000
		Total Project Costs	$14,370,000	$11,300,000	$11,300,000	$11,300,000
		Available Budget	$14,370,000	$11,300,000	$11,300,000	$11,300,000

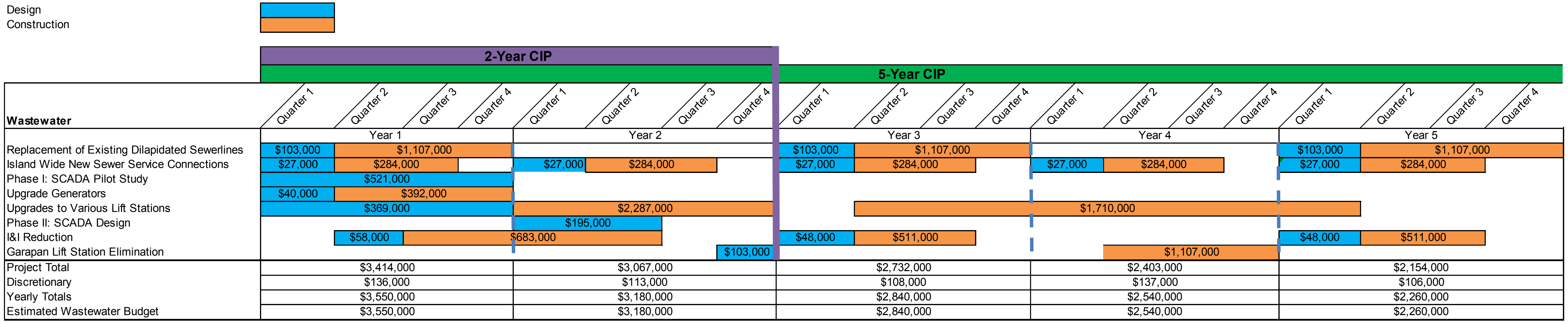
[a] Complete project descriptions can be found in Appendix S.

[b] All costs have been rounded to the nearest thousand. Actual cost estimates can be found in Appendix V.

Project Implementation Approach

Figure ES-4 provides an implementation schedule for the first of four 5-year CIP programs developed for the Saipan Wastewater Master Plan.

Figure ES-4. **Implementation Schedule for First 5-Year CIP (FY2016-FY2020)**



Design	Construction
🟦	🟧

Wastewater	Year 1				Year 2				Year 3				Year 4				Year 5			
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Replacement of Existing Dilapidated Sewerlines	🟦 $103,000	🟧 $1,107,000							🟦 $103,000	🟧 $1,107,000							🟦 $103,000	🟧 $1,107,000		
Island Wide New Sewer Service Connections	🟦 $27,000	🟧 $284,000			🟦 $27,000	🟧 $284,000			🟦 $27,000	🟧 $284,000			🟦 $27,000	🟧 $284,000			🟦 $27,000	🟧 $284,000		
Phase I: SCADA Pilot Study	🟦 $521,000																			
Upgrade Generators	🟦 $40,000	🟧 $392,000																		
Upgrades to Various Lift Stations	🟦 $369,000				🟧 $2,287,000					🟧 $1,710,000										
Phase II: SCADA Design					🟦 $195,000															
I&I Reduction		🟦 $58,000	🟧 $683,000						🟦 $48,000	🟧 $511,000							🟦 $48,000	🟧 $511,000		
Garapan Lift Station Elimination								🟦 $103,000						🟧 $1,107,000						

	Year 1	Year 2	Year 3	Year 4	Year 5
Project Total	$3,414,000	$3,067,000	$2,732,000	$2,403,000	$2,154,000
Discretionary	$136,000	$113,000	$108,000	$137,000	$106,000
Yearly Totals	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000
Estimated Wastewater Budget	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000

Operation and Maintenance List

Throughout the course of developing the Wastewater Master Plan for Saipan, a number of non-capital improvement recommendations were made that fall under general operation and maintenance activities. The project team recommends the operation and maintenance activities listed below.

Lift Stations

General Recommendations

- Provide standardized pumps and controls at all lift stations.
- Provide proper signage, such as site ID and warning: high voltage signs, at all lift stations.
- Increase the redundancy and reliability at each pump station.
- Relocate existing check valves to new valve pits at lift stations.
- Upgrade riser pipe from cast iron to stainless steel as needed (noted in Lift Stations S-4, S-5, and W-4).
- Maximize collection system runs to reduce the need for new lift stations.

Area-specific Recommendations

- Repair the manholes in the Tanapag area collection system. This system is known to have I/I problems, and the manholes are severely deteriorated.
- Conduct routine maintenance of the Capitol Hill collection system to address root intrusion.
- Frequently clean the collection system in the Garapan area. Accumulated oil and grease is resulting in backwater effects and odor problems.
- Reinspect the Chalan Kanoa area of the collection line in 5 years.
- Reinspect the San Antonio along Middle Road area of the collection line in 5 years.
- Install a variable frequency drive (VFD) as an interim upgrade to the T-1 Pump Station until the force main size can be increased to 10 inches.

Electrical System

- Properly provide high leg marking in accordance with the NEC.
- Where a generator backup system is provided, ensure the high-leg phase between the utility and the generator system match.
- Perform a complete assessment of the facility grounding system and correct deficiencies as required.
- Ensure compliance with code-required working clearances for all electrical equipment.
- Provide explosion-proof seals in accordance with NEC requirements.
- Utilize watertight splice kits for all splices located in handholes.
- Install all wiring/cabling in conduit.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.
- Seal all handhole conduit openings.
- Clean all electrical handholes of dirt, debris, and foreign materials.
- Maintain a stock of spare parts for electrical equipment.

- Train personnel at every opportunity in all aspects of theory, principles of operations, installation practices, maintenance, and troubleshooting.
- Consider installing Transient Voltage Surge Suppressors (TVSS) at the service entrance equipment.
- Install fuses on all fusible disconnect switches. Consider utilizing non-fusible disconnect switches where possible. Where protection is required, consider providing enclosed circuit breakers.
- Consider installing provisions for connection of a portable generator system where a backup generator system is not necessarily required.
- Replace all lighting with an energy-efficient lighting system.
- Provide an automatic control system with manual override for exterior lighting.
- Install generators on concrete pads and provide vibration isolators.

Force Mains

- Collect field information for Lift Stations W-3 and W-10 as there is limited to no information available.
- Pressure test the old ACP force main at the A-1 Lift Station to verify its integrity. Until this test is done and depending on the results, further use of this old ACP force main is not recommended.
- Embark on a customer connection program to aggressively connect those customers who are most accessible to the southern area of the Sadog Tasi system (S-10, S-11, and S-12 Lift Stations) where there is carrying capacity available.
- Pressure-test the force main at the S-3 Lift station.

Wastewater Treatment Plants

General Recommendations

- Document plant data by logging key operational information and process parameters to aid future operators in terms of understanding and operating the system.
- Develop a training program for plant operators and implement changes to the personnel system to recognize and reward staff who reach specified education and certification milestones.
- Improve the inventory and tracking system for tools and equipment, and build a stock of required tools to facilitate regular and efficient maintenance work.
- Ensure nameplates for equipment are correctly labeled.
- Monitor and control the brine discharge into the sewage system.
- Continue using aerobic digestion as the stabilization process for both WWTPs.

NPDES Permits

Sadog Tasi WWTP

- Conduct quarterly water column monitoring.
- Widen the existing range of pH limit values (7.4 to 8.6) to be more consistent with that for Agingan WWTP, which has an allowable range of 6 to 9.
- Consider the use of a higher dilution factor to address *Enterococci* values.

- Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.
- Review the permit requirement to achieve 85 percent or more reduction in influent BOD and TSS concentrations.

Agingan WWTP

- Propose the use of *Hyalella azteca* as the only species for WET testing as *Daphnia magna* is a freshwater species not suitable for a saline environment.
- Consider the use of a higher dilution factor to address *Enterococci* values.
- Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.
- Review the permit requirement to achieve 85 percent or more reduction in influent BOD and TSS concentrations.

Sadog Tasi WWTP

- Allocate resources to collect and review operational data such as dissolved oxygen (DO) measurements, mixed liquor suspended solids (MLSS) concentrations, sludge recycle and wasting rates, and sludge solids content.
- Maintain a DO of 1 mg/L in the last basin before the clarifier so that denitrification does not occur in the clarifier, causing a rising sludge blanket.
- Configure sludge transfer from the aerobic digester to the belt filter press (BFP). Continue thickening the digested sludge as long as the operational issues with sludge pumping can be overcome (e.g., by drilling more holes into the suction pipe).
- Add a disinfection step to achieve the *Enterococci* limits in the permit based on the current plant treatment processes alone. Alternatively, a revision of the NPDES permit for Sadog Tasi that accounted for dilution at the outfall would allow for consistency with standard EPA guidance and place the plant into compliance.

Agingan WWTP

- Install a flow meter within the plant to record total plant flow.
- Operate with one aeration basin under current conditions.

Saipan Harbor Outfall

- Perform maintenance on the outfall and diffuser section, which should include replacing the broken clamping strap and the corroded anchor cable on the diffuser section, and clearing all marine growth and other debris from the diffuser risers.
- Fit all six riser ports with Tideflex check valves.
- Install a seventh port fitted with a Tideflex check valve on the diffuser endgate to provide additional flow capacity as well as prevent buildup of sediment in the diffuser section.

Future Loading

Reevaluate future wastewater flows in 5 years to determine whether bottleneck conditions continue to exist.

Unsewered Areas

- Regularly sample drinking water wells, especially wells where there has been a lack of monitoring, to document nitrate concentrations.
- Focus sampling in areas within a specified radius of drinking water wells considered “hot.”
- Study septic discharge from homestead areas.
- Conduct a Groundwater Under Direct Influence (GWUDI) study in unsewered areas.
- Study projected future impacts of increased homesteading with and without the benefit of a sewer system.
- Identify effluent sources by utilizing chloroform deoxyribonucleic acid (DNA) polymerase chain reaction (PCR) chromatography methodology and specific genetic markers for human, bovine, avian, or other DNA.
- Conduct a comprehensive study of the potential impacts of septic systems on drinking water quality and stormwater discharge and impacts on the reef and other near-shore marine life.

Recommendations to address the nitrate concentrations in the Isley wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.
- Conduct a detailed groundwater study of the Isley Wellfield.
- Based on the results of the groundwater study, consider elevating the priority for installation of a gravity collection system within the Dan Dan Homestead.
- Connect homes and businesses along Tun Herman Pan Road (Dagu area) that are not presently connected to the sewer system.
- Once feasible, reduce production within the Isley wellfield, particularly from the northern and eastern rim wells that have the highest levels of nitrate.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.
- Consider additional treatment to continue use of the well field if the blended water supply starts to reach the MCL level for nitrate.

Recommendations to address the nitrate concentrations in the Obyan wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.

Recommendation to address the nitrate concentrations in the Koblerville wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.

Recommendations for all wells where nitrate monitoring is occurring:

- Review nitrate concentrations at each well as the samples are analyzed to determine whether nitrate concentrations are increasing over time.

- Evaluate unsewered areas in order of priority to determine the source of water contamination. The order of priority for these areas is as follows:
  1. Isley
  2. Kagman
  3. Obyan
  4. Koblerville
  5. San Vicente/As Lito/Dan Dan
  6. Central Well Fields
  7. Northern Well Fields
- Implement the recommendations from the Allied Pacific Environmental Consulting (APEC) report (2011):
  - Conduct a 12-month spatial sampling program of agricultural and drinking water wells, especially for wells where there is a lack of data.
  - Continue to sample quarterly at wells of concern and seasonally for all other wells in the same area where there are wells of concern until the 12-month sampling plan is developed and implemented. No additional nitrate sampling is necessary in the central and northern well fields no additional nitrate sampling is necessary.
  - Conduct additional focused sampling for twelve months in areas within a certain radius of wells considered hot based on the 12-month spatial sampling program.
- Recommend that DEQ consider developing and adopting a comprehensive onsite wastewater disposal management approach that oversees the full range of issues related to the widespread use of septic systems: planning, siting, design, installation, operations, monitoring, and maintenance.

GIS Use and Operation

- Update the GIS when major or significant system components are replaced or added.
- Survey, map, and document by title or written declaration CUC ownership of all easements, right-of-way corridors, and real estate (land parcels) on public lands containing CUC water system assets. The following process is recommended for documenting CUC's real property interests utilizing the GIS program where appropriate:
  - Meet with the Department Public Lands (DPL) to discuss CUC's real estate ownership goals, intention to seek titles to real properties containing CUC water (and wastewater) system assets, and the process to achieve these requirements.
  - Establish a prioritized list of CUC water system assets by island that need real estate ownership documentation, keeping DPL in the information loop.
  - Determine the general real estate requirements for each prioritized asset, such as parcel size and easement/right of way width.
  - Using the GIS program/database, generate a conceptual layout of the real estate requirements of each water system asset (in order of priority for documentation).

  - Submit partial requests (demands) to DPL for survey, mapping, and grant of title to the real property or declaration of easement/right of way containing each CUC water system asset. CUC requests should be made in manageable increments in consultation with DPL and in the predetermined order of priority for real property ownership documentation.
  - Provide for the orderly filing of real property information at CUC and for the input and maintenance of the real estate information in the GIS program database.

Risk Assessment

- Continue to ensure that critical system knowledge is recorded and stored such that any new employee can easily access and understand the information.
- Update the asset hierarchy at the same time new information is obtained or as assets are improved upon or removed from the system.
- Review and revise as necessary the asset hierarchy every year; review likelihood of failure (LOF) scores annually as well.
- Review consequence of failure (COF) scores every 3 to 5 years to ensure levels of service have not drastically changed.

Organizational Structure

- Continue to refine the Engineering function under the direction (and office) of the Chief Engineer.
- Integrate the Water Task Force into the water and wastewater engineering support groups under the Chief Engineer while maintaining 24-hour water for all customers as a key mission and goal.
- Place the GIS and modeling functions under the direct supervision of the Chief Engineer and managed by one staff member trained in GIS and systems modeling.
- Assign an engineer whose dedicated, primary duty is to provide engineering support to water and wastewater systems operations.

Resident Professional and Technical Workforce Development and Training

- Identify current CUC employees who have demonstrated a high potential for advancement to professional, technical, or high-level operational positions required for the management and operation of CUC’s water and wastewater systems; develop and implement a program customized for each candidate to pursue a targeted, high-level position.
- Identify and contact professionals and technicians who were former CNMI residents and recruit those who indicate a desire to relocate back to the CNMI.
- Track local islanders who are pursuing higher education on the U.S. mainland or elsewhere and target them for incentivized recruitment efforts.
- Offer internships to CNMI students seeking higher education abroad and who wish to spend summers in the CNMI in CUC Engineering and Operations.
- Visit local high schools during “Career Day” to promote employment at CUC as a career opportunity under various professional, technical, and operations positions.
- Approach Northern Marianas College to develop a technical curriculum for current and prospective CUC employees.
- Conduct periodic training workshops for all CUC engineers and engineering technicians on the capabilities and features of the GIS and system modeling programs.

Dealing with Absenteeism

- Educate and support middle and lower level supervisors regarding attendance policies and enforcement.
- Discontinue “sick leave” accruals and adopt the more common Paid Time Off or Personal Leave concept.
- Revise the Reduction in Force (RIF) approach to favor/give preference to retaining employees based on merit rather than seniority.
- Conduct “all hands” meetings to address common issues.

Elevating the Standard of Level of Care of CUC Facilities

- Develop and post written guidelines and performance standards defining the minimum level of care required at CUC facilities.

Summary

The Saipan Wastewater Master Plan provides a comprehensive evaluation of the condition of existing assets, assesses the hydraulic capacity of the wastewater collection system to reduce dry and wet weather overflows, identifies how NPDES discharge requirements can be met, creates a 20-year CIP with an implementation schedule, and identifies a number of recommended operational practices for CUC to consider incorporating into its wastewater program. The CIP assumes that EPA SRF funding will be available and will decrease over time. This assumption was based on the Master Plan companion document, the “Financial Plan for Drinking Water and Wastewater Systems,” which clearly demonstrated that the citizens of Saipan, Rota, and Tinian do not have any additional capacity with which to absorb additional utility costs based on the ratio of utility bills to revenue. This situation will continue until there is a significant improvement in the overall economies of the three islands.

The EPA SRF grants for drinking water and wastewater projects are in a single fund, which allows CUC to prioritize how the dollars are allocated between the two CIP programs. The four 5-year CIP implementation schedules for the drinking water and wastewater systems assume that the fund will be allocated equally. If a situation arises where there is an urgent unmet need in one of the CIP programs, CUC, with concurrence with DEQ and EPA, should have the right to reallocate funds to meet this unexpected need. Any additional non-EPA grant funds that CUC obtains will be used based on the conditions of the specific grant and, if the grant is flexible in its application, if flexibility allows will allow the current CIP programs to be expedited.

The goal of the Wastewater Master Plan is to provide a cost-effective and implementable roadmap to upgrade, expand, and maintain the wastewater system; meet permit requirements; and plan for future growth. The two biggest constraints to the speed in which this Master Plan will be implemented will be available funding and political support, both which are out of the control of CUC. CUC staff are highly capable in all aspects of the drinking water system from design to operations and maintenance, so with adequate funding and local political support the future of the wastewater system in Saipan is very bright.

Structure of the Master Plan

This Wastewater Master Plan for Saipan provides the details associated with the information presented in this Executive Summary:

- Section 1 introduces the document and provides background information.
- Section 2, titled "Project Scope," is a detailed discussion of each of the items specified in the project scope that highlights key tasks and activities.
- Section 3 provides information collected or developed to supplement the items described in Section 2, with the intended result being a more complete and accurate Master Plan.
- Section 4 describes the Master Plan itself, summarizing the Stipulated Order requirements, proposed planning and design criteria moving forward, and ultimate recommendations that address the Stipulated Order requirements and achieve the planning and design criteria.

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Acronyms and Abbreviations

°C	Degrees Celsius
AC	Asbestos cement
AACE	Association for the Advancement of Cost Engineering
ACM	Asbestos cement pipe
ADCP	Acoustic Doppler Current Profiler
AMWA	Association of Metropolitan Water Agencies
AOR	Actual oxygenation rate
APEC	Allied Pacific Environmental Consulting
AST	Aboveground storage tank
ATS	Automatic transfer switch
BFP	Belt filter press
BOD	Biochemical oxygen demand
BPS	Booster pump station
CCTV	Closed-circuit television
CDP	Census Designated Place
CFU	Colony-forming units
CIP	Capital Improvement Plan
Cl	Chlorine
cm/s	Centimeters per second
CMU	Concrete masonry unit
CNMI	Commonwealth of the Northern Marianas
COF	Consequence of Failure
CORS	Continuously operating reference stations
CPES	CH2M Parametric Estimating System
CUC	Commonwealth Utility Corporation
CW	CNMI-Only Transitional Worker
DCA	Dueñas Camacho & Associates, Inc.
DEQ	Division of Environmental Quality
DIA	Diameter
DNA	Deoxyribonucleic acid
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
F/M	Food-to-microorganism ratio

FEMA	Federal Emergency Management Agency
FOG	Fats, oils, and grease
FSS	Flocculated suspended solids
ft	Foot, feet
GIS	Geographic information system
GPD	Gallons per day
gpm	Gallons per minute
GPS	Global positioning system
HDPE	High-density polyethylene
HID	High-intensity discharge
HP	Horsepower
HRT	Hydraulic retention time
I/I	Inflow and infiltration
in	Inch
IPS	Influent pump station
IWA	International Water Association
IWDS	Individual wastewater disposal system
lb	Pound
LOF	Likelihood of Failure
LOS	Level(s) of service
m/s	Meters per second
MCC	Motor control cabinet
MG	Million gallons
mg/L	Milligrams per liter
mgd	Million gallons per day
MLSS	Mixed liquor suspended solids
MMC	Motor control center
MT	MultiTrode
MVA	Marianas Visitors Bureau
NA	Not Applicable
NDPES	National Discharge Pollutant Elimination System
NEC	National Electrical Code
NH_3	Ammonia
NO	Not operational
NO_3	Nitrate

NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity unit
O&M	Operations and maintenance
O_2	Oxygen
P	Phosphorus
PCR	Polymerase chain reaction
ppt	Parts per thousand
Pro2D	Professional Process Design
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
RAS	Return activated sludge
RC	Reinforced concrete
SAP	Sampling and Analysis Plan
SCADA	Supervisory control and data acquisition
SDW	Safe Drinking Water
SOP	Standard operating procedure
SOPAC	Pacific Islands Applied Geosciences Commission
SOR	Standard oxygenation required
SOTE	Standard oxygen transfer efficiency
sq. ft.	Square feet
SRT	Solids retention time
SS	Stainless steel
SSF	Slow sand filter
SSO	Sanitary sewer overflow
SVI	Sludge volume index
TDH	Total dynamic head
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TM	Technical memorandum
TSS	Total suspended solids
TVSS	Transient voltage surge suppressors
USCIS	U.S. Citizenship and Immigration Services
V	Volt
VC	Vitrified clay
VFD	Variable frequency drive

VSS	Volatile suspended solids
WAS	Waste activated sludge
WET	Whole effluent toxicity
WQ	Water quality
WW	Wastewater
WWTP	Wastewater treatment plant
ZID	Zone of initial dilution

SECTION 1
Project Information

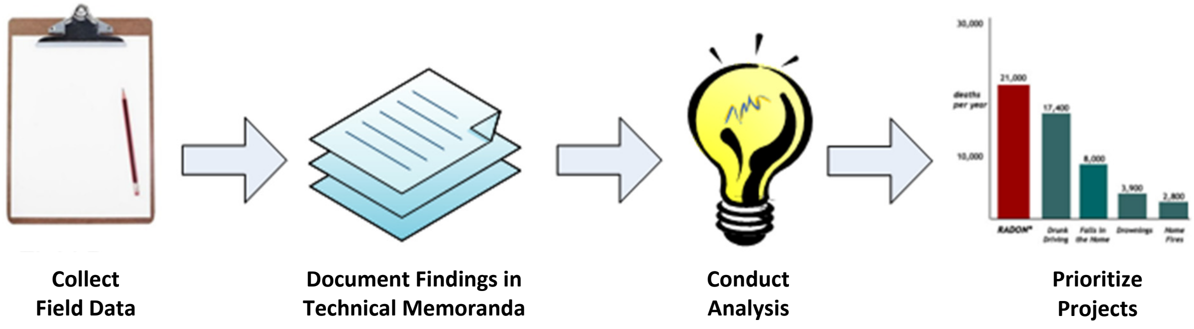
1.1 Background

The Commonwealth Utilities Corporation (CUC) was formed in the late 1980s, at which time it took over the Commonwealth of the Northern Mariana Islands' (CNMI's) water and wastewater utilities operation from the Department of Public Works (DPW) for the purpose of managing the utility programs and services. From the time CUC received the wastewater infrastructure, extensive problems have existed with the system infrastructure, including excessive sewer overflows during dry and wet periods, and underfunded operational budgets. In 2008 the U.S. Environmental Protection Agency (EPA) and CUC entered into Stipulated Order Number One for Preliminary Injunctive Relief (Civil Case No. CV 08-0051). The Stipulated Order required, in part, that CUC develop and submit for EPA approval a comprehensive drinking water and wastewater Master Plan to determine current and future infrastructure needs for a 20-year period and to provide a long-term master plan for CUC drinking water and wastewater system improvements for the three major islands of CNMI: Saipan, Rota, and Tinian.

1.2 Introduction

This document is intended to fulfill one of the requirements of Stipulated Order Number One. This Master Plan focuses on findings and recommendations for the wastewater system on the island of Saipan. (Findings and recommendations for Tinian and Rota have been submitted as separate standalone Master Plans.) The individual technical memoranda (TMs) that were compiled to form this Master Plan were part of an overall process that began with gathering raw data from field assessments, information requests, and knowledge transfer from CUC. After the initial data collection phase, the next step was processing the raw data into organized information in TM format. The information was in turn analyzed using a variety of techniques. The output of the analytical process was consolidated into a list of potential projects. The projects were ranked using criteria that conformed to EPA project prioritization requirements and CUC business objectives. Figure 1.2-1 provides a graphical representation of that process.

Figure 1.2-1. **Master Planning Process**



SECTION 2

Project Scope

The contents of Section 2, “Project Scope" are as follows:

2.1 Chartering Meeting

On August 22, 2011 a chartering meeting was held at CUC's Dan Dan office to kick off the Master Plan project. Those in attendance at the chartering meeting included CUC management, engineering, field, operational, and laboratory staff members. Also in attendance were members from the Master Plan consulting team (project team) including project management and support staff from Dueñas, Camacho & Associates (DCA), CH2M, EMCE Consulting Engineers, and EFC Engineers & Architects. The primary objectives for the chartering meeting were to introduce the consulting team to CUC staff; gain a common understanding of the project objectives; review the scope of work, deliverables, and schedule; and discuss CUC's expectation and desired outputs from the project.

The chartering meeting was held during the initial 2 weeks of field inspections that were performed by the project team with the assistance from CUC engineering and operations staff members. Initial results from the field findings, particularly with regard to lift station and drinking water well and booster station inspections, were also presented during this chartering meeting.

The agenda for the meeting includes the following items:

- Team Introductions/Attendance Roster
- Scope of Work
- Project Schedule and Milestones
- First 90-Day Activities
- Well Inspection Preliminary Results
- Identification of Problem Areas System-wide
- CUC Expectations

Key points discussed during the chartering meeting are summarized below:

- The Master Plans will be developed with an eye toward providing dual benefits to CUC, that is, not only will the Master Plans meet Stipulated Order requirements, but they will also, for example, assist with operational improvements and reduce cost of operations.
- The Financial and Rate Impact Analysis and Financial Plan will help to pair capital improvement projects with available funding sources. The project team will meet with the Water Task Force (WTF) to gather information for use in constructing a Master Plan that does not duplicate ongoing WTF projects and integrates existing and planned work that is consistent with the conclusions of the planning study.
- Possible funding sources for CUC may include the U.S. Departments of Homeland Security, Housing and Urban Development, Commerce, and Agriculture, as well as the EPA. For the purposes of this Master Plan and potential funding sources for capital improvements, only the EPA SRF grant funding was considered. Additional grants from other sources will provide CUC with the flexibility to increase the speed of implementing the Master Plan or fund unanticipated needs.

The initial results of the condition assessment inspections for lift stations that were presented at the chartering meeting are discussed in detail in the condition assessment section of this Master Plan.

CUC staff discussed their expectations for the Master Plan project, as summarized below:

- As required by the National Environmental Policy Act, all recommendations must demonstrate a real need and not be recommended solely to satisfy the Stipulated Order.
- The existing water basemap will be updated and a new wastewater basemap will be developed.
- All recommended projects must be vetted by CUC staff prior to inclusion in the final Master Plan.
- Development of a dynamic and relevant Master Plan will require regular interaction between the project team and CUC staff. The project team will need continued support from the plant operators as well.

2.2 Wastewater Infrastructure System Condition Assessment

This section includes the following subsections:

- 2.2.1, Literature Review
- 2.2.2, Inspection and Condition Assessment and Capacities of Existing Wastewater Collection Facilities
- 2.2.3, Inspection and Condition Assessment and Capacities of Existing Wastewater Treatment Plant Facilities
- 2.2.4, Saipan Harbor Outfall Dilution Study
- 2.2.5, Agingan Outfall Assessment
- 2.2.6, Wastewater Collection System Hydraulic Model
- 2.2.7, Unsewered Areas Condition Assessment
- 2.2.8, Geographic Information System Application and Development
- 2.2.9, Asset Risk Assessment for Commonwealth Utilities Corporation Wastewater System

2.2.1 Literature Review

Table 2.2.1-1 provides a list of documents reviewed as part of Master Plan development. This section also provides a summary of information gathered during meetings.

Table 2.2.1-1. **Literature Review for Wastewater**

Document	Prepared by	Year
CUC-RFP-11-007	CUC	2010
Pre-Design Report for Southern & Central Sanitary Sewer Systems	Winzler & Kelly	2001
Feasibility Study: Privatisation of Various Utilities of the Commonwealth of the Northern Mariana Islands	CH2M	1997
Management Audit of the CUC	Metzler	1994
Saipan Wastewater Facilities Master Plan	DCA & CH2M	1993
Stipulated Order No.1	EPA	2008
Electric, Water and Wastewater Rate Study	Economist.com	2007
Final Value Engineering (VE) Study for Kagman Wastewater Treatment and Collection System	Earthtech	2005
Northern Mariana Islands Administrative Code (NMIAC) - CUC	Commonwealth Utility Corporation (CUC)	2004
Rainfall Climatology for Saipan	Water and Environmental Research Institute	2004
Kagman Sewer Collection System (Phase 1 and 2)	SSFM	2003
Summary of OSDS Survey for Kagman and Dan Dan	CNMI Division of Environmental Quality (DEQ)	2010
Commonwealth of Northern Mariana Islands Wastewater Treatment and Disposal Rules and Regulations	DEQ	2004
Kagman and Dan Dan Wells Nitrate/Nitrite Data Analysis	APEC	2011

Table 2.2.1-1. **Literature Review for Wastewater**

Document	Prepared by	Year
Spatial and Temporal Nitrate Variations in Groundwater from Southern Saipan Project Synopsis Report	DEQ & CUC	2009
Commonwealth of Northern Mariana Islands Drinking Water Regulations	DEQ	2005
Northern Mariana Islands Administrative Code, Chapter 65-120, Part 1000 “IWDS and OWTS Siting Criteria”	DEQ	2004
Predicting Ground-Water Nitrate-Nitrogen Impacts	N.N. Hantzsche and E.J. Finnemore	1992
Wastewater Engineering: Treatment and Reuse, 4th Ed.	Metcalf & Eddy	2003
University Curriculum Development for Decentralized Wastewater Management – Onsite Nitrogen Removal	S. Oakley	2004
Nitrate-Nitrogen Concentrations in the Northern Guam Lens and Potential Nitrogen Sources	Mauryn Quenga-McDonald	2002
Decentralized Systems Technology Fact Sheet: Septage Treatment/Disposal	EPA	1999
Decentralized Systems Technology Fact Sheet: Septic Tank – Soil Absorption Systems	EPA	1999
Seepage Pits may Endanger Groundwater Quality	EPA	2001
Source Water Protection Practices Bulletin: Managing Septic Systems to Prevent Contamination of Drinking Water	EPA	2001
Groundwater Resources of Saipan, Commonwealth of the Northern Mariana Islands	U.S. Geological Survey	2003
CUC Sadog Tasi Wastewater Treatment Plant Operation and Maintenance Manual	Winzler & Kelly & Belt Collins, updated by Aqua-Aerobic Systems	1999 (updated 2011)
Sadog Tasi WWTP NPDES Permit MP0020010	EPA	2007
Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms	EPA	2002
Manual on the Causes and Control of Activated Sludge Bulking and Foaming, 2nd Edition	D. Jenkins, M.G. Richards, G.T. Daigger	1993
CUC Agingan Wastewater Treatment Plant Operation and Maintenance Manual	Dames & Moore Consulting Engineers, updated by CUC	1995, updated 2011
Agingan WWTP NPDES Permit MP0020028	EPA	2009
10-States Standards	Wastewater Committee of the Great Lakes--Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers	2004
Technical Support Document: Landfilling of Sewage Sludge	EPA	1988
NPDES Discharge Monitoring Reports	CUC Laboratory	2009-2012
Technical Support Document for Water Quality-based Toxics Control	EPA	1994
Amended Section 301(h) Technical Support Document	EPA	1994
National Recommended Water Quality Criteria Table	EPA	2012

Table 2.2.1-1. **Literature Review for Wastewater**

Document	Prepared by	Year
Oceanographic Survey, Shoreline Mapping and Preliminary Hydrodynamic Modeling Report, Saipan, Commonwealth of the Northern Mariana Islands	J. Kruger, S. Kumar, H. Damlamian, A. Sharma	2010
Northern Marianas Islands Administrative Code	DEQ	2004
California Department of Public Health Regulations (Title 22)	California Department of Public Health	2009
CNMI Construction Grant Priority System		
2012 CUC Clean Water Priority Listing (SRF Priority Projects)	CUC	February 2012
CNMI Integrated 305(b) and 303(d) Water Quality Assessment Report	DEQ	2010
Historical Air Force Construction Handbook	Air Force Civil Engineer Support Agency	2007
CUC As-Builts	Various	Various

Information-Gathering Meetings

In addition to the literature review, a great amount of information on the history of CUC's infrastructure and details on the ways in which CUC's systems are currently maintained and operated was obtained through regular communications with CUC, CNMI Division of Environmental Quality (DEQ), and EPA. Throughout the life of the Master Planning project, numerous in-person meetings, conference calls, webinars, workshops, and site visits acted as avenues to collect this type of information; Table 2.2.1-2 provides a list of these information-gathering meetings.

Table 2.2.1-2. **Summary of Information Gathered**

Meeting Subject	Topic(s) Covered	Parties Involved	Date
Site Visits	Condition Assessment Inspections of lift stations, wells, booster stations, slow sand filter, WWTPs	CUC, Project Team	August 2011
Chartering Meeting	Project Kickoff, Initial Condition Assessment Findings	CUC, Project Team	8/22/11
Financial Planning Webinar	Financial Planning	CUC, Project Team	9/18/11
Risk Assessment Workshops	Asset inventory, asset risk scoring	CUC, DEQ, Project Team	October 2011
Slow Sand Filter TM Review Conference Call	Slow Sand Filter	CUC, Project Team	12/23/11
Slow Sand Filter Phone Call	Slow Sand Filter	Kerry Meyer (CH2M HIL), Travis Spaethe (formerly CUC)	12/28/11

Table 2.2.1-2. **Summary of Information Gathered**

Meeting Subject	Topic(s) Covered	Parties Involved	Date
Workshops	Review of work in progress: GIS, water and wastewater models, SSF, population projection, GWUDI, outfall mixing study, WWTP assessment Groundwater data review with DEQ Identification of water and wastewater CIP project scoring criteria and development of complete project lists Flow meter relocation	CUC, DEQ, Project Team	2/18/12 – 3/2/12
Workshops	Review of water and wastewater models; review of water and wastewater project scoring criteria; GWUDI site visits; CIP project scoring for water and wastewater	CUC, DEQ, WTF, Project Team	6/4/12 – 6/15/12
Unsewered Areas Analysis Webinars	Review on Unsewered Areas Analysis	CUC, Project Team	8/23/12, 12/5/12
Project Prioritization Webinar	Selection of projects for cost development, and eventual inclusion in CIP	CUC, Project Team	10/25/12
Response to EPA Comments Conference Call	Reviewed project team's responses to EPA comments on Work In Progress Master Plan document	CUC, EPA, Project Team	11/8/12
CIP Project Cost Estimation Webinar	Reviewed cost estimation methods for CIP projects	CUC, Project Team	11/8/12
Workshops	GWUDI determination; review of water and wastewater CIP project cost estimates; development of CIP implementation schedule; financial model; organizational management interviews; leak detection data gathering	CUC, DEQ, WTF, Project Team	12/3/12 – 12/14/12

2.2.2 Inspection and Condition Assessment of Existing Wastewater Collection Facilities

The project team performed field condition assessments of the existing wastewater collection facilities in August 2011. The purpose of the condition assessments was to identify defective or deteriorated system components in need of repair, rehabilitation, or replacement. The wastewater collection system condition assessment included the following elements:

- Sewer pipe via closed-circuit television (CCTV) inspections
- Lift stations (wet well and pumps)
- Force mains
- Screen conditions
- Generator conditions
- Lift station housings
- Lift station electrical/controls
- Lift station appurtenances (e.g., valves, flow meters, etc.)

Findings from the inspection and condition assessment of wastewater collection system facilities were used in conjunction with other information gathered during the master planning efforts to identify operational improvements and capital improvement projects to include in the Capital Improvement Plan (CIP). Findings documented in the condition assessment inspections were also utilized in the asset risk assessment process to quantify the physical condition of all assets based on specific criteria developed by CUC and the project team. This section discusses the condition assessment methodology, findings, and recommendations.

Existing Wastewater Collection Facilities Inventory

The existing wastewater collection facilities include infrastructure upstream of the treatment facilities. This infrastructure, which includes 64 miles of gravity sewer and 43 lift stations (of which 42 are active), force mains, generators, and pump station buildings, are owned and operated by CUC. The age of this infrastructure ranges from over 50 years to less than 5 years. The sewer lift stations all contain submersible-type pumps. Various configurations of the lift stations range from small communal lift stations that sewer four to ten homes up to the large terminating lift stations that sewer an entire sewer collection basin.

For the purpose of this Master Plan, the sewer collection system was divided into two service areas: Sadog Tasi and Agingan. Each service area is further divided into sewersheds. Additional information on the sewersheds is provided in the hydraulics section (Section 2.2.6) of this Master Plan.

The Sadog Tasi service area contains 34 miles of sewer line and 18 lift stations. Table 2.2.2-1 lists the lift stations in this service area by identification number, locations, the date the lift station was assessed by the project team, and whether an inlet screen was present. Appendix A, Wastewater Collection System Map, displays these lift station locations on a map of Saipan.

Table 2.2.2-1. **Sadog Tasi Lift Station Assessment Details**

Lift Station ID	Location	Date Assessed	Inlet Screen?
SR-2	Marpi	8/25/11	No
SR-1	San Roque	8/25/11	Yes
SR-3	Aqua Resort	8/25/11	No
T-1	Tanapag	8/23/11	No
T-2	Tanapag	8/23/11	No
S-1	Lower Base	8/22/11	No
S-2	Garapan	8/23/11	No
S-3	Lower Base	8/22/11	Yes
S-4	Garapan	8/23/11	No
S-5	Garapan	8/23/11	No
S-6	Gualo Rai	8/23/11	Yes
S-8	Garapan	8/23/11	No
S-9	Garapan	8/23/11	No
S-10	Beach Road	8/25/11	No
S-11	Beach Road	8/25/11	No
S-12	Beach Road	8/25/11	No
T-3	Power Plant	8/22/11	No
TAM	Lower Base	8/25/11	No

The Agingan service area contains 30 miles of sewer lines and 25 lift stations. Table 2.2.2-2 lists the lift stations in this service area by identification number, locations, and the date the lift station was assessed by the project team, and whether an inlet screen was present. Appendix A, Wastewater Collection System Map, displays these lift station locations on a map of Saipan.

A generator is located at each lift station, with the exception of A-6 and A-8, for emergency standby power; the generator was inspected as part of the lift station condition assessment process in addition to the force mains, valves, electrical and control equipment, and screens when they were present at lift stations.

Table 2.2.2-2. **Agingan Lift Station Assessment Details**

Lift Station ID	Location	Date Assessed	Inlet screen
W-6	Chalan Kiya	8/23/11	No
W-5	San Jose	8/23/11	Yes
W-4	San Jose	8/23/11	No
A-7	San Jose	8/23/11	No
A-6[a]	Susupe	8/25/11	No
A-5	Susupe	8/25/11	No
A-11	Susupe	8/23/11	No
A-9	Chalan Kanoa	8/25/11	No
A-8[a]	Chalan Kanoa	8/24/11	No
A-10	Chalan Kanoa	8/24/11	No
A-4	Chalan Kanoa	8/25/11	No
A-3	San Antonio	8/24/11	No
A-2	San Antonio	8/24/11	Yes
A-1	Agingan	8/24/11	Yes
A-16	Agingan	8/24/11	Yes
A-13	Airport	8/24/11	Yes
A-14	Airport	8/24/11	Yes
W-9	Dan Dan	NA	No
W-7	Dan Dan	NA	No
W-10	Dan Dan	8/24/11	No
W-8	Finasisu	8/23/11	No
A-15	As Lito	8/24/11	Yes
A-12	Totoville	8/24/11	Yes
W-3	Koblerville	8/25/11	No
W-11	Koblerville	8/23/11	No

[a] All lift stations have a generator installed with the exception of lift stations A-6 and A-8.

The follow sections provide site-specific information collected as part of the wastewater infrastructure assessment.

Field Condition Assessments and Data Gathering Methodology

The condition of the collection system was determined by reviewing the age of the collection system, known failures, flow metering, field inspections, and conducted limited CCTV inspections. Personnel from the project team, together with CUC personnel, visited 42 pump stations over the course of 4 days from August 22 through August 25, 2011. Following the site visits, Over 10,000 feet of collection system was inspected using CCTV. A review of the as-built drawings and Geographic Information System (GIS) data was used to determine the pipe age and type. Interviews with CUC operations staff and engineers were conducted to determine known points of failure at the lift stations and throughout the collection system.

The results of these field condition assessments are qualitative; assignment of quantitative scores for the physical condition, likelihood of failure, and overall risk of failure for all wastewater system assets was accomplished during the risk assessment workshops (see Section 2.2.9). The qualitative findings from the condition assessments were an important piece of information used by the project team, in conjunction with CUC input and hydraulic modeling results, in developing the numeric risk scores.

Lift Station Condition Assessments

CUC conducted a series of inspections at each of its lift stations throughout March 2011. Information on the pump brands, horsepower, generator models, wet wells, and sites was noted and the data entered on a spreadsheet. A copy of this spreadsheet is provided in Appendix B. The project team has referred to this spreadsheet to obtain information on the pumps and motors.

Lift Station Site Access

Access into the site, generator room, valve pits, wet wells, control panels, upstream manholes, downstream manholes, screening pits, and metering pits was provided to the project team by CUC personnel during normal working hours. CUC personnel provided access to each pump station control panel and engaged each pump station generator (when operable). When inspecting the electrical equipment, control panels, and generators, qualified CUC personnel were on site to ensure safety while the project team worked near electrical equipment. Additional CUC personnel were present when traffic control was needed.

Lift Station Assessment Methodology

The project team typically consisted of four personnel (two civil engineers, one structural engineer, and one electrical engineer). Three to four CUC personnel assisted the project team by pumping down each wet well so that the condition of the wet wells and pumps could be visually inspected. Two pump stations, W-9 and W-7, are no longer in use by CUC and thus were not inspected. Two pump stations, T-1 and TAM, had pumps that were not in operation at the time of the site visit.

The force mains were visually inspected at readily accessible areas such as valve pits and, in a few cases, points of termination (i.e., discharge manholes). The project team did not excavate to visually inspect any of the force mains. Information on the force mains was gained through visual assessment of the valve pits and reviewing the as-built drawings and design plan information. Interviews with CUC operations staff and engineering were conducted to determine past failures of the force mains. In addition, hydraulic modeling was conducted to evaluate force main operating conditions.

Check valves have posed operational problems for the CUC operators. While most of the check valves were visually inspected, a few were located within a portion of a wet well that was obstructed from view. Additionally, at Check Valve W-10, the valve pit was buried and not readily accessible. Information on the pump station check valves that were inspected is presented in the site-specific findings presented later in this section and in the field inspections forms provided in Appendix C. Interviews with CUC operations staff and engineering were conducted to determine past failures of the check valves.

In the majority of cases the make and model of the check valves, isolation valves, pumps, and motors were not readily visible to the project team. In nearly all cases, the make and model information on these apparatuses was painted over and/or the tags were removed. Information on size and make of each valve was ascertained by the project team based on the nameplate, configuration and orientation of the valves. Information on the pumps and motors was ascertained through CUC records. Note that the assessment forms provided in Appendix C refer to a spreadsheet provided by CUC that lists pump and motor information. This spreadsheet is provided in Appendix B.

Several lift stations have a screening facility just upstream of the pumps to collect debris and reduce ragging in the pumps. The screens are installed in a screening pit, which required CUC staff assistance to gain access. Once screening pits were opened by CUC staff, the project team inspected the screens and the screen pit.

Structural inspections were performed during lift station inspections to document the structural integrity of the housing for electrical/control equipment and wet well, screening pit, and metering pit access/hatches.

Lift Station Field Inspection Forms

The project team used the inspection forms presented in Appendix C to record data collected during the lift station condition assessments, including the inspection of generators, electrical gear, controls, and screens. These forms were split into the following respective disciplines: civil, structural, mechanical, and electrical.

- The civil portion includes such items as site layout, site security, and surrounding vegetation.
- The structural portion includes the building envelope (if present), wet well dimensions and orientation, screen, access hatch(es), and ventilation.
- The mechanical portion includes the force main, isolation valves, check valves, generator fuel storage, pumps, and controls.
- The electrical portion includes the electrical service, main electrical, lights, and generator.

The project team completed the assessment forms and took photographs at each lift station site to document the condition of the assets. Interviews with CUC personnel were conducted on-site to ascertain pump information such as the number of pumps, operational issues, and common pump station problems. This information was added to the assessment forms.

At the end of each work day, the data from the hard-copy assessment forms were entered into an electronic version of the assessment form. All lift station inspection forms are included in Appendix C.

Assessment of Existing Sewer Collection System (Gravity Pipes)

The project team assessed gravity pipes in the existing wastewater collection system using the following approach:

- A GIS database was developed to categorize collection system age and material type. Further information about the GIS is located in Section 2.2.8.
- Discussions were held with CUC wastewater collection system operators to identify known problematic areas and areas of past failure.

- CCTV inspections were performed for over 10,000 feet of the collection system. The CCTV inspections were performed throughout the collection system and focused on the older asbestos cement (AC), vitrified clay (VC), and unknown material gravity pipes.

Collection System Characterization

Information gathered from the GIS and discussions with CUC was used to characterize the collection system pipes. Additionally, discussions with CUC staff allowed for a qualitative assessment of the condition of the collection system. Tables 2.2.2-3 and 2.2.2-4 present a breakdown of the pipe type and size in each service area based on the initial CUC as-built drawing review. Appendix A provides graphic depictions of collection system pipes by type. Maps that identify the location of asbestos cement pipe (ACM) and VCP pipe are also provided in Appendix A.

Table 2.2.2-3. **Sadog Tasi Service Area Pipe Type and Size Details (based on information in CUC as-builts)**

	Type					
Size (in)	**AC**	**Iron**	**PVC**	**RC**	**VC**	**Total (ft)**
6	493	2,968	7,170	-	7,324	**17,955**
8	534	-	73,864	379	13,604	**88,381**
10	137	580	19,197	-	4,626	**24,540**
12	3,140	1,426	21,592	-	3,536	**29,694**
15	1,936	9,534	-	-	-	**11,470**
18	-	-	823	-	-	**823**
20	-	-	889	-	-	**889**
21	-	-	2,066	-	-	**2,066**
24	-	-	5,129	-	-	**5,129**
36	-	-	-	132	-	**132**
Total (ft)	**6,240**	**14,508**	**130,730**	**511**	**29,090**	**181,079**

Table 2.2.2-4. **Agingan Service Area Pipe Type and Size Details (based on information in CUC as-builts)**

	Type					
Size (in)	**AC**	**Iron**	**HDPE**	**PVC**	**VC**	**Total (ft)**
6	18,518	-	-	1,847	261	**20,626**
8	22,088	-	-	31,000	1,821	**54,909**
10	16,622	30	-	6,981	853	**24,486**
12	-	-	-	10,590		**10,590**
15	-	-	-	12,161	16,380	**28,541**
18	-	-	-	6,849	-	**6,849**
20	-	-	-	172	-	**172**
21	-	-	-		-	**-**
24	-	-	1,329	13,765	-	**15,094**
36	-	-	-	-	-	**-**
Total (ft)	**57,228**	**30**	**1,329**	**83,365**	**19,315**	**161,267**

Over 60 percent of the entire CUC wastewater collection system is constructed of PVC pipe. Based on meetings with CUC operating and engineering staff, the PVC pipe is performing well, which is in line with common industry results for PVC pipe.

Approximately 20 percent of the entire CUC wastewater collection system is made up of AC pipe. AC pipe is found in Garapan, San Jose, Susupe, Chalan Kanoa, and San Antonio, and along Chalan Monsignor Guerroro Road. The AC pipe has met its life expectancy and is a known major point of failure within the wastewater collection system. Areas in Garapan, San Jose and along Chalan Monsignor Guerroro Road have all experienced a sewer line collapse in the last 10 years. Appendix A presents output from the GIS database that shows the locations of the AC sewer lines.

In contrast to AC pipe, approximately 14 percent of the CUC wastewater collection system is made up of VC pipe, including the main collection line along Beach Road (San Jose to San Antonio). This VC pipe is performing well with no documented failures. Appendix A presents output from the GIS database that shows the locations of the VC sewer lines.

The remaining potions of the CUC wastewater collection system are made up of HPDE, cast iron, and concrete pipe. There have been no known failures of pipe made with these material types.

CCTV Inspections

Due to the large amount of failure and the age of the pipe, special attention was given to the CCTV inspection of AC and VC pipe. Areas where inflow/infiltration (I/I) impacts are thought to be significant were also a focus of the CCTV inspections. Detry Plumbing conducted the CCTV inspections. Prior to conducting the inspection, the project team coordinated the locations to be inspected with CUC. (Appendix A presents the locations inspected with CCTV.) Detry Plumbing pressure-cleaned the pipes prior to performing the CCTV inspection. The CCTV inspection results and associated recommendations are summarized here:

- 1,300 feet of 15-inch PVC pipe was inspected in Tanapag, an area known to have I/I problems. This collection system was installed in the mid-1980s. The 10-inch PVC pipe was observed to be in good condition with no documented leaks or root intrusion. The manholes within this collection system are severely deteriorated and are in need of repair.
- 2,100 feet of 10-inch pipe was inspected in Capitol Hill. Upon inspection, it was determined that this area was not VC pipe as initially anticipated. It appears that this pipe is reinforced concrete. This area was initially chosen due to the pipe age (over 50 years old) and presumed material type. Root intrusion was identified in this collection system. The project team also noted inconsistencies with the as-builts on file. The project team updated the GIS to reflect the identified field conditions. It is recommended that CUC conduct routine maintenance of this collection system area.
- 2,000 feet of 12-inch AC Pipe was inspected in Garapan. As expected, this section of the collection system is in need of replacement. Sloughing off of the sewer line sides was observed. Accumulated pipe material and heavy grease buildup was also observed. The accumulated oil and grease is resulting in backwater effects and odor problems. Frequent cleaning of this area and replacement of the AC pipe is recommended.
- 1,200 feet of 8-inch PVC pipe was inspected in Garapan. This section of collection system was installed in the early 1980s. The section appeared to be in good condition with no observed oil and grease buildup or I/I concerns. An old hose was observed in the collection system and removed by Detry Pluming. The PVC pipe and manholes within the area are in good condition.
- 1,900 feet of 8-inch AC Pipe was inspected in San Jose. This section of the collection system was installed in the 1970s and is in need of replacement. Signs of past failure were observed. A portion of the AC pipe was previously replaced with PVC pipe. Sloughing off of the sewer line sides and accumulated pipe material were observed. Infiltration was observed at the manhole bases. Replacement of this AC pipe is recommended.
- 1,000 feet of 10-inch AC pipe was inspected in Chalan Kanoa. This section of the collection system was installed in the 1970s. Given the material type and age, this section of pipe appeared in fair condition with no observed I/I. It is recommended that CUC reinspect this area of the collection line in 5 years.
- 2,000 feet of 15-inch VC pipe was inspected in San Antonio along Middle Road. This clay pipe was installed in the 1970s and appeared to be in good conditions with no observed I/I. It is recommended that CUC reinspect this area of the collection line in 5 years.

The information collected during the CCTV assessment, field condition assessment, records review, and modeling were used to establish the following Asbestos-Cement Pipe Replacement schedule. This replacement schedule is intended to guide CUC though the replacement of dilapidated sewer lines:

- 8,200 feet of ACP within Garapan. This must also include the 1,500 feet of ACP forcemain from Lift Station S-5.
- 6,300 feet of ACP within San Jose.
- The ACP associated with the collection line along Chalan Monsignor Guerrero will be replaced under the As Terlaje Sewer line Upgrade and Lift Station elimination project.

The remaining ACP replacement will occur during the 20-year planning period of this Master Plan.

CUC has begun regular CCTV inspections of the remaining sections of the collection system. The information collected will be used to refine the locations in need of repair or replacement.

Assessment of Physical Condition of Lift Stations

Results of the lift station inspections are presented in the sections below. Site-specific information can be found later in this section.

Site Assessment

A brief narrative and a tabulated summary of the findings at each pump station is presented in the following subsections. The detailed inspection findings can be found in the site-specific inspection forms presented in Appendix C.

Civil

Most of the sites had a standard 4-inch mesh, 8-foot high chain-link fence with barbed wire. The sites were commonly overgrown with vegetation. There is no water service to many of the pump stations, making maintenance and cleaning difficult. Access hatches to the wet wells commonly use a square key to open, which provides a limited form of protection.

Wet Wells

Various types of wet well configurations were observed. Most of the lift stations within the Agingan collection system, particularly along Beach Road, were circular. Older lift stations within the Sadog Tasi collection system were square.

Most of the protective coatings in the wet wells have deteriorated or were not present. Hydrogen sulfide attack of the structure was also observed within many of the wet wells. Table 2.2.2-5 presents the findings of the wet-well coating inspections.

Table 2.2.2-5. **Status of Wet Well Coatings**

Pump Station ID	Current Status of Wet Well Coating
A-1	Partially Coated (95% deteriorated)
A-2	Partially Coated (95% deteriorated)
A-3	Partially Coated (50% deteriorated)
A-4	Partially Coated (95% deteriorated)
A-6	Partially Coated (95% deteriorated)
A-7	Partially Coated (75% deteriorated)
A-8	Partially Coated (85% deteriorated)
A-9	Partially Coated (95% deteriorated)
A-10	Partially Coated (75% deteriorated)
A-11	Partially Coated (75% deteriorated)
A-13	Partially Coated (95% deteriorated)
A-14	Partially Coated (95% deteriorated)
A-15	Not Coated
A-16	Not Coated
GR-1	Not Coated
S-1	Not Coated
S-2	Not Coated
S-3	Partially Coated (75% deteriorated)
S-4	Not Coated
S-5 (Hyatt)	Not Coated

Table 2.2.2-5. **Status of Wet Well Coatings**

Pump Station ID	Current Status of Wet Well Coating
S-8	Partially Coated (80% deteriorated)
S-9	Not Coated
S-10	Partially Coated (80% deteriorated)
S-11	Not Coated
S-12	Partially Coated (75% deteriorated)
SR-1	Not Coated
SR-2	Not Coated
SR-3	Partially Coated (95% deteriorated)
T-1	Partially Coated (85% deteriorated)
T-2	Partially Coated (30% deteriorated)
T-3	Unknown (wet well was full of wastewater at time of inspection)
W-3	Partially Coated (75% deteriorated)
W-4	Partially Coated (95% deteriorated)
W-5	Not Coated
W-6	Not Coated
W-8	Partially Coated (90% deteriorated)
W-10	Partially Coated (95% deteriorated)
W-11	Not Coated
W-12	Partially Coated (50% deteriorated)

Structural and Architectural

Most buildings were built using cast-in-place (CIP) concrete/concrete masonry unit (CMU) construction. Deficiencies commonly noted were damaged insect screens and cracking on wall penetrations. Spalling was noticed on the roofs of a few of the lift station facilities.

Most of the access hatches to the wet wells, particularly those within the road, were not properly rated for heavy traffic. Access hatch beam supports appeared to be insufficient and were corroded. Access hatch collars showed signs of spalling and cracking.

Pump System

The pump and motors range between 5 to 30 hp. Nearly all of the pump stations had only one pump and motor with no redundant second pump. The pumps assessed were all in operation, but the actual condition was not discernible. The project team used interviews and meetings with CUC operations and engineering personnel to gather information on the condition of the pump assets. The project team was able to inspect the control panels to verify the presence or absence of the pumps. Nearly all control panels were set up for two pumps, but only one pump was wired to the control panel. Little to no information on the pump size and total dynamic head (TDH) was available at the time of the inspections; this is discussed in further detail in the wastewater hydraulic modeling section of this Master Plan. Appendix B presents the information provided by CUC on the lift station pumps and motors.

Control System

The pump control system at most of the lift stations is a MultiTrode system that uses a sensing rod dropped into a wet well. This rod is equipped with sensors that gauge the water level. A signal is then sent back to the motor control, where a relay sends the signal to engage or disengage the pump. While this system is simple to install and set up, it frequently is fouled by oil and grease.

Other control systems observed at lift stations consisted of pressure sensors and float switches.

Force Main

Most force mains within the collection system range from 4 to 8 inches. The pump stations within the Agingan collection system along Beach Road all tie into a common 16-inch force main. Many lift stations that are not connected to a force main lift the wastewater and discharge it into an adjacent manhole.

One common operational difficulty with CUC's force mains is the use of old cast iron, bell type elbows. These elbows frequently leak at the joints, and replacement of the elbow is often difficult due to its location and size. Many of the elbows found in CUC's collection system are not of a standard size, also making replacement challenging.

Hydraulic assessment of the force mains, including evaluation of velocity, head loss, and pressure, was conducted via system hydraulic modeling.

The age and material type of each forcemain are presented in Table 2.2.2-6 for Agingan and Table 2.2.2-7 for Sadog Tasi. This information was gathered from as-built, record drawings and design drawing review. In some cases the information was not available or unknown. Interviews with Operations personnel were conducted during site inspection to confirm or supplement the information gathered from the records review.

Table 2.2.2-6. **Forcemain Specifics – Agingan**

Station ID	Installation Year	Forcemain Material Type
A-1	1970	ACP
A-2	2005	PVC
A-3	2005	PVC
A-4	2003	PVC
A-5	2003	PVC
A-6	2003	PVC
A-7	Unknown	PVC
A-8	1982	PVC
A-9	1969	PVC
A-10	2003	PVC
A-11	2003	PVC
A-13	1999	PVC
A-14	1999	PVC
A-15	1999	PVC
A-16	1999	PVC
W-3	Unknown	Unknown
W-4	Unknown	Unknown

Table 2.2.2-6. **Forcemain Specifics – Agingan**

Station ID	Installation Year	Forcemain Material Type
W-5	1987	PVC
W-6	1987	PVC
W-10	Unknown	PVC
W-11	2004	PVC
W-12	2002	PVC

Table 2.2.2-7. **Forcemain Specifics – Sadog Tasi**

Station ID	Installation Year	Forcemain Material Type
GR-1 (S-6)	1985	PVC
S-1	2002	PVC
S-2	1994	PVC
S-4	1982	ACP
S-5	1976	ACP
S-8	1982	PVC
S-9	1982	PVC
S-10	2002	PVC
S-11	1997	PVC
S-12	1997	PVC
SR-1	1987	PVC
SR-2	Unknown	PVC
SR-3	Unknown	PVC
T-1	1987	PVC
T-2	Unknown	Unknown
T-3	N/A	N/A
TAM	Unknown	Unknown

The following discussion on past upgrades, current conditions, and recommendations related to collection systems, pump stations, and pump station forcemains. Appendix A includes a system map that identifies pipe age by location.

Agingan

The backbone of the Agingan collection system was built between the 1960s and 1970s. ACP and VC pipe was widely used during this time. Aside for some pocket upgrades, much of the collection system in the San Antonio, Chalan Kanoa, Susupe, and San Jose areas is made up of ACP/VC pipe and is between 30 to 40 years old.

Upgrades of the lift stations within the Beach Road areas of the Agingan collection system have been completed over the years. Pump station renovations for the W-4 though W-7 lift stations and A-1 through A-11 lift stations were done in 1987. These upgrades consisted of pump and wetwell upgrades and did not include upgrades to the forcemains or associated collection lines.

A significant round of upgrades occurred in 2003 to 2005. These upgrades included hydraulic improvements and forcemain upgrades to the A-2 through A-6, A-8, A-9 and A-10 lift stations. A shared PVC forcemain was constructed along Beach Road that connected to all but one of the lift stations between Susupe and the Agingan pump station. Due to project funding limitations, the A-6 lift station was not included as part of these upgrades. It is recommended that the main Beach Road forcemain be extended to include the A-6 lift station.

A relatively recent addition to the Agingan wastewater service area is the collection loop from the Saipan International Airport, around the As Lito area through Koblerville, and down to the Agingan wastewater treatment plant (WWTP). This collection system was built of PVC pipe in the late 1990s. Another recent addition to the Agingan service area is the Tottotville collection system and associated lift station W-12 built in the early 2000s.

A few lift stations within the Agingan wastewater service area warrant further discussion. These lift stations include:

- W-4, W-5, and W-6. These lift stations are located along Chalan Monsignor Guerroro street and have not been significantly upgraded since 1987. This area of the collection system is known for frequent failure of the AC collection pipe due to the abrupt change in grade causing turbulent flows that release hydrogen sulfide gas. This gas attacks the ACP system. Modeling of this area suggest that upgrades to these three lift stations could result in eliminating two of the three. Further discussion of hydraulic modeling section under the Lift Station Recommendations of this Master Plan.
- W-3 and W-10. These two lift stations serve very small service areas and present few operational concerns. As a result, there is limited to no information available for these lift stations. As part of a larger recommendation, CUC should collect field information on these two lift stations. There have been no known reported failures of these lift stations and the site assessment yielded no concerns, therefore no further evaluation of these lift station is provided under this Master Plan.
- A-1 and W-11. These two lift stations are considered dormant and not in use. The A-1 lift station and ACP forcemain are still useable and CUC does occasionally use the A-1 lift station to bypass the newer A-16 lift station. Because of this operational use, it is recommended that a pressure test of the old ACP forcemain be performed to verify its integrity. Until this test is done and depending on the results, further use of this old ACP forcemain is not recommended. W-11 is not currently connected to any active service area.

Sadog Tasi

The early components of the Sadog Tasi wastewater collection system include the Capitol Hill and Navy Hill collection systems built in the 1950s of VC pipe. A portion of Garapan (located west of Beach Road) was built in the 1970s of ACP. Both of these collection systems are in use today. The Navy and Capitol Hill systems are the oldest collection systems on Saipan. While these systems are the oldest, they have not been as prone to frequent failure as the ACP systems. The ACM system located in Garapan has had at least two failures between 2011 and 2013. This line is located in the tourist center of Saipan and in most areas is located at or below the water lens. Upgrade of this line is recommend as a priority.

Upgrades to the Sadog Tasi collection system were largely governed by commercial development. The Beach Road collection system built in the later 1990s includes the S-10, S-11, and S-12 lift stations. This system runs through a populated area of the Saipan, but there are few relative connections. There is carrying capacity in this southern area of the Sadog Tasi's system. It is recommended that CUC embark on a customer connection program to aggressively connect those customers who are most accessible to this and other collection systems.

As stated earlier, Garapan is considered the tourist center of Saipan. The following lift stations serve Garapan: S-2, S-4, S-5, S-8 and S-9. CUC recently completed system upgrades to the S-8 lift station, which eliminated the S-2 lift station. The S-5 lift station is identified as having an ACP forcemain. Upgrade of this line should be considered as part of the elimination of dilapidated sewer project. Evaluation of the system hydraulics indicates the S-4 could be elevated by rerouting its flow toward a deepened wetwell at S-9, eliminating the short ACP forcemain from S-4.

Limited record information is available for the following areas of the Sadog Tasi system. The project team relied on interviews, system condition assessments, and available documentation to evaluate these systems:

- Lower Base. No record drawing is available that describes the Lower Base system. This system was built to support the garment industry, port operations, and more recently government offices. The T-3, TAM, and S-1 lift stations are located within this area. An upgrade to the S-1 lift station was completed in 2000, but this area is still plagued with infiltration and inflow problems. The Lower Base system serves as the junction point for the northern villages of Tanapag and San Jose as well as Capitol Hill. CUC has begun the design work needed to upgrade the Lower Base Collection System.
- San Roque System. The Tanapag and San Roque systems were built in the 1980s of PVC pipe. Modeling and inspection indicate a large amount of the I&I in the Tanapag area. I&I reduction is recommended as an upgrade to this area.

  The San Roque and Tanapag collection systems are built on the backbone of the San Roque lift stations. SR-1 serves the village of San Roque and was upgraded in 1999. SR-2 serves the Marianas Resort and was also upgraded in 1999. The SR-3 lift station that serves the Aqua Resort Club ties into the SR-1 forcemain.
- Sadog Tasi. The S-3 Lift station is the receiving lift station for the Sadog Tasi service area. The limited information available for this station reviewed suggest that the lift station and forcemain were built in 1969. The lift station was upgraded in 1999. The plans reviewed for this upgrade indicate the old forcemain was used. The construction material for this forcemain is not known. Given that this material is not known and the age of the forcemain, it is recommended that a pressure integrity test be done on this forcemain.

Check Valve

Check valves, where they exist, are located within wet wells and valve boxes. Most check valves are ball-type valves. These check valves rely on a ball that rises when the pump engages and drops when subjected to back pressure.

Check valves located within the wet wells pose maintenance and operational difficulties. One operational difficulty is backflow. It is common that, when a lead pump kicks on, the lag pump check valve, which is often missing, is stuck in the open position. This results in backflow and double pumping of the same wastewater. The ball check valves used at the lift stations do not have an indicator, so the operator cannot determine whether the check valve is in the proper position.

Aboveground Fuel Storage

Aboveground storage tanks (ASTs) for generator fuel were observed at the lift stations where generators are in place. These ASTs were commonly made of single-wall steel and have a capacity of 55 gallons. Nearly all of the ASTs were not within proper secondary containment.

The fuel supply and fuel return system typically consisted of steel, single-walled pipe. This pipe has no form of secondary containment between the AST and the generator.

Electrical System

The electrical systems at all lift stations were assessed based on general visual observations. Inspection of the lift station electrical systems included assessment of the following components: electrical service, generator, and general lighting and power. For the most part, the overall condition of the electrical systems was found to be fair, but several installations were in poor condition. Those determined to be in poor condition have systems that have not received major repairs or upgrades for many years, likely since their original installation. The lift stations found to be in fair to good condition were generally those that have been constructed within the last 10 years. The following subsections provide additional information on each of these electrical system components.

Electrical Service

A majority of the lift stations are provided with electrical service at 240V, three-phase, delta configuration, though several lift stations were observed to have an open delta configuration. Service to the lift stations is generally via overhead service drops. Service equipment generally involves the service feeder terminating to a main circuit breaker or fuse. The overall condition of the electrical service is fair with the following main concerns:

- Where service is open delta configuration, all installations do not currently identify the high-leg phase. The high-leg phase was also found to vary from station to station, indicating an inconsistency in the wiring of the pole-mounted transformers.
- The grounding system needs to be reviewed carefully to ensure compliance with the latest National Electrical Code (NEC) regulations. These include, but are not limited to, proper neutral-to-ground bonding and equipment grounding.

Generator System

A majority of the generator systems currently installed are old and require maintenance to make them operable. In many instances missing parts, such as batteries, or nonoperational equipment, such as battery chargers, are the reason the generator system is not operational. In other instances, a generator is operable but its associated automatic transfer switch (ATS) requires repair. As a result, a majority of the lift stations with a generator system do not currently have an automatic backup power system. The generator system may be operational, but several steps would need to be performed to have the lift station manually transferred to and from the backup generator system. Table 2.2.2-8 summarizes the generator startup tests, including the instances where tests could not be conducted due to the reasons explained above.

As indicated in Table 2.2.2-8 and discussed previously, most of the generator systems were not tested because all of the required working parts were not in place. Generator systems that were tested using a simulated power outage condition were generally those installations with newer generators.

Other issues that were observed are listed below. Site-specific issues are provided on the site assessment forms that can be found in Appendix C.

- Several installations do not have the generator installed on a concrete pad.

- A few installations did not have the generators installed on vibration isolators.
- The high-leg phase at the generator is not the same as the high-leg phase of the utility power. This could result in damage of equipment by, for example, a lightning strike.
- A few installations did not provide adequate working space clearance around the generator.

Table 2.2.2-8. **Site-Specific Generator Testing Information**

	Test Procedure			
Site ID	**Normal (Simulated Power Outage)**	**Manual Start-Up at Generator Control Panel**	**Generator Not Tested**	**ATS Not Tested**
A-1			X	X
A-2	X			
A-3			X	X
A-4	X			
A-5	X			
A-6	No on-site generator – only a manual transfer switch with provision for connection of portable generator connection is provided			
A-7		X		X
A-8	No on-site generator – only a manual transfer switch with provision for connection of portable generator connection is provided			
A-9			X	X
A-10			X	X
A-11			X	X
A-13			X	X
A-14			X	X
A-15			X	X
A-16	X			
GR-1			X	X
S-1			X	X
S-2			X	X
S-3		X		X
S-4			X	X
S-5			X	X
S-8			X	X
S-9			X	X
S-10		X		X
S-11			X	X
S-12			X	X
SR-1			X	X
SR-2			X	X
T-1	X			
W-4			X	X
W-5		X		X
W-6			X	X
W-8			X	X
W-10			X	X
W-11			X	X
W-12			X	X

General Lighting and Power

The majority of interior lighting consists of fluorescent lighting controlled via manual toggle switches. Exterior lighting is a mixture of incandescent, compact fluorescent, and high-intensity discharge (HID) fixtures controlled automatically via photocell. A few installations are missing fixtures. Several other installations require lamp and/or ballast replacement.

Site-Specific Findings on Electrical System

Table 2.2.2-9 presents a summary of site-specific findings on the electrical system of each lift station. Detailed observations/findings are provided on the site assessment forms in Appendix C.

Table 2.2.2-9. **Site-Specific Electrical Findings**

Site ID	Electrical Findings
A-1	• Main circuit breaker enclosure is not bonded to ground. • Interior lighting is in poor condition. • Exterior lighting is in poor condition. • Receptacles and devices are in poor condition.
A-2	• High leg marking is not provided.
A-3	• High leg marking is not provided. • Conductor splicing in handhole is not watertight.
A-4	• High leg marking is not provided. • Working space in front of main circuit breaker is insufficient and does not comply with code.
A-5	• High leg marking is not provided.
A-6	• High leg marking is not provided. • Working clearance in front of panel board is insufficient and does not comply with code. • Plastic bag is used as an attempt to waterproof wire splice in handhole.
A-7	• High leg marking is not provided. • Lighting is connected to high leg phase. Could be the cause of why lights are not working.
A-8	• High leg marking is not provided.
A-9	• High leg marking is not provided.
A-10	• High leg marking is not provided.
A-11	• High leg marking is not provided.
A-13	• Exterior lighting is in poor condition.
A-14	• Exterior lighting is in poor condition.
A-15	• Exterior lighting is in poor condition.
A-16	• High leg marking is not provided. • Main circuit breaker is not bolted to the enclosure. • Exterior lighting is in poor condition.
GR-1	• High leg marking is not provided.
S-1	• High leg marking is not provided. • Exterior lighting is in poor condition. • Unused conduits in handhole are not sealed. • Plastic bag is used as an attempt to waterproof the splicing of conductors in the handhole.

Table 2.2.2-9. **Site-Specific Electrical Findings**

Site ID	Electrical Findings
S-2	• High leg marking is not provided. • Main circuit breaker is housed in a disconnect switch enclosure. • Interior lighting is in poor condition. • Exterior lighting is in poor condition. • Conduits to control panel are not properly terminated, exposing the wires from the end of conduit to the control panel.
S-3	• Receptacles and devices are in poor condition. • Pump power supply cables are exposed on the electrical room floor. • Wires to motor control panels are not in conduit. • Wires to step-down transformer installed partially exposed. • Wires to light switch installed exposed.
S-4	• High leg marking is not provided. • No color coding is provided for electrical wiring. • Missing fuse on phase “B” of main fusible disconnect switch. Terminals are connected using electrical wire.
S-5	• High leg marking is not provided. • Main circuit breaker is housed in a disconnect switch enclosure. • Abandoned conductors (no longer in use) for the pumps are not secured.
S-8	• High leg marking is not provided. • Interior lighting is in poor condition. • Receptacles and devices are in poor condition. • Service equipment is not bonded to ground. • No color coding is provided for electrical wiring. • Power supply wires for the pumps are not installed in conduit.
S-9	• High leg marking is not provided. • Exterior lighting is in poor condition.
S-10	• Both interior and exterior lighting are not operational.
S-11	• High leg marking is not provided.
S-12	• High leg marking is not provided.
SR-1	• High leg marking is not provided. • Main fuse disconnect switch is missing fuse on Phase “C”. Electrical wiring is used to connect terminals (a fuse is not provided).
SR-2	• High leg marking is not provided. • Power supply cable to the pump is run exposed on the ground to the handhole.
T-1	• High leg marking is not provided.
T-3	• High leg marking is not provided. • Receptacles and devices are in poor condition. • Cables to control panel are not installed in conduit.
TAN	• High leg marking is not provided. • No lighting is provided. • Receptacles are in poor condition.

Table 2.2.2-9. **Site-Specific Electrical Findings**

Site ID	Electrical Findings
W-3	• High leg marking is not provided. • Main circuit breaker enclosure is not bonded to ground. • Electrical wiring is not properly color coded.
W-4	• High leg marking is not provided.
W-5	• High leg marking is not provided. • Plastic bag is used as an attempt to waterproof the splicing of conductors in handhole. • Handhole is filled with foreign materials (water, sand, unused conduit, plastic, grass). Conduit openings are not properly sealed.
W-6	• High leg marking is not provided. • Exterior lighting is in poor condition.
W-8	• High leg marking is not provided. • Interior lighting is in poor condition.
W-10	• High leg marking is not provided. • Interior lighting is in poor condition. • Exterior lighting is in poor condition.
W-11	• No power at the submittal during time of inspection.
W-12	• High leg marking is not provided. • Working clearance in front of main circuit breaker is insufficient and does not comply with Code.

Electrical System Recommendations

The following recommendations are intended to improve/repair/upgrade the electrical system at the lift stations:

- Properly provide high leg marking in accordance with the NEC. Where a generator backup system is provided, ensure the high-leg phase between the utility and the generator system match.
- Consider installing Transient Voltage Surge Suppressors (TVSS) at the service entrance equipment.
- Perform a complete assessment of the facility grounding system and correct deficiencies as required.
- Install fuses on all fusible disconnect switches. Consider utilizing non-fusible disconnect switches where possible. Where protection is required, consider providing enclosed circuit breakers.
- Where backup power is determined to be required, replace generator with a new emission-compliant system. Provide new ATSs as required.
- Where a backup generator system is not necessarily required, consider installing provisions for connection of a portable generator system.
- Replace all lighting with an energy-efficient lighting system. Provide an automatic control system with manual override for exterior lighting. Provide light fixtures suitable for the environment in which they are to be installed (e.g., corrosive environment, wet location rated, damp location rated, etc.).
- Install generators on concrete pads and provide vibration isolators.

- Ensure compliance with code-required working clearances for all electrical equipment.
- Provide explosion-proof seals in accordance with NEC requirements.
- Utilize watertight splice kits for all splices located in handholes.
- Install all wiring/cabling within conduit.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.
- Seal all handhole conduit openings.
- Clean all electrical handholes of dirt, debris, and foreign materials.
- Maintain a stock of spare parts for electrical equipment.
- Train personnel at every opportunity in all aspects of theory, principles of operations, installation practices, maintenance, and troubleshooting.

Site-Specific Lift Station Findings

Tables 2.2.2-10 and 2.2.2-11 present site-specific information on each lift station's control system, check valves, and riser pipe, along with additional comments as necessary. Detailed site-specific inspection information for each lift station can be found on the inspection forms provided in Appendix C.

Table 2.2.2-10. **Site-Specific Findings – Agingan**

Station ID	Control System	Check Valve	Wet Well Riser	Site Comment
A-1	MT	Not present	Cast iron	Pumps are constantly turning on/off
A-2	MT	In pit, swing type	SS	Wet well coating is failing, bar screen is clogged
A-3	MT	In pit, swing type	SS	Wet well was flooded
A-4	Floats	In pit, swing type	SS	
A-5	MT	In pit, swing type	SS	Beginning of 16-inch Beach Road force main
A-6	MT	In pit, swing type	SS	Site has large (16-inch) discharge piping
A-7	Floats	In wet well	Cast iron	Pump station surges downstream manhole
A-8	Pressure sensor	In pit, swing type	SS	Pump discharge is 20 feet from the wet well
A-9	Floats	In pit, swing type	SS	
A-10	Pressure sensor	In pit, swing type	SS	Site has adequate secondary containment for AST
A-11	MT	In pit, swing type	SS	AST has secondary containment
A-13	MT	In pit, ball type	Cast iron	Heavy oil and grease, plugged screen
A-14	MT	In pit, ball type	Cast iron	Site has inoperable magnetic meter
A-15	MT	In pit, swing type	Cast iron	Site has soft starter for pump
A-16	MT	In pit, ball type	Cast iron	Site has soft starter for pump
W-3	MT	Not present	Unknown	Wet well is in the road and buried
W-4	MT	In wet well	Cast iron	Leaking elbow
W-5	MT	In wet well	Cast iron	Wet well in intersection
W-6	MT	In wet well	Cast iron	

Table 2.2.2-10. **Site-Specific Findings – Agingan**

Station ID	Control System	Check Valve	Wet Well Riser	Site Comment
W-10	Floats	In pit, ball type	Cast iron	Pump station serves a small collection area; the wet well is located in the road
W-11	MT	In pit, ball type	Cast iron	Pump station is not online
W-12	MT	In pit, swing type	Cast iron	Site serves Tottotville

Note: SS = stainless steel, MT = MultiTrode

Table 2.2.2-11. **Site-Specific Findings – Sadog Tasi**

Station ID	Control System	Check Valve	Wet Well Riser	Site Comment
GR-1 (S-6)	MT	In pit, swing type	Cast iron	Site has an inoperable magnetic meter, plugged screen
S-1	MT	In pit, ball type	Cast iron	Riser elbow is leaking
S-2	MT	In wet well	Cast iron	Lift station will be removed from the system
S-4	MT	In wet well	Cast iron	Leaking elbow
S-5	MT	In pit, swing type	Cast iron	Leaking elbow
S-8	MT	In pit, swing type	Cast iron	Risers in the wet well are temporary
S-9	MT	In wet well	Cast iron	
S-10	MT	In pit, not observed	Cast iron	Station has adequate secondary containment for AST, leaking elbow
S-11	MT	In pit, not observed	Cast iron	Wet well is in the road
S-12	MT	In pit, ball type	Cast iron	
SR-1	MT	In pit, flooded	Cast iron	Hoist system has been removed
SR-2	MT	In pit, ball type	Cast iron	Unusual bubbles were seen in the wet well
SR-3	Floats	In pit, swing type	Cast iron	Station has mixed material fittings and piping
T-1	MT	In pit, ball type	Cast iron	Per CUC staff, chronic failures of this lift station. Pump failure observed during site visit.
T-2	Floats	In pit, ball type	SS	
T-3	Floats	N/A	N/A	
TAN	Floats	N/A	PVC	Privately owned and operated lift station belonging to Tan Holdings Corp. Inflow limited due to abandoned facility that once served it.

Note: SS = stainless steel, PVC = polyvinyl chloride, MT = MultiTrode

Summary of Recommendations

The following recommendations were identified based on collection system condition assessments and CCTV inspections:

- Standardize the pumps that are selected and replace non-standard pumps at existing and new wastewater pump stations. Currently, there is no set flow rate and head for the pump stations, making upgrade, repair and replacement difficult. It may also lead to oversized pumps, resulting in cavitation, high power cost, and downstream surging. Determining the appropriate pump size will require wet well monitoring at each pump station to determine the pump drawdown and flow rate. Once this is known, CUC can use this information to determine the total dynamic head of the pump. The flow rate and total dynamic head must be logged in a database for CUC operators and engineers to use for pump repair, maintenance, and replacement.

- Increase the redundancy and reliability at each pump station. Many of the pumps stations are operating with one pump online and no redundant pump. This condition is exacerbated by faulty check valves. Adding redundant pumps will require retooling the pump controls to alternate operation between the pumps.
- Relocate existing check valves to new valve pits at lift stations.
- Upgrade riser pipe from cast iron to stainless steel at lift stations S-4, S-5, and W-4.
- Relocate check valves from wet well to new valve pit at S-4.
- Relocate and retool W-5 to receive gravity flow from W-4 and W-6. This recommendation will eliminate pump stations W-4 and W-6 and relocate W-5 to an accessible location, likely adjacent to the existing generator building.
- Provide for standardized pumps and controls at all lift stations. This includes standardizing the pump sizes where possible. The short term goal will be to have available spare pumps and motors. The long term goal will be to have redundant pumps at every lift station.
- Provide proper signage, such as site ID and warning high voltage signs, at all lift stations.
- Conduct a pilot trial on the use of an ultrasonic level gage in wet wells to replace existing control systems. Existing MultiTrode control systems are problematic and frequently fail, resulting in pumping the wet wells dry.
- The T-3 wet well will be decommissioned and demolished as part of the ongoing Lower Base Sewer System Upgrades. A new gravity collection line will serve the areas presently served by T-3.
- T-1 lift station pump failures need to be addressed.
- Conduct a detailed CCTV inspection of all AC lines. The AC sewer lines have had recent failures, are old, and are highly susceptible to sulfuric attack. The findings of CCTV inspections will set the replacement need and schedule for these AC lines.
- In the area of Tanapag inspected by CCTV, the manholes are severely deteriorated and are in need of repair.
- In the area of Capitol Hill inspected by CCTV, it is recommended that CUC conduct routine maintenance.
- In the Garapan area where CCTV inspection occurred, frequent cleaning and replacement of the AC pipe is recommended.
- In the San Jose area inspected by CCTV, replacement of this AC pipe is recommended.
- In the area of Chalan Kanoa inspected by CCTV, it is recommended that CUC reinspect this area of the collection line in 5 years.
- In the area of San Antonio along Beach Road where CCTV inspection occurred, it is recommended that CUC reinspect in 5 years.

The Project Identification and Prioritization section of this Master Plan consolidates all recommendations from this section into specific projects.

2.2.3 Inspection and Condition Assessment of Existing Wastewater Treatment Plant Facilities

The inspection and condition assessment of the existing WWTP facilities on Saipan contributed to the development of a comprehensive wastewater Master Plan. This section discusses the following for both the Sadog Tasi WWTP and the Agingan WWTP.

Sadog Tasi Wastewater Treatment Plant

The Sadog Tasi WWTP receives wastewater from the northern sewered areas in Saipan.

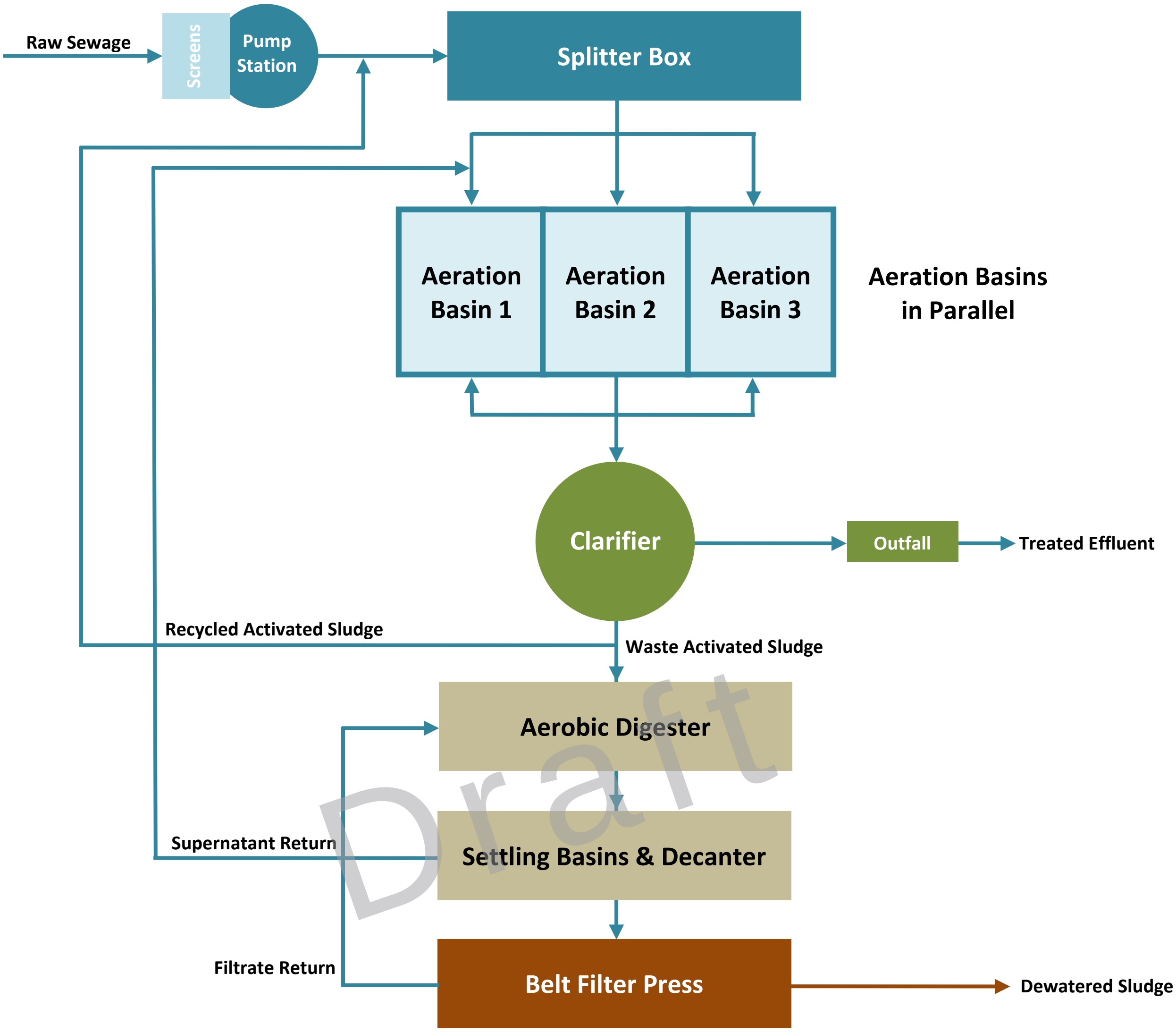
Treatment Process Overview

This section describes the treatment processes currently in use at Sadog Tasi WWTP. Relevant and major changes made to the plants that may have an impact on the process efficiency and capabilities are also highlighted. The process schematic shown in Figure 2.2.3-1 and the subsequent assessment refers to the existing plant configuration after a recent plant upgrade.

Raw sewage is pumped into the WWTP via an offsite pump station (Lift Station S3/S3A). Large debris are collected and removed by a bar screen located upstream of the pump station. The screened influent is then split via a splitter box and channeled to three aeration basins. The splitter box controls the flow of raw influent and return activated sludge (RAS), and allows the operator to control flow to any or all of the aeration basins.

A spray-wash system that consists of individual hoses (a modification of the original system) is available to control foam and grease accumulation in the aeration basins. Foam and grease are manually sprayed and broken down using these hoses. Otherwise, manual removal of foam, grease balls, and other floating material is carried out using a fine mesh screen attached to the end of a long pole. Material removed is sent to the landfill for disposal. The clear liquid on top of the clarifier is decanted by flowing it over a weir into the effluent launder where it is then discharged to the outfall.

Figure 2.2.3-1. **Sadog Tasi Wastewater Treatment Plant Process Outline**



The treatment process is an activated sludge system. At present, the aeration basins operate in parallel configuration. The sluice gates between the basins were removed because they were dysfunctional. However, removing the sluice gates prevents flow from one aeration basin to another, making operation-in-series impossible under the current plant configuration. A recent change order to the existing Sadog Tasi WWTP improvement project will result in the installation of an overflow weir between Basins 2 (center basin) and 3 (the northernmost), which will allow series flow between these two basins. Additionally, Basin 2 will be able to be used as a temporary clarifier so that the actual clarifier may be dewatered for maintenance purposes.

Mixed liquor flows through the aeration basins (shown in Figure 2.2.3-2) by gravity from the inlet to the weir box on the opposite end of the basin. Oxygen is introduced into the basin by mechanical aerators (that replaced membrane diffusers) to satisfy the activated sludge microorganisms and to keep the sludge dispersed in the mixed liquor. The aerators operate in automatic mode.

Figure 2.2.3-2. **Sadog Tasi WWTP Aeration Basins and Clarifier**

The mixed liquor then flows by gravity to the clarifier (see Figure 2.2.3-2). In the clarifier, activated sludge solids are separated from the mixed liquor. The sludge settles at the bottom of the basin, forming a thick sludge blanket. Mixed liquor suspended solids (MLSS) in the aeration basins are maintained by balancing the amount of activated sludge in the clarifier. Balance is achieved by controlling the amount of RAS that is returned to the splitter box via the RAS pumping. Another portion of settled sludge is wasted to the aerobic digester via waste activated sludge (WAS) pumping for further treatment.

The digested sludge from the aerobic digester moves to the settling basins before it is sent to a belt filter press (BFP) to reduce its water content and volume. Alternatively, digested sludge can also be pumped to the BFP directly from the digester, bypassing the use of the settling basins, by configuring valves on the sludge pump suction piping. The dried sludge is then sent to a landfill for disposal.

No disinfection process is used in the treatment process.

Changes Made to Sadog Tasi Wastewater Treatment Plant

Notable changes to the original plant design that affect operations have been made. Aeration and mixing in the aeration basins have been conducted by mechanical floating aerators since 2010, replacing the diffusers. The sluice gates for the aeration basins that were malfunctioning have been removed, preventing transfer of wastewater from basin to basin. As a work-around to transfer wastewater, portable pumps are now used to drain the aeration basins during maintenance.

As previously mentioned, a manually operated spray-wash system is currently used in the aeration basins to prevent grease balls and foam from forming on the aeration basin surface. A recently completed improvement project included the installation of a foam spray-nozzle system along the center clarifier walkway. Four nozzles were installed to direct foam and scum toward the scum beach. In addition, the scum beach and scraper attachment were replaced with parts from the original equipment manufacturer (EIMCO Technologies). The air-lift pump that removed scum from the clarifier has also been removed, and scum currently flows via gravity out of the clarifier. The sludge-feed pump system that pumps sludge from the aerobic digester to the BFP has been reduced from two pumps to only one.

Other recent plant modifications are as follows:

- Addition of a strainer/screen to the digester to catch solids from the septic pumper truck.
- Installation of new discharge piping, check valves, and isolation valves for the RAS and WAS pump stations.
- Addition of a scum baffle around the digester settling basin overflow pipes to prevent discharge of solids with supernatant to aeration basin 1.
- Addition of holes in the sludge intake piping inside the settling basins to improve sludge withdrawal performance.
- In the aeration basins, the diffusers and blowers have been decommissioned. They have been replaced by floating aerators in each basin, which are easier to maintain.
- The aeration basin sluice gates used for the transfer of wastewater between the aeration basins had not been used to operate the basins in series and were removed. The three aeration basins now run in parallel mode.

Installation of grinder pumps with automated controls for the scum pit is currently an ongoing project. The equipment has been ordered and delivered as of January 2013.

At the time of inspection (August 23, 2011), the plant was experiencing lower than expected MLSS values for an extended aeration system. An average MLSS concentration of approximately 2,300 mg/L was reported. In an effort to increase the MLSS concentration, the plant was being operated with a reduced sludge wasting rate to build up the MLSS in the aeration basins.

A summary of the design parameters for the Sadog Tasi WWTP, captured from available documentation, is provided as Table 2.2.3-1. While some information is not available from existing documentation, it is recommended that data from current operations be progressively recorded to aid future operations and maintenance (O&M) efforts.

Table 2.2.3-1. **Design Criteria for Sadog Tasi Wastewater Treatment Plant**

Design Parameter	Design Criteria
Average Design Flow, Q_{ave}	2.9 MGD
Peak Wet Weather Flow	5.0 MGD
Temperature	30°C (Summer), 20°C (Winter)
Influent Biochemical Oxygen Demand (BOD)	200 mg/L
Influent Total Suspended Solids (TSS)	200 mg/L
Influent Total Kjeldahl Nitrogen (TKN)	20 mg/L
Effluent BOD Limit	30 mg/L
Effluent TSS Limit	30 mg/L
Effluent Ammonia Nitrogen (NH_3-N)	10 mg/L
Aeration Basins	
Detention Time @ Q_{ave} for Aeration Basins (HRT)	14.5 hours
Solids Retention Time (SRT)	Information not available
Volume of Aeration Basins (Total)	2.62 MG
Assumed Actual Oxygenation Rate (AOR)/ Standard Oxygen Required (SOR)	1.25 lb O_2/BOD/day
Assumed Oxygen Requirements	4.6 lb O_2/# NH_3

Table 2.2.3-1. **Design Criteria for Sadog Tasi Wastewater Treatment Plant**

Design Parameter	Design Criteria
Assumed Load Factor, Food-to-Microorganism Ratio (F/M)	0.14 lb BOD/lb MLSS/day
Type of Aeration	2 @ 40 HP FSS Aqua-Jet Floating Aerators per Basin
Standard Oxygen Transfer Efficiency (SOTE) @ Q_{ave}	32%
Secondary Clarification	
Number of Clarifiers	1
Diameter (DIA)	100 ft
Sidewater Depth	16 ft
Overflow Rate @ Q_{ave}	611 GPD/ft^2
Sludge Removal Method	Suction Feed to Submersible Pump
Weir Loading @ Q_{ave}	8680 GPD/linear ft
Aerobic Sludge Digestion	
Number of Basins	1
Volume of Basins	1 MG
Maximum Water Depth	20 ft
Maximum Solids Feed to Digester	8,894 lbs/day
Maximum Volume Feed to Digester (Waste Activated Sludge, WAS @ 0.75%)	112,200 GPD
Solids Loading	0.06 lb VSS/ft^3/day
Theoretical Detention Time at 2% Solids	18.7 days
Assumed Oxygen Requirements for WAS	5500 lbs/day
Type of Aeration	2 @ 75 HP Aqua-Jet Floating Aerators
Method of Sludge Concentration	Gravity
Settling Basin Size	2 @ 37 ft x 26.5 ft
Sludge Pumping	
WAS Pumps	2 @ 3 HP submersible pumps with 230 GPM capacity (each)
RAS Pumps	2 @ 7.5 HP submersible pumps with 700 GPM capacity (each)
Digested Sludge Pumps	1 @ 10 HP variable progressive cavity with 368 GPM capacity (each)
Sludge Handling	
Dewatering Type	2-meter Belt Filter Press

Overview of NPDES Permit Requirements for Sadog Tasi Wastewater Treatment Plant

This section summarizes the National Pollutant Discharge Elimination System (NPDES) permits for the Sadog Tasi WWTP. It also provides information on effluent limitations and other requirements necessary to protect the environment, public health, and safety. A summary table for the permit requirements for Sadog Tasi WWTP is provided as Table 2.2.3-2.

Table 2.2.3-2. **National Discharge Pollutant Elimination System Permit Requirements for Sadog Tasi WWTP**

	Sadog Tasi WWTP (Permit No. MP0020010) (Based on Average Daily Design Flow of 4.8 MGD)							
	Mass Limits (lbs/day)			**Concentration Limits**			**Monitoring Frequency**	**Sample Type**
	Monthly Average	**Weekly Average**	**Daily Maximum**	**Monthly Average**	**Weekly Average**	**Daily Maximum**		
Flow	N.A.	N.A.	N.A.	Monitoring and Reporting Required			Continuous	Continuous
Biochemical Oxygen Demand (5-day)[1]	1,201	1,801	N.A.	30 mg/L	45 mg/L	N.A.	3 days/week	8-hour Composite
Total Suspended Solids[1]	1,201	1,801	N.A.	30 mg/L	45 mg/L	N.A.	3 days/week	8-hour Composite
Settleable Solids	N.A.	N.A.	N.A.	1 ml/L	N.A.	2 ml/L	Once/day	Discrete
Oil and Grease	Monitoring and Reporting Required						Quarterly	Discrete
Whole Effluent Toxicity[2]	N.A.	N.A.	0.26	N.A.	N.A.	Pass	Semi-Annually	24-hour Composite
Enterococci	N.A.	N.A.	N.A.	2,230 CFU/ 100 mL	N.A.	4,474 CFU/100 mL	Weekly	Discrete
Total Chlorine (Cl) Residual	0.25	N.A.	0.5	6.2 µg/L	N.A.	12.4 µg/L	3 days/week	Discrete
pH	Not more than 0.5 units from a value of 8.1						3 days/week	Discrete
Nitrate-Nitrogen	760	N.A.	1,600	19 mg/L	N.A.	39 mg/L	Quarterly	24-hour Composite
Total Nitrogen	1,200	N.A.	2,300	29 mg/L	N.A.	58 mg/L	Quarterly	24-hour Composite
Ortho-phosphate	80	N.A.	200	2 mg/L	N.A.	4 mg/L	Quarterly	24-hour Composite
Total Phosphorus	80	N.A.	200	2 mg/L	N.A.	4 mg/L	Quarterly	24-hour Composite
Unionized Ammonia	30	N.A.	80	0.8 mg/L	N.A.	2 mg/L	Quarterly	24-hour Composite
Copper	0.1	N.A.	0.2	2.4 µg/L	N.A.	4.8 µg/L	Quarterly	24-hour Composite
Lead	Not Regulated							
Nickel	0.3	N.A.	0.5	6.7 µg/L	N.A.	13.4 µg/L	Quarterly	24-hour Composite
Silver	0.04	N.A.	0.08	0.9 µg/L	N.A.	1.9 µg/L	Quarterly	24-hour Composite
Zinc	1.8	N.A.	3.8	45 µg/L	N.A.	90 µg/L	Quarterly	24-hour Composite
Radioactive Material	The discharge of radioactive materials at any level to the receiving waters is strictly prohibited							
Other Priority Toxic Pollutants (except Asbestos) [2]	Monitoring and Reporting Required						Oct 2007/ Oct 2010	
Others Requirements:	*Discharge to be free from:* 1. Materials that will settle to form objectionable sludge or bottom deposits. 2. Floating debris, oil, grease, scum, or other floating materials. 3. Substances in amounts sufficient to produce taste or odor in the water or detectable from the flavor in the flesh of fish, or in amounts sufficient to produce objectionable odor, turbidity, or other conditions in the receiving water. 4. High temperatures; biocides; pathogenic organisms; toxic, corrosive, or other deleterious substances at levels or in combinations sufficient to be toxic or harmful to human health or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water. 5. Substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life. 6. Toxic pollutants in concentrations that are lethal to, or that produce detrimental physiological responses in human, plant, or animal life. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species and/or significant alterations in population or community ecology or receiving water biota. *Discharge shall not cause:* 1. The fecal coliform concentration in the receiving waters to exceed a geometric mean of 200 CFU/100 mL in not less than five samples equally spaced over a 30-day period, nor any single sample to exceed 400 CFU/100 mL at any time. 2. The concentration of dissolved oxygen (DO) in the receiving waters to be less than 75 percent saturation. 3. The concentrations of total filterable suspended solids in the receiving waters to be increased from ambient conditions at any time, or to exceed 40 mg/L except when due to natural conditions. 4. The salinity of the receiving waters to be altered more than 10 percent of the ambient conditions, or more than that which would otherwise adversely affect the sedimentary patterns and indigenous biota, except when due to natural causes. 5. The temperature of the receiving waters to vary by more than 1.0°C from ambient conditions. 6. The turbidity at any point in the receiving waters, as measured by nephelometric turbidity units (NTUs), to exceed 1.0 NTU over ambient conditions except when due to natural conditions. 7. The concentration of suspended matter at any point in the receiving waters to be increased from ambient conditions at any time, and shall not exceed 40 mg/L except when due to natural conditions. 8. The health and life history characteristics of aquatic organisms in receiving waters affected by the discharge to differ substantially from those for the same receiving waters in areas unaffected by the discharge. Also, the discharge shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life in the receiving waters.							

[1] The arithmetic mean of the BOD and TSS values, by concentration, for effluent samples over a calendar month shall not exceed 15 percent of the arithmetic mean, by concentration, for influent samples.

[2] Based on the fifth edition of Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms (EPA-821-$-02-012, October 2002; Table IA, 40 CFR Part 136) ("Acute Toxicity TMM") Manual.

[3] Priority toxic pollutants are listed in 40 CFR 131.36 (b) (1). Permittee shall collect 24-hour composite samples for metals, 2,3,7,8-TCDD (dioxin), pesticides, base-neutral extractables, and acid-extractables. The permittee shall collect discrete samples for cyanide, total phenolic compounds and volatile organics.

The NPDES permit (MP0020010) for the discharge of effluent from Sadog Tasi WWTP through the Saipan Lagoon Outfall became effective July 1, 2008 and expires June 30, 2013[1]. The NPDES permit specifies the following:

- Effluent limitations and monitoring requirements
- General discharge specifications and prohibitions
- Toxicity monitoring requirements
- Pretreatment requirements
- Bio-solids limitations and monitoring requirements
- Receiving water monitoring requirements and conditions

At the Sadog Tasi WWTP, concentration limits for both BOD and TSS are 30 mg/L and 45 mg/L for the monthly and weekly averages, respectively. In addition, the permit is interpreted to state that the monthly average effluent BOD and TSS concentrations are not to be more than 15 percent of the monthly average influent BOD and TSS concentrations, i.e., the WWTP must achieve at least 85 percent reduction by concentration. Other water quality parameters that are regulated include settleable solids, *Enterococci* concentrations, total Cl residual, pH, nitrate, nitrogen, orthophosphate, phosphorus, ammonia, copper, nickel, silver, and zinc. Other parameters, such as flow and fats, oil, and grease (FOG), do not have limits, although monitoring is required.

The purpose of the permit is to protect the environment from discharges that have undesirable effects on the ecosystem or the environment (e.g., radioactive materials in the discharge, high temperature discharges, and toxic pollutants). Toxicity testing of the Sadog Tasi effluent is required to use the freshwater amphipod *Hyalella azteca*, and a full laboratory report is to be submitted to EPA Region 9 and the CNMI DEQ. The permit also regulates pre-treatment requirements to minimize the introduction of hazardous wastes into the wastewater system, bio-solids treatment system, bio-solids disposal location, and receiving waters.

Assessment of Hydraulic Capacity of Sadog Tasi Wastewater Treatment Plant

Sadog Tasi WWTP was originally designed for a maximum flow of 9.2 MGD, with an average daily flow of 4.8 MGD. According to the “Saipan Wastewater Facilities Master Plan” (Dueñas & Associates/CH2M, 1993), the maximum recommended flow for the plant should be capped at 5.0 MGD due to concerns of effluent discharge polluting the harbor. However, according to the WWTP O&M manual (updated by Aqua-Aerobic Systems and re-issued in March 2011), the plant is now only able to treat an average daily flow of up to 2.9 MGD. Subsequent sections in this report will discuss the expected maximum treatment capacity of the current configuration of the plant based on process modeling.

Sadog Tasi WWTP has currently been receiving approximately 2 to 3 MGD during the wet season and 1 to 1.5 MGD during the dry season (see Figure 2.2.3-3). This is well below its design capacity, and the WWTP likely has sufficient hydraulic capacity to handle wastewater flows entering the plant over the next 20 years based upon design capacity. Flow has been steady at approximately 2.5 MGD on average until 2011 when the plant’s monthly average influent flow experienced a drastic drop and is now reported to be approximately 1.5 MGD. The apparent reduction in wastewater flows entering the plant could be related to the installation of a new effluent flow meter, which now gives a more accurate flow reading as compared to the previous flow meter. Nonetheless, the decrease in wastewater influent flow has had no severe effect on plant operations hydraulically as the basins

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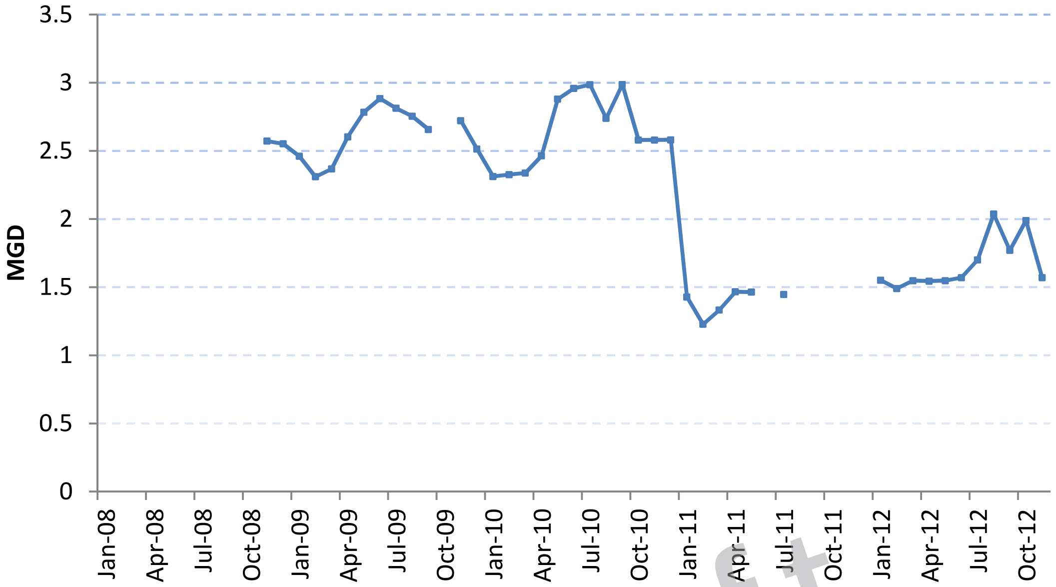
[1] As of March 31, 2015, no new permit has been issued per Brian Bearden/CUC.

that are now running in parallel can be taken offline individually when reduced flows are experienced at Sadog Tasi WWTP.

Figure 2.2.3-3. **Monthly Average Influent Flow into Sadog Tasi Wastewater Treatment Plant**



Assessment of Existing Performance of Sadog Tasi WWTP

This section discusses in detail the BOD and TSS loadings that enter the WWTPs and the process performance of the WWTPs in relation to specific water quality parameters in the effluent water. These water quality parameters are also discussed in comparison with the NDPES requirements to assess the overall performance of the treatment process and operations at both WWTPs. Consolidated water quality data can be found in Appendix D for Sadog Tasi WWTP

Influent and Effluent Quality

The influent BOD has been averaging approximately 130 mg/L since 2008, with some degree of fluctuation of +/- 25 percent until May 2011 when the concentration dropped to less than 100 mg/L. Influent TSS experiences greater fluctuations than BOD, especially during the period from January 2008 to December 2009, averaging approximately 160 mg/L. Similar to influent BOD, influent TSS has also shown a drop in values to about 80 mg/L since May 2011. The drops in concentration for BOD and TSS since May 2011 may be due to a combination of factors, such as wet weather infiltration or inflow into the sewers.

The Sadog Tasi WWTP was originally designed for influent BOD and TSS values of 200 mg/L each. Since the start of the sampling period in January 2008, the WWTP has been receiving lower than design BOD levels, 37.5 percent to 80 percent of the design BOD. During that same sampling time period, the WWTP has been receiving TSS levels at 50 percent to 175 percent of design TSS. Despite the fluctuations in the incoming BOD and TSS loadings, the WWTP generally meets the monthly average value limits on TSS and BOD. There have been occasions when the plant cannot meet the percent removal requirement in the NPDES limit (greater than 85 percent reduction in BOD and TSS concentrations) despite meeting the monthly average effluent limits. This inability is mainly attributed to the plant receiving low-strength wastewater, i.e., wastewater with low influent BOD and TSS values.

Based on the available effluent water quality (WQ) data, Sadog Tasi WWTP has been compliant for most of the sampling period from January 2008 to November 2012, with monthly average BOD and TSS values falling below the NPDES permit levels of 30 mg/L for each parameter. There was, however, a period of non-compliance of both BOD and TSS from February 2010 to September 2010 and one instance in September 2009 for BOD. From February 2010 to September 2010 the Sadog Tasi WWTP was being retrofitted, during which the clarifier was put temporarily out of service. See Figures 2.2.3-4 and 2.2.3-5 for influent and effluent TSS and BOD concentrations.

Figure 2.2.3-4. **Monthly Average Influent and Effluent Total Suspended Solids Concentrations at Sadog Tasi Wastewater Treatment Plant**

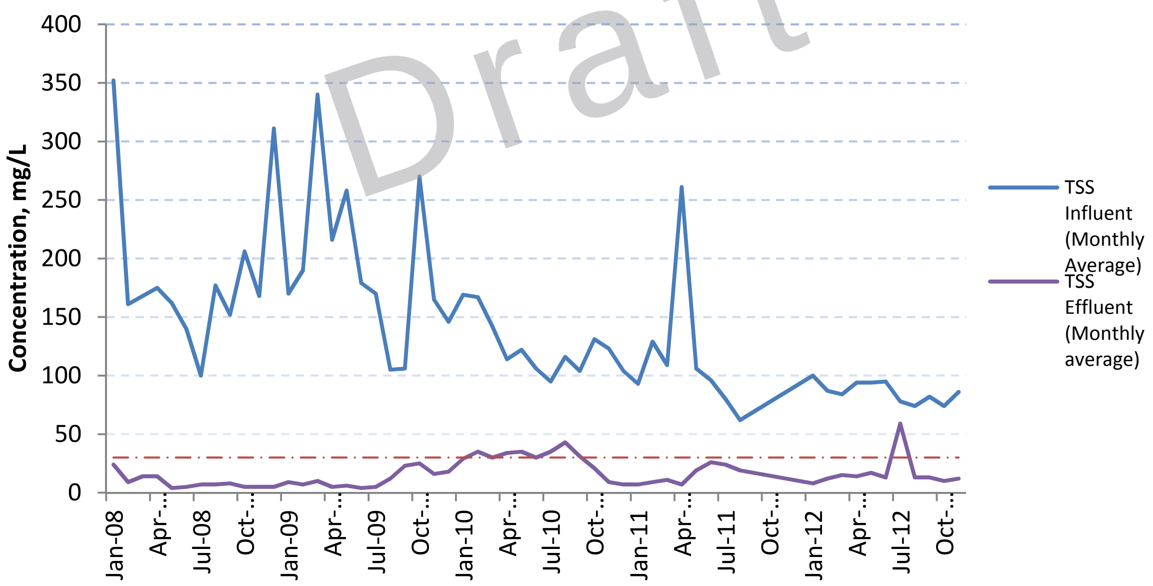
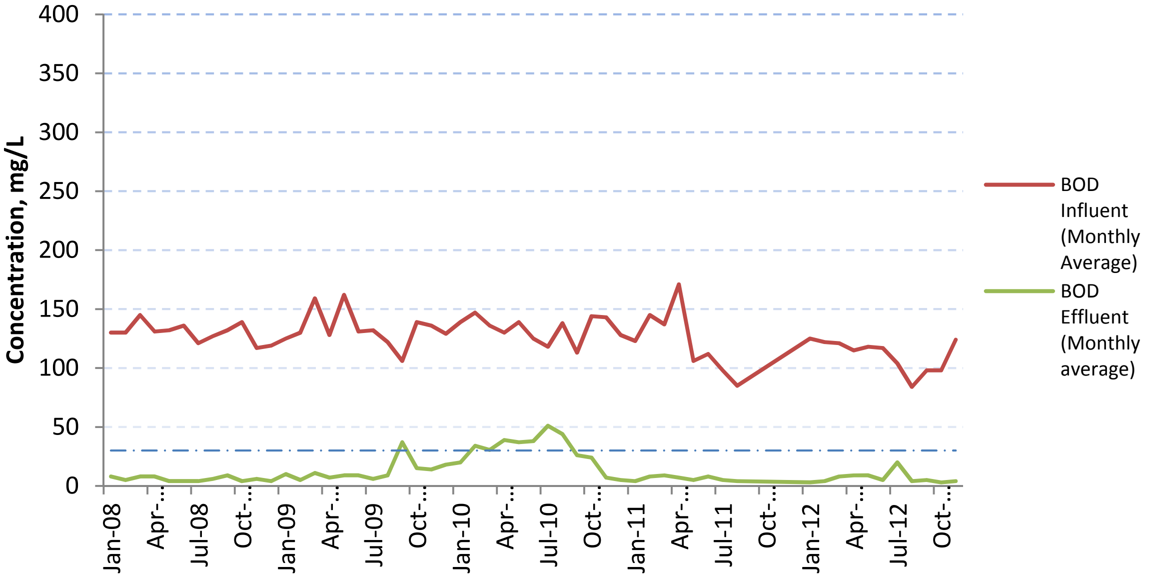


Figure 2.2.3-5. **Monthly Average Influent and Effluent 5-Day Biochemical Oxygen Demand Concentrations at Sadog Tasi Wastewater Treatment Plant**



Sadog Tasi WWTP receives unusual discharge flows in addition to the normal influent flow, namely:

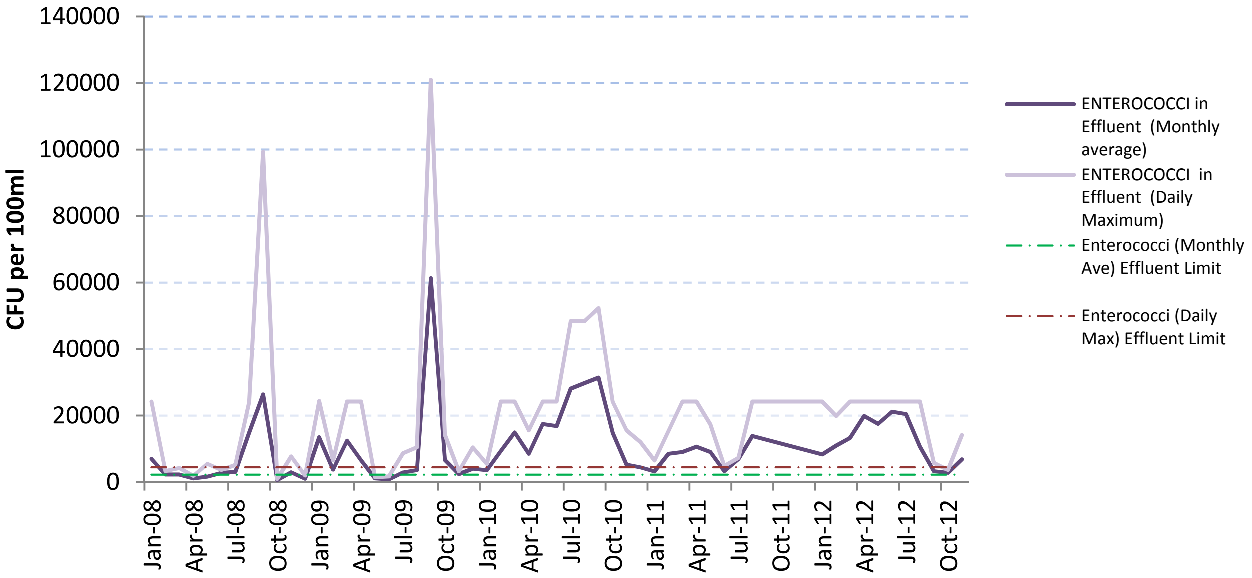
- Dairy wastes from Coca-Cola factory two to three times a year
- Septage from privately owned septic tanks
- FOG from various sources, such as restaurant grease traps

These flows are dumped directly into the aerobic digester at the WWTP.

Effluent *Enterococci* values have consistently exceeded the NPDES permit levels of 2,230 colony-forming units (CFU)/ 100 ml for monthly average readings and 4,474 CFU/100 ml for daily maximum readings (Figure 2.2.3-6). The actual *Enterococci* values for the entire sampling period from January 2008 to November 2012 were 10,351 CFU/100 ml and 19,779 CFU/100 ml for the monthly average and daily maximum readings, respectively. The *Enterococci* values in the last 3 months are in a decreasing trend and with a revised NPDES Permit limit based on the recomputed dilution values recommended in this Master Plan, these values would meet the permit requirements. Further monitoring and data collection would be required to confirm the trend.

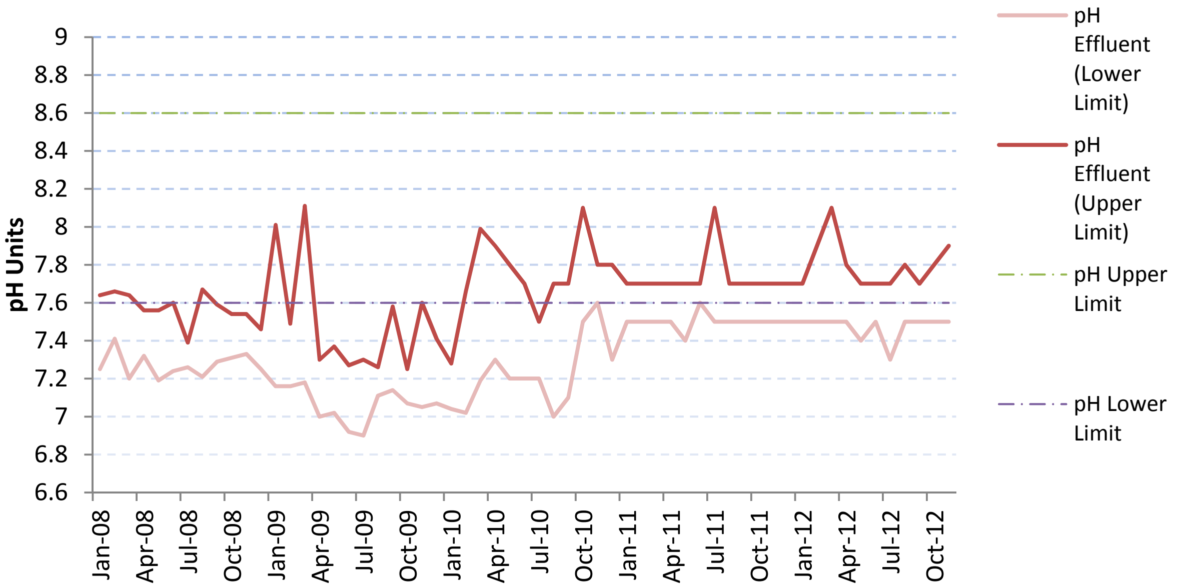
It is apparent that the high *Enterococci* values have had minimal impact on receiving waters. The sharp spikes of *Enterococci* concentrations in the effluent were not reflected in readings taken in the receiving waters apart from one exception in June 2010 when an extremely high concentration (1,517 CFU/100 ml) was detected. This spike was likely due to the carryover effects of a high, once-off discharge (daily maximum registered of 11,199 CFU/100 ml in the same month), possibly the result of a malfunction in the treatment process.

Figure 2.2.3-6. **Effluent *Enterococci* Concentrations at Sadog Tasi Wastewater Treatment Plant**



The Sadog Tasi WWTP effluent pH has been noncompliant with NPDES limits, with an average pH of 7.24 to 7.63 over the sampling period (January 2008 to November 2012, Figure 2.2.3-7). The lower and upper limits for effluent pH per the NPDES limits are 7.6 and 8.6, respectively. Despite being noncompliant, the effluent pH value has been generally steady throughout the recording period. The band of pH values allowed in the NPDES limit for Sadog Tasi WWTP appears to be very narrow, especially compared to that for Agingan WWTP (with an allowable range from 6 to 9). A wider and more practical range of allowable pH values that more closely reflect receiving water pH levels, and also more consistent with that for Agingan WWTP, is recommended.

Figure 2.2.3-7. **Effluent pH at Sadog Tasi Wastewater Treatment Plant**



Effluent copper and zinc have generally exceeded NPDES limits during the sampling period, averaging 18 µg/L and 50 µg/L over the sampling period respectively (see Figure 2.2.3-8). NPDES limits for monthly average readings are 2.4 µg/L and 45 µg/L for copper and zinc, respectively.

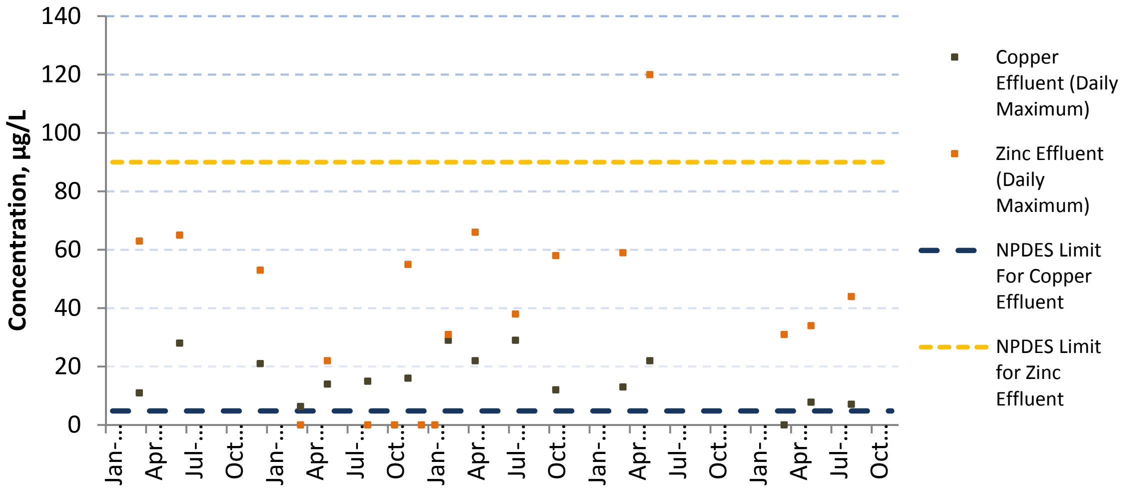
After consulting with CUC and DEQ, it is believed that the most likely source of copper and zinc is from the existing facilities throughout the island that have copper plumbing, coupled with the reverse-osmosis produced water. This assumption is based on lead and copper testing results from DEQ. Some of these facilities, for example the Commonwealth Health Center (CHC), the Horiguchi Building (which houses the Federal Court and other Federal offices) and the LSG Flight Kitchen, have had results which approach the Maximum Contaminant Level (MCL) for copper, which is 1.3 mg/L. The low ionic content and mildly acidic pH of reverse osmosis product water results in leaching of copper from pipes, and lead, zinc, and silver from solder and fittings. Given that the water quality criterion for copper is three orders of magnitude lower than the MCL of copper, even these relatively limited sources of copper, zinc, silver, and lead are likely to pass through the wastewater treatment process in sufficient concentrations to result in occasional exceedances.

DEQ has begun to require pH control in facilities that have shown elevated lead and copper results. For example, CHC now adds lime to its water on a daily basis to buffer the pH. However, even with the addition of site-specific pH controls, one of the root causes of the exceedances is the strict prohibition on the allowance of mixing zones for toxics in the CNMI Water Quality Standards. The CNMI Water Quality Standards are stricter than the requirements of the Clean Water Act, which allows dilution to be considered in the development of effluent limitations for toxics, following EPA guidance. DEQ and CUC have discussed the possibility of revising the CNMI Water Quality Standards to allow the granting of mixing zones. The following quotation is from DEQ's 2009 Mixing Zone approval for the Agingan Point wastewater treatment plant:

> DEQ notes that its regulations with respect to the prevention of "acute lethality" are more stringent than the USEPA's guidelines, which allow for the establishment of mixing zones using the methodologies explained in the revised *Technical Support Document for Water Quality-Based Toxics Control* (EPA/505/2-90-001, 1991; TSD). Future revisions of the CNMI standards may include such allowances.

A separate outfall mixing analysis and assessment is being performed as part of the development of this Master Plan to support the proposed inclusion of a mixing zone dilution factor for metals and other toxic pollutants. Acceptance of this proposal will make the permit requirements for both Sadog Tasi and Agingan WWTPs more consistent with standard EPA guidance and result in Sadog Tasi effluent being within NPDES limits.

Figure 2.2.3-8. **Effluent Copper and Zinc Concentrations at Sadog Tasi Wastewater Treatment Plant**



Other parameters, including phosphorus, nitrogen, and turbidity, are generally in compliance, with no significant peaks in concentration or continuous cases of non-compliance. See Figures 2.2.3-9 and 2.2.3-10 for trending graphs for the various parameters. For these parameters, due to the low flows going through the plant, all standards at the edge of the mixing zones are easily achieved (see the outfall assessments in Sections 2.2.4 and 2.2.5).

Figure 2.2.3-9. **Effluent Nitrogen and Phosphorous Concentrations at Sadog Tasi Wastewater Treatment Plant**

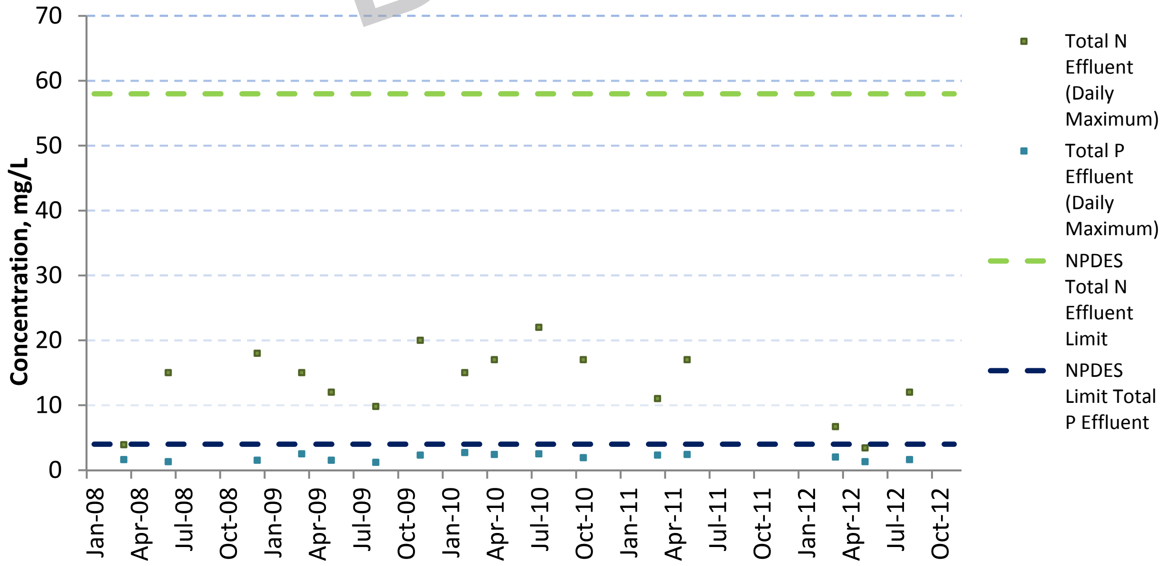
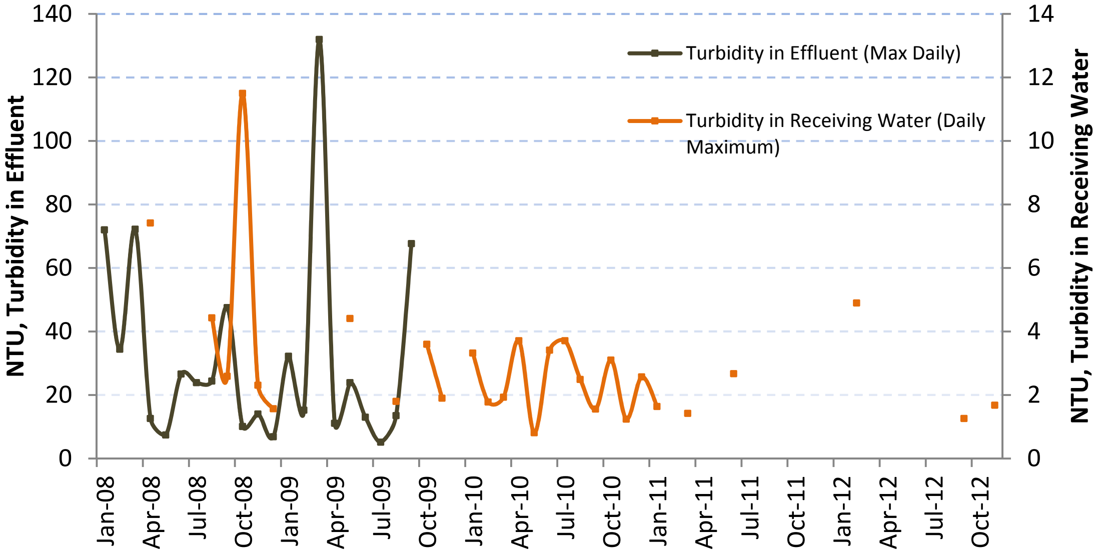


Figure 2.2.3-10. **Turbidity in Effluent and Receiving Waters at Sadog Tasi Wastewater Treatment Plant**



Sadog Tasi whole effluent toxicity (WET) tests have generally yielded positive (“pass”) results. The species used for testing—*Hyalella azteca*—is a species that is tolerant to salinity. See Table 2.2.3-3 for WET testing results.

Table 2.2.3-3. **Whole Effluent Toxicity Testing Results for Sadog Tasi Wastewater Treatment Plant**

Date	Species: *Hyalella azteca*
March 2008	Fail
March 2009	Pass
August 2009	Pass
March 2011	Pass

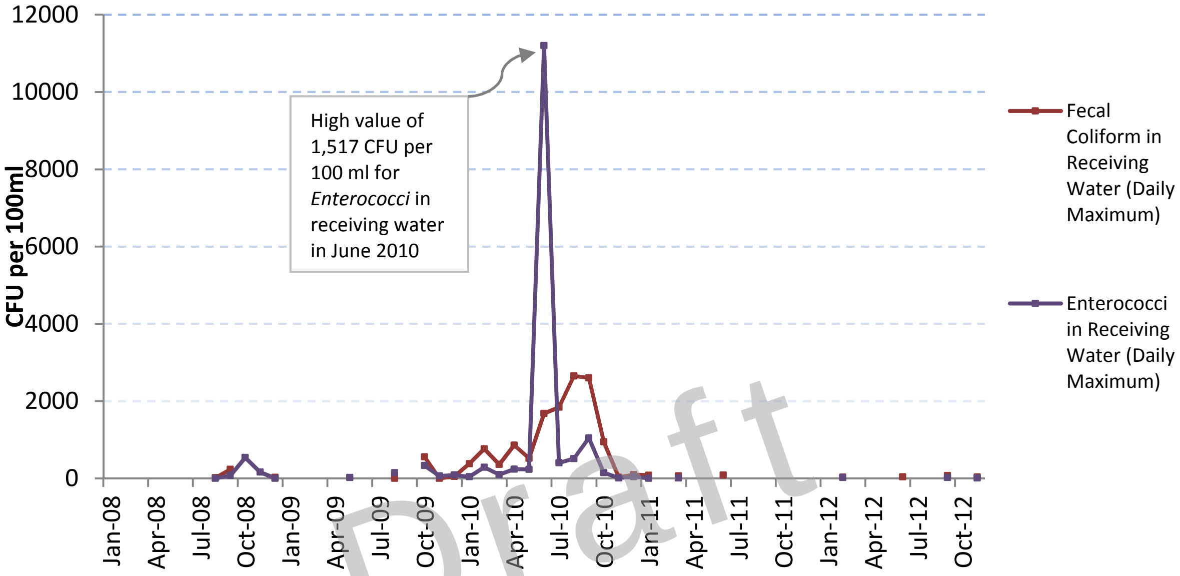
Gaps in monitoring frequency and regularity were observed in the available data. For example, no monitoring data for effluent turbidity after September 2009 were available, and pH and bacterial concentrations in receiving waters were not monitored from January 2009 to April 2009 and again from June 2009 through July 2009.

Limited operational data, such as DO measurements, MLSS concentrations, sludge recycle and wasting rates, and sludge solids content, are available. If resources are available to collect and review these data, plant operators could use this information to make process decisions in their day-to-day operational activities.

Receiving Water Quality

In terms of water quality, the receiving waters of the Sadog Tasi WWTP showed stable values with few exceptions. One exception included a sharp increase in *Enterococci* in June 2010. Fecal coliform readings in receiving waters also showed an increase from June 2010 to September 2010. These readings might be directly attributed to the plant construction previously discussed. See Figure 2.2.3-11 for trending graphs.

Figure 2.2.3-11. **Receiving Waters *Enterococci* and Fecal Coliform Concentrations at Sadog Tasi Wastewater Treatment Plant**



High value of 1,517 CFU per 100 ml for *Enterococci* in receiving water in June 2010

pH is generally stable in the receiving waters, mostly due to the presence of natural buffers within the receiving waters. Only one instance occurred where the daily minimum pH value dropped significantly to 7.66 (October2009), although that result could be an outlier (see Figure 2.2.3-12). The nitrogen levels averaged 0.25 mg/L in the receiving waters over the recording period, with a zero reading recorded in April 2010, while average phosphorus levels are negligible at 0.06 mg/L in the receiving waters (see Figure 2.2.3-13).

The NDPES permit for Sadog Tasi WWTP requires a weekly water column monitoring frequency for turbidity. This weekly monitoring requirement is very onerous because already limited resources need to be diverted to logistical needs, such as boating, to carry out the sampling activities at such a frequency. In comparison, the Agingan permit requires a quarterly monitoring frequency.

Figure 2.2.3-12. **Receiving Waters pH at Sadog Tasi Wastewater Treatment Plant**

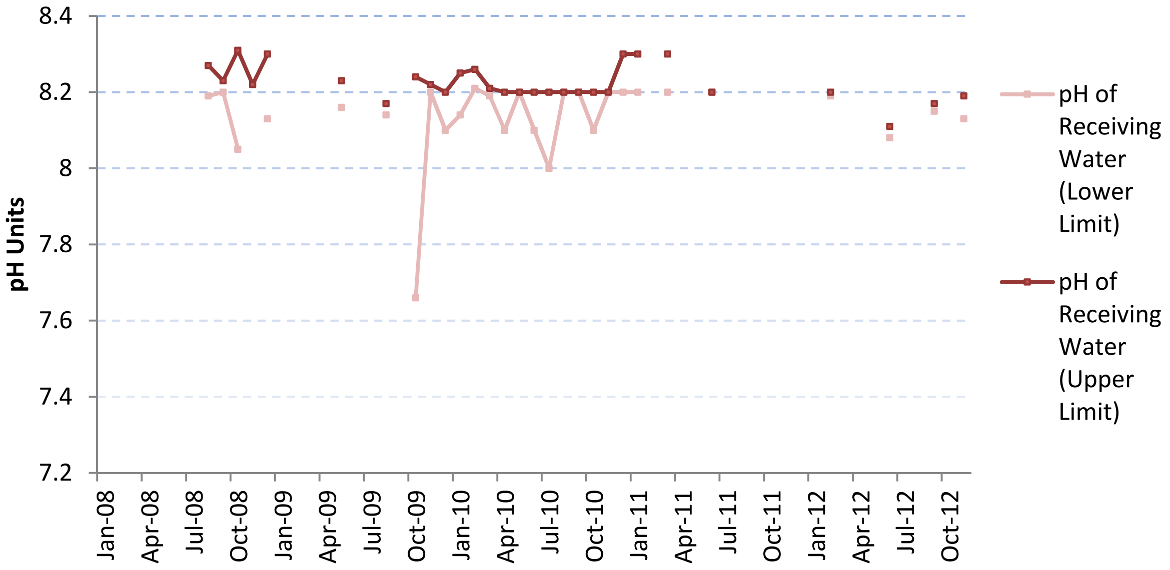
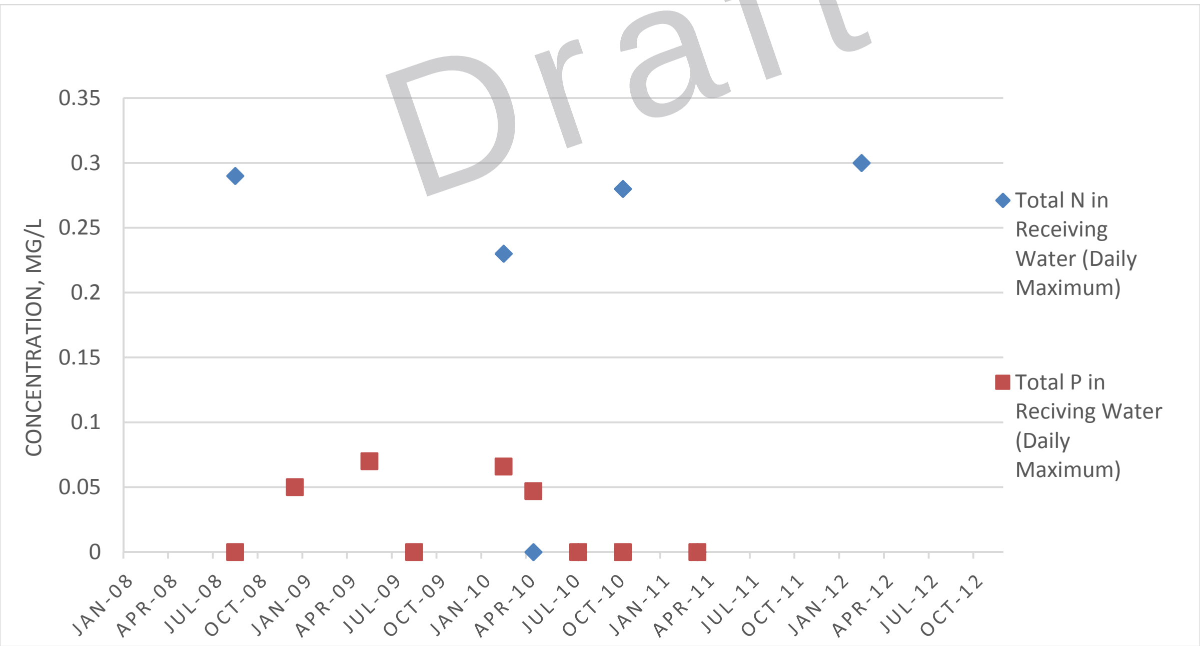


Figure 2.2.3-13. **Receiving Waters Nitrogen and Phosphorous Concentrations at Sadog Tasi Wastewater Treatment Plant**



Operational Observations

Operational observations from Sadog Tasi WWTP recorded during the WWTP assessment are as follows:

- Low MLSS concentration is a current concern, and the operator has been recycling most of the sludge to try to increase the MLSS concentration. Influent BOD and TSS are also noticeably lower than that for which the plant was originally designed. These current low loading rates make it a challenge for the plant to achieve a stable concentration of MLSS in the aeration basins, which makes plant performance more susceptible to process upsets caused by unusually high incoming loads or wet weather flows.
- It was observed that some nameplates on electrical boards do not accurately identify the equipment being served. While this does not affect operations, it poses a risk for personnel not familiar with the plant equipment as one could inadvertently turn the wrong piece of equipment on or off.
- The O&M manual for Sadog Tasi WWTP provides stepwise instructions for the basic operation of the treatment plant, but does not document the operating range of key process parameters based on past and current operating experience. Including records of operating parameters such as HRT, SRT, sludge recycle and wasting rates, and polymer dosing values in the O&M manual will provide continuing operations guidance and basis for future adjustments. While the present main operator is experienced, the manual should document operational information to aid future operators in terms of understanding and operating the system.
- There is no regular schedule for process control sampling within the plant. Currently, process control adjustments are done on an ad hoc basis.
- Currently there are no certified wastewater treatment plant operators employed by CUC. Overall, plant operators are not highly experienced in plant operations. The EPA Stipulated Order and the CNMI (DEQ) regulations require that CUC have one certified operator, and it is desirable to have more trained operators present at the WWTP than required. However, it is difficult for CUC to recruit and retain certified operators. CUC should consider instituting a training program, and more importantly, implement changes to its personnel system to recognize and reward staff who reach certain education and certification milestones.
- Sadog Tasi WWTP currently does not have any preliminary screening or grit removal equipment present at the plant. Bar screens are present only at the influent pump station S-3. The S-3 pump station previously had a “Muffin Monster” grinder to reduce large debris entering the plant into small particles. However, the “Muffin Monster” grinder created maintenance issues and failed after a short period. It has since been taken out of service.
- Foaming was observed in the aeration basin at the time of inspection. The following subsection addresses this operational challenge in more detail.
- The operator noted that there are currently some reliability issues with the clarifier. Plans were being made to replace some parts, such as the scum removal mechanism, and to install a spray nozzle system to improve foam and scum removal (completed as of January 2013).
- The sludge withdrawal pump tends to choke, resulting in the need for manual decanting of the digester. A possible remedy mentioned was to increase the number of holes in the suction pipe for the sludge withdrawal pump (completed as of January 2013). Another alternative is to perform sludge withdrawal to the BFP by pumping directly from the digester basin where sludge concentration is lower.

- Emergency generators for Sadog Tasi WWTP have recently been overhauled, and they have been successfully test-operated.
- An additional tank, similar in size to the main treatment tank and known as the “Japanese Tank,” is in operation. Waste sludge has been dumped into the tank for several years and it contains approximately 5 to 8 feet of water. Approximately 30 feet deep, the tank would require heavy dredging for it to be used.
- The Sadog Tasi WWTP facility generally is in need of plant maintenance equipment, such as dump trucks and Bobcats (loaders).

Activated Sludge Foaming

The foam observed at Sadog Tasi WWTP appeared to be caused by filamentous microorganisms as it occurred as a thick, stable, brown foam on the aeration basin surfaces. Some commonly known filamentous organisms such as *Nocadia* and *Microthrix parvicella* can cause activated sludge foaming by growing on grease and oil. Growth of *Nocadia* and *Microthrix parvicella* occurs at longer sludge ages and under low oxygen conditions.

A potential source of oil and grease is the discharge of FOG from sources such as restaurant grease traps into the digesters, which can be recycled back into the aeration basins via the supernatant overflow. There might be some benefit in limiting oil and grease from being recycled, possibly through a baffle before the overflow. A reduction in the sludge age can also help to control the foaming in some cases. Long sludge ages can occur when operators limit sludge wasting to build up mixed liquor suspended solids in the aeration basin. CUC should consider adopting other strategies to try to sustain a viable biomass in the aeration basins at Sadog Tasi. This alternative is assessed in the subsequent section using a process model.

Physical control of foaming can be achieved through the use of scum traps and water spray containing Cl to remove the foam from the aeration basin. The foam should not be recycled back to the plant. Foam disposal into the aerobic digester should also be avoided as it can increase the problem of foaming in the digester.

Agingan WWTP

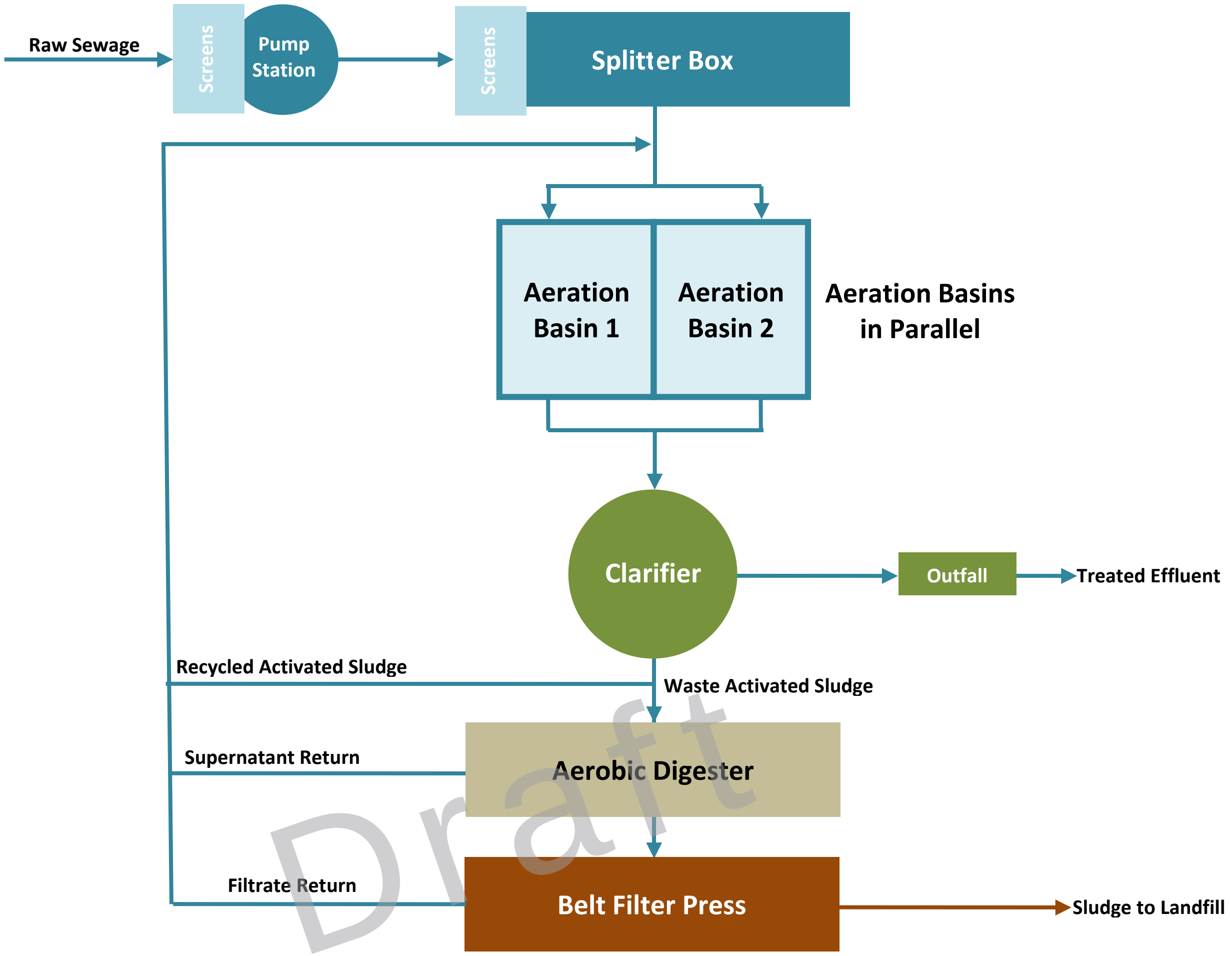
The Agingan WWTP receives wastewater from the southern sewered areas in Saipan.

Treatment Process Overview

This section outlines the treatment processes currently in use at Agingan WWTP. Relevant and major changes made to the plant that may have an impact on the process efficiency and capabilities are also highlighted. Raw sewage is pumped into the WWTP via an offsite pump station (Station A-16). The WWTP has undergone a substantial redesign; it was under construction at the time of the operational inspection and review. The new process schematic is shown in Figure 2.2.3-14.

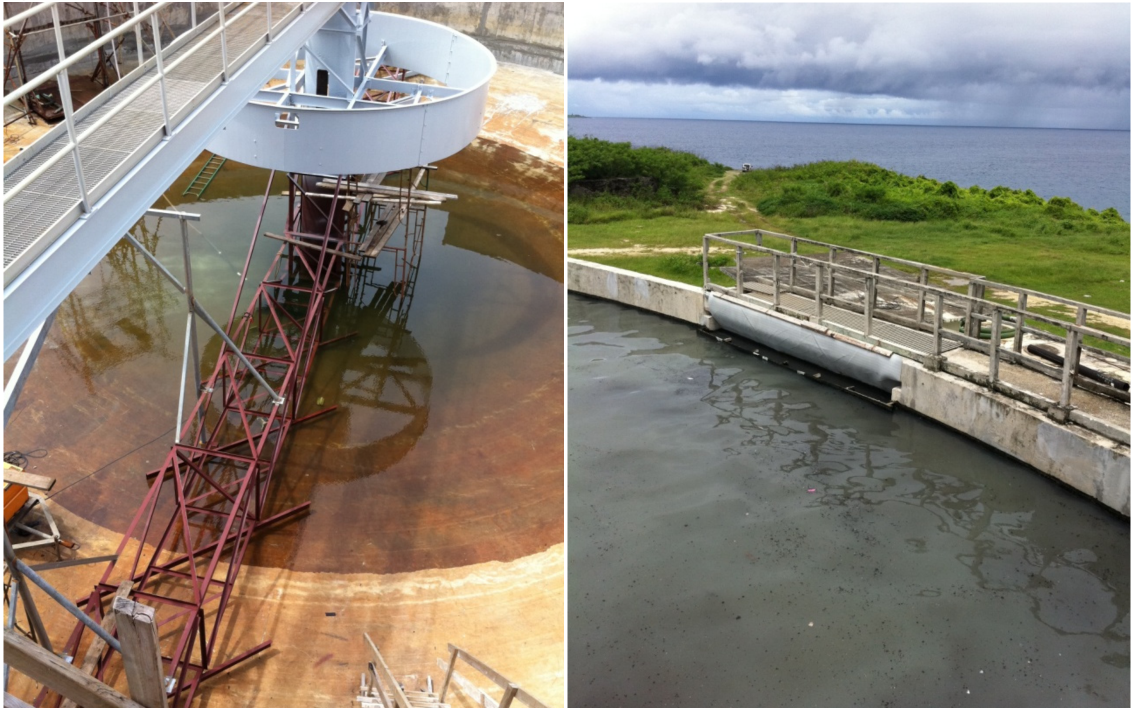
The current treatment process at the Agingan WWTP utilizes an activated sludge system (secondary treatment) that is equipped with aerated biological reactors to treat the sewage. Also known as the carousel system, the activated sludge system consists of two plug flow aeration basins, each with an aeration zone at the start of the tank. A portion of the sludge from the clarifier is recycled back to the aeration basins to ensure process continuity, while the remainder is wasted. The waste sludge is treated in an aerobic digester before it is withdrawn directly from the digester and sent to a BFP to reduce its water content and volume. After the BFP, the sludge cakes are sent to onsite drying beds for further drying. No disinfection process is used within the treatment process.

Figure 2.2.3-14. **Agingan WWTP Treatment Process Outline**



The retrofit of the Agingan WWTP involved rehabilitating its current infrastructure to improve its operability (Figure 2.2.3-15). Because the adjustable weirs in the aeration basins were never utilized, the flexibility to adjust the weirs was removed. At the time of the plant evaluation and field observations, the weirs were fixed at 12.5 feet from the bottom of the tank. As a result, the impeller was submerged in a minimum liquid level of 4 inches at low flows and maximum liquid level of 9 inches at peak flows. The new aerators' impellers have a slightly different submergence performance characteristic compared to those that were replaced; for this reason CUC raised the weir elevations to meet the manufacturer's recommended submergence depth. Per the aerator manufacturer, weir elevations were set relative to the top plate of the new impellers, at ¼-inch above the top of the impeller plate. Without adjustable weirs, aeration power can only be adjusted by shutting off unneeded aerators. CUC is considering installing variable frequency drives (VFDs) to enable an alternative method of controlling aeration rates. However, the additional complexity of a VFD installation may not be justified as the present system appears to be able to meet effluent limits under its current configuration.

Figure 2.2.3-15. **Agingan Wastewater Treatment Plant Retrofitting Works**



The average MLSS values for the Agingan WWTP carousel system have been recorded at approximately 2,300 mg/L, which falls within the general recommended range of 2,000 mg/L to 3,000 mg/L for plug flow systems. However, Agingan WWTP has been facing operational challenges due to construction activities, although these challenges should be rectified once the retrofitting work is complete.

A summary of the design parameters for the Agingan WWTP, captured from available documentation, is provided as Table 2.2.3-4. While some information is not available from existing documentation, it is recommended that data from current operations be progressively recorded to aid future O&M needs.

Table 2.2.3-4**. Design Criteria for Agingan Wastewater Treatment Plant**

Design Criteria	
Design Parameter	**Agingan WWTP**
Average Design Flow, Q_{ave}	3.0 MGD
Peak Wet Weather Flow	Information not available
Temperature	Information not available
Influent Biochemical Oxygen Demand (BOD)	200 mg/L
Influent Total Suspended Solids (TSS)	200 mg/L
Influent Total Kjeldahl Nitrogen (TKN)	Information not available
Effluent BOD Limit	30 mg/L
Effluent TSS Limit	30 mg/L
Effluent Ammonia Nitrogen (NH_3-N)	Information not available

Table 2.2.3-4. **Design Criteria for Agingan Wastewater Treatment Plant**

Design Criteria	
Design Parameter	**Agingan WWTP**
Aeration Basins	
Detention Time @ Q_{ave} for Aeration Basins (HRT)	Information not available
Solids Retention Time (SRT)	11.5 days
Volume of Aeration Basins (Total)	1.22 MG
Assumed AOR/Standard Oxygen Required (SOR)	Information not available
Assumed Oxygen Requirements	Information not available
Assumed Load Factor, F/M	0.123 lb BOD/lb MLSS/day
Type of Aeration	1 @ 100 HP single-speed aerator per basin
Standard Oxygen Transfer Efficiency (SOTE) @ Q_{ave}	Information not available
Secondary Clarification	
# of Clarifiers	1
DIA	47.5 ft
Sidewater Depth	Information not available
Overflow Rate @ Q_{ave}	Information not available
Sludge Removal Method	Centrifugal pump
Weir Loading @ Q_{ave}	Information not available
Aerobic Sludge Digestion	
Number of Basins	1
Volume of Basins	0.61 MG
Maximum Water Depth	Information not available
Maximum Solids Feed to Digester	Information not available
Maximum Volume Feed to Digester (Waste Activated Sludge, WAS @ 0.75%)	Information not available
Solids Loading	3520 lb TSS/day
Theoretical Detention Time at 2% Solids	Information not available
Assumed Oxygen Requirements for WAS	Information not available
Type of Aeration	50 HP Aerator
Method of Sludge Concentration	Information not available
Settling Basin Size	Information not available
Sludge Pumping	
WAS Pumps	2 @ 5 HP centrifugal pumps with 300 GPM capacity (each)
RAS Pumps	2 @ 15 HP centrifugal pumps with 2000 GPM (each)
Digested Sludge Pumps	1 @ 15 HP positive displacement with 200 GPM (each)
Sludge Handling	
Dewatering Type	2-meter belt filter press

Assessment of the Physical Condition of Agingan Wastewater Treatment Plant

This section briefly discusses and summarizes the assessment of the physical condition of treatment facilities and equipment at Agingan WWTP. The condition assessment is based on both visual observations and from information gathered during discussions conducted during the visits to the WWTP.

Agingan WWTP was being retrofitted and was under construction at the time of the visit. As part of the retrofit, plant equipment and facilities are being rehabilitated and process improvements to the current systems are being built in. Most mechanical equipment was observed to be new and in good condition.

Listed below are the observations made on the facility's condition during the visit:

- Pump station A-1 acts as backup to A-16. The collection system before A-16 has upstream manholes that are low-lying and can overflow whenever both A-16 and A-1 fail, resulting in overflows into nearby homes and the beach.
- Weir elevations in the aeration tanks are fixed at 0.25 inches above the top of the impeller plate as per manufacturer recommendation.

Overview of NPDES Permit Requirements for Agingan Wastewater Treatment Plant

This section summarizes the NPDES permits for Agingan WWTP. It also provides information on effluent limitations and other requirements necessary to protect the environment and public health and safety. A summary table for the permit requirements for Agingan WWTP is provided as Table 2.2.3-5.

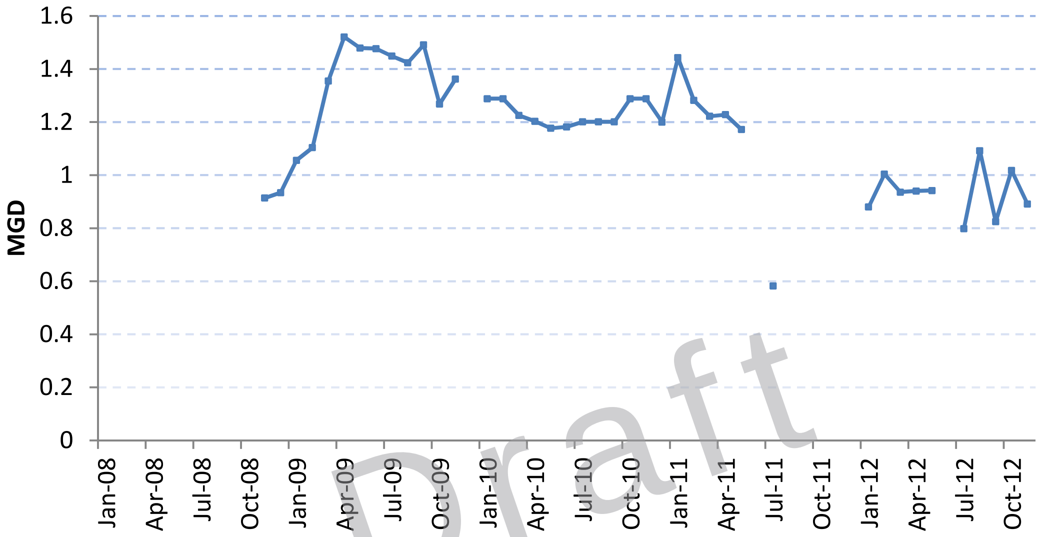
The NPDES permit (MP0020028) for the discharge of effluent from Agingan WWTP through the Agingan Point Outfall became effective October 1, 2009 and expires September 30, 2015. The structure of the permit is similar to that for the Sadog Tasi WWTP with a few differences. The primary parameter limits of BOD and TSS are the same as that for Sadog Tasi WWTP (30 mg/L and 45 mg/L for the monthly and weekly averages, respectively). In addition, the permit is interpreted to state that the monthly average effluent BOD and TSS concentrations are not to be more than 15 percent of the monthly average influent BOD and TSS concentrations, i.e., the WWTP must achieve at least 85 percent reduction by concentration.

Similar to the permit for Sadog Tasi WWTP, the purpose of the permit for Agingan WWTP is to protect the environment from discharges that have undesirable effects on the ecosystem or the environment. Toxicity testing of Agingan WWTP effluent is required to involve the freshwater amphipod *Daphnia magna* in addition to the amphipod *Hyalella azteca*. Submittal of a full toxicity laboratory report to EPA is required for Agingan WWTP. The permit also regulates pre-treatment requirements to minimize the introduction of hazardous wastes into the wastewater system, the bio-solids treatment system, the bio-solids disposal location, and receiving waters.

Assessment of Hydraulic Capacity of Agingan Wastewater Treatment Plant

Agingan WWTP was originally designed to treat an average daily flow of 3.0 MGD. However, based on flow records, the actual average flow is approximately 1.3 MGD over the recording period. The maximum flow recorded between January 2008 and November 2012 was approximately 2.5 MGD, a one-time occurrence, with daily maximum flows averaging at approximately 1.6 MGD. Based on this flow data, Agingan has been experiencing flows at a rate lower than its design capacity. Based on flow trending (see Figure 2.2.3-16), the flow has stabilized since January 2010, although flow did decrease significantly to 0.58 MGD in July 2011.

Figure 2.2.3-16. **Monthly Average Influent Flow to Agingan Wastewater Treatment Plant**



Flows to the Agingan WWTP are conveyed from Pump Station A-16 as Agingan WWTP does not have a dedicated influent pump station (IPS). During maintenance work or pump failure at A-16, Pump Station A-1 is used to convey flows into Agingan WWTP. However, inflows are only measured at the A-16 pump station. When Pump Station A-1 is operating, it pumps to the WWTP through an old, 10-inch AC pipe force main, which runs through the Voice of America broadcasting tower facility and other non-CUC properties. Although this forcemain provides a useful backup when there is a problem with the 18-inch PVC force main from Pump Station A-16, the 10-inch AC force main is very old and its condition is not known. It is also difficult to access as it runs through private properties.

Some data from the A-16 flow data were missing for the sampling period between January 2008 and August 2011. If a new flow meter is installed before the headworks within the WWTP or at the plant effluent pipe, it may serve as a backup flow meter when the A-16 flow meter fails or when pump Station A-1 is in operation instead of A-16; it may also serve as a countercheck against the upstream flow readings under normal circumstances. A backup flow meter will also ensure that the information on flow loadings into the plant is readily available to the plant operator.

Table 2.2.3-5. **National Discharge Pollutant Elimination System Permit Requirements for Agingan WWTP**

	Agingan WWTP (Permit No. MP0020028) (Based on Average Daily Design Flow of 3.0 MGD)							
	Mass Limits (lb/day)			**Concentration Limits**				
	Monthly Average	**Weekly Average**	**Daily Maximum**	**Monthly Average**	**Weekly Average**	**Daily Maximum**	**Monitoring Frequency**	**Sample Type**
Flow	N.A.	N.A.	N.A.	Monitoring and Reporting Required			Continuous	Continuous
Biochemical Oxygen Demand (5-day)[1]	751	1,126	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite
Total Suspended Solids[1]	751	1,126	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite
Settleable Solids	Not Regulated							
Oil and Grease	Monitoring and Reporting Required						Quarterly	Discrete
Whole Effluent Toxicity[2]	N.A.	N.A.	N.A.	N.A.	N.A.	Pass	Semi-Annually	24-hour Composite
Enterococci	N.A.	N.A.	N.A.	5,746 CFU/100mL	N.A.	11,529 CFU/100mL	Weekly	Discrete
Total Cl Residual	0.3	N.A.	0.3	N.A.	N.A.	12.4 µg/L	3 days/ week	Discrete
pH	Within range of 6-9 standard units						3 days/ week	Discrete
Nitrate-Nitrogen	1,252	N.A.	2,503	50 mg/L	N.A.	100 mg/L	Monthly	24-hour Composite
Total Nitrogen	1,878	N.A.	3,768	75 mg/L	N.A.	150.5 mg/L	Monthly	24-hour Composite
Ortho-phosphate	125	N.A.	250	5 mg/L	N.A.	10 mg/L	Monthly	24-hour Composite
Total Phosphorus	125	N.A.	250	5 mg/L	N.A.	10 mg/L	Monthly	24-hour Composite
Unionized Ammonia	50	N.A.	100	2 mg/L	N.A.	4 mg/L	Monthly	24-hour Composite
Copper	0.12	N.A.	0.12	N.A.	N.A.	4.8 µg/L	Quarterly	24-hour Composite
Lead	0.33	N.A.	0.33	N.A.	N.A.	13.3 µg/L	Quarterly	24-hour Composite
Nickel	0.35	N.A.	0.35	N.A.	N.A.	13.4 µg/L	Quarterly	24-hour Composite
Silver	0.05	N.A.	0.05	N.A.	N.A.	1.9 µg/L	Quarterly	24-hour Composite
Zinc	2.2	N.A.	2.2	N.A.	N.A.	90 µg/L	Quarterly	24-hour Composite
Radioactive Material	The discharge of radioactive materials at any level to the receiving waters is strictly prohibited							
Other Priority Toxic Pollutants (except Asbestos)[3]	Monitoring and Reporting Required						Oct 2009 Oct 2012	
Others Requirements:	*Discharge to be free from:* 1. Materials that will settle to form objectionable sludge or bottom deposits. 2. Floating debris, oil, grease, scum, or other floating materials. 3. Substances in amounts sufficient to produce taste or odor in the water or detectable from the flavor in the flesh of fish, or in amounts sufficient to produce objectionable odor, turbidity, or other conditions in the receiving water. 4. High temperatures; biocides; pathogenic organisms; toxic, corrosive, or other deleterious substances at levels or in combinations sufficient to be toxic of harmful to human health or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water. 5. Substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life. 6. Toxic pollutants in concentrations that are lethal to, or that produce detrimental physiological responses in human, plant, or animal life. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species and/or significant alterations in population or community ecology or receiving water biota. *Discharge shall not cause:* 1. The concentration of DO in the receiving waters to be less than 75 percent saturation. 2. The concentrations of total filterable suspended solids in the receiving waters to be increased from ambient conditions at any time, or to exceed 40 mg/L except when due to natural conditions. 3. The salinity of the receiving waters to be altered more than 10 percent of the ambient conditions, or more than that which would otherwise adversely affect the sedimentary patterns and indigenous biota, except when due to natural causes. 4. The temperature of the receiving waters to vary by more than 1.0°C from ambient conditions. 5. The turbidity at any point in the receiving waters, as measured by nephelometric turbidity units (NTUs), to exceed 1.0 NTU over ambient conditions except when due to natural conditions. 6. The health and life history characteristics of aquatic organisms in receiving waters to differ substantially from those for the same receiving waters in areas unaffected by the discharge. Also, the discharge shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life in the receiving waters.							

[1] The arithmetic mean of the BOD and TSS values, by concentration, for effluent samples over a calendar month shall not exceed 15 percent of the arithmetic mean, by concentration, for influent samples.

[2] Based on the fifth edition of Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms (EPA-821-$-02-012, October 2002; Table IA, 40 CFR Part 136) ("Acute Toxicity TMM") Manual.

[3] Priority toxic pollutants are listed in 40 CFR 131.36 (b) (1). Permittee shall collect 24-hour composite samples for metals, 2,3,7,8-TCDD (dioxin), pesticides, base-neutral extractables, and acid-extractables. The permittee shall collect discrete samples for cyanide, total phenolic compounds and volatile organics.

Assessment of Existing Performance of Agingan WWTP

This section discusses in detail the BOD and TSS loadings that enter the WWTP and the process performance of the WWTP in relation to specific water quality parameters in the effluent water. These water quality parameters are also discussed in comparison with the NDPES requirements to assess the overall performance of the treatment process and operations. Consolidated water quality data can be found in Appendix E for Agingan WWTP.

Influent and Effluent Quality

The Agingan WWTP was originally designed for influent BOD and TSS values of 200 mg/L per parameter. Based on the available WQ data from January 2008 to November 2012, the average influent BOD for Agingan WWTP was 120 mg/L. Influent TSS readings before July 2008 were unstable, but stabilized to a value of approximately 100 mg/L since then, although TSS concentrations have decreased slightly since January 2011. The TSS values in April, September, and October 2012 were higher than average, causing a spike in the graph. Influent BOD has been stable throughout the reporting period with an average value of 110 mg/L. In recent months BOD concentrations in the influent have decreased to approximately 80 mg/L. Similar to what is observed in the Sadog Tasi data, these low influent BOD values can result in the WWTP exceeding NDPES limits for minimum 85 percent BOD removal, even when the limit on the average monthly value has been met. Starting in January 2011, the plant underwent a period of non-compliance in meeting the NPDES limits for effluent BOD and TSS concentrations. This non-compliance was most likely due to the ongoing construction work at the plant, during which the clarifier is offline for retrofitting work. See Figures 2.2.3-17 and 2.2.3-18 for TSS and BOD trending graphs, respectively.

Figure 2.2.3-17. **Monthly Average Influent and Effluent Average Total Suspended Solids Concentrations at Agingan Wastewater Treatment Plant**

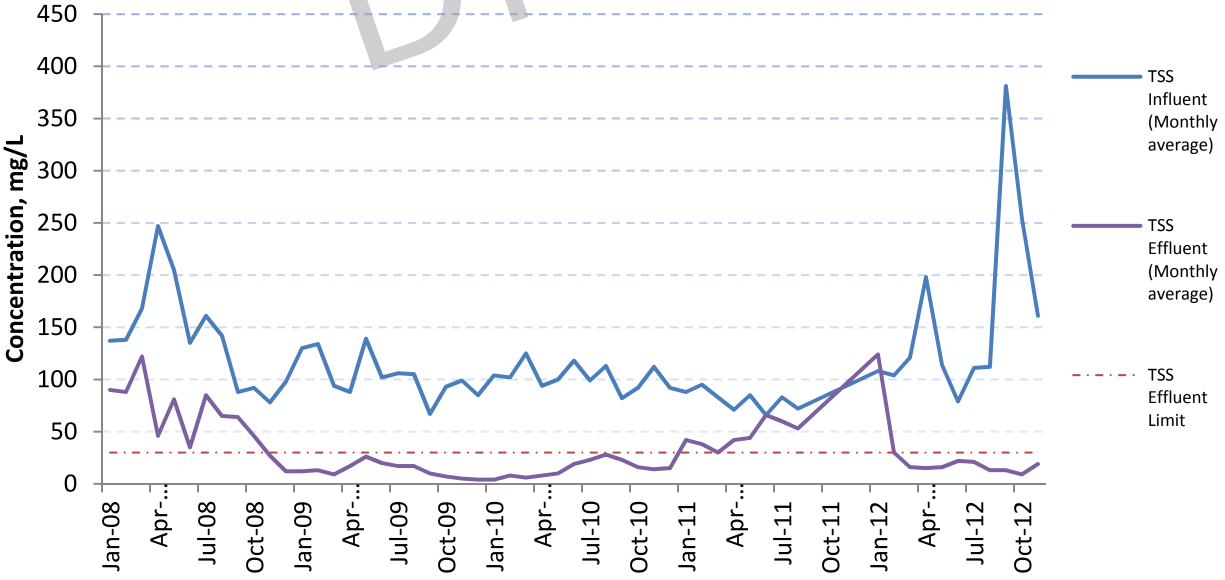
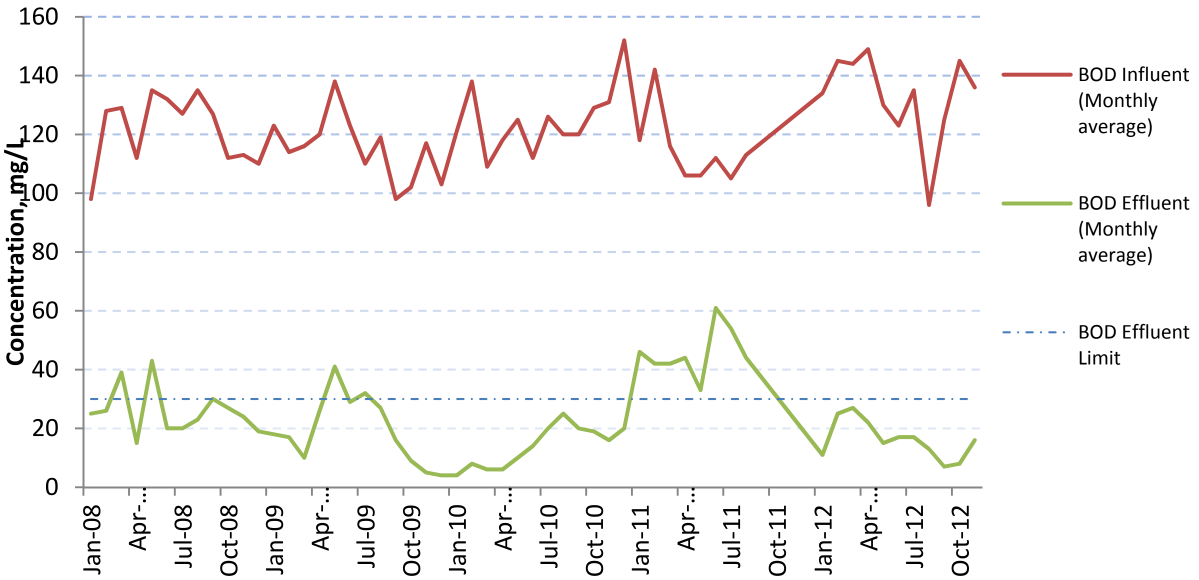


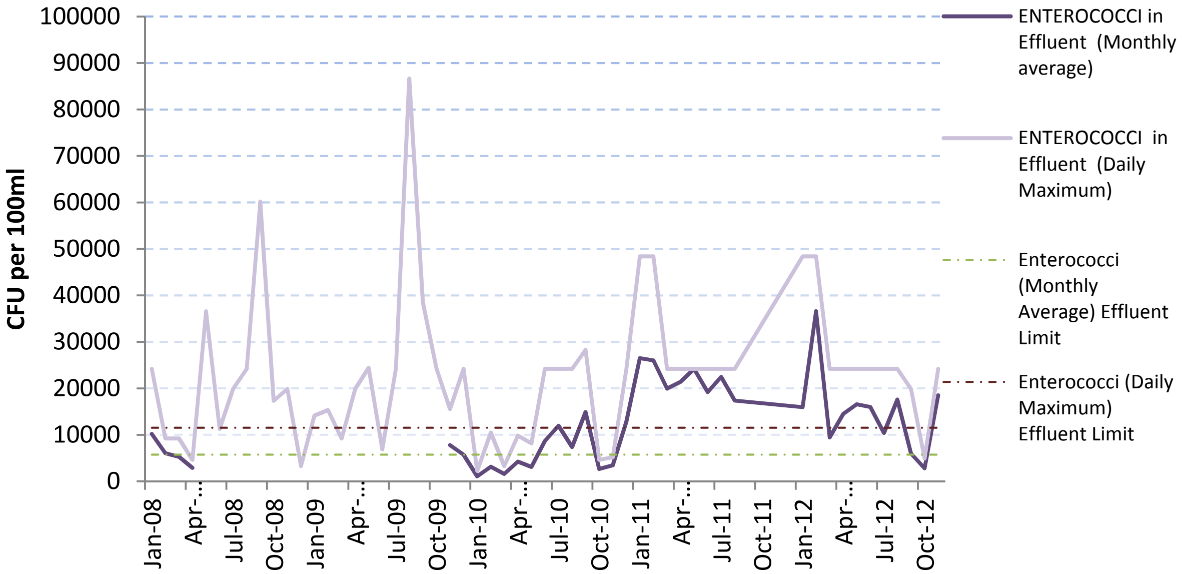
Figure 2.2.3-18. **Monthly Average Influent and Effluent 5-Day Biochemical Oxygen Demand Concentrations at Agingan Wastewater Treatment Plant**



Based on the available effluent water quality data (January 2008 to November 2012), the Agingan WWTP was unable to meet NPDES effluent standards for two periods since 2008. The first non-compliant period occurred in the initial recording period for the WWTP, from January 2008 to November 2008, where non-compliance for both TSS and BOD occurred above the permit threshold of 30 mg/L for both TSS and BOD parameters. During this period, the clarifier drive failed for extended durations and sludge solids built up within the clarifier without any proper means of removal, thus adversely impacting effluent quality. The second non-compliant period occurred from January 2011 through January 2012. The second non-compliance period at the Agingan WWTP was most likely due to the ongoing construction of retrofits at the plant, during which the clarifier was offline for retrofitting work. In an effort to decrease the high effluent TSS concentrations experienced during construction, a BFP cloth was used at the clarifier effluent weir to filter effluent solids. Other than these two non-compliant periods, plant effluent was generally compliant for most of the period from January 2009 to December 2010, except when the influent flow was higher than 1.4 MGD and the influent BOD was higher than 120 mg/L.

Effluent *Enterococci* values have consistently exceeded the NPDES permit levels of 5,746 CFU/100 ml for monthly average readings and 11,529 CFU/100 ml for daily maximum readings (Figure 2.2.3-19). The monthly average *Enterococci* concentration value for the period from January 2008 to November 2012 was approximately 12,274 CFU/100 ml, while the daily maximum was reported to be approximately 22,625 CFU/100 ml. The *Enterococci* values from March 2012 to September 2012 are generally lower than the values from January 2011 to January 2012, which could indicate a decreasing trend. With a revised NPDES permit limit based on the recomputed dilution values recommended in this Master Plan, these values would have met permit limits. However, further monitoring and data collection are required to confirm such a trend.

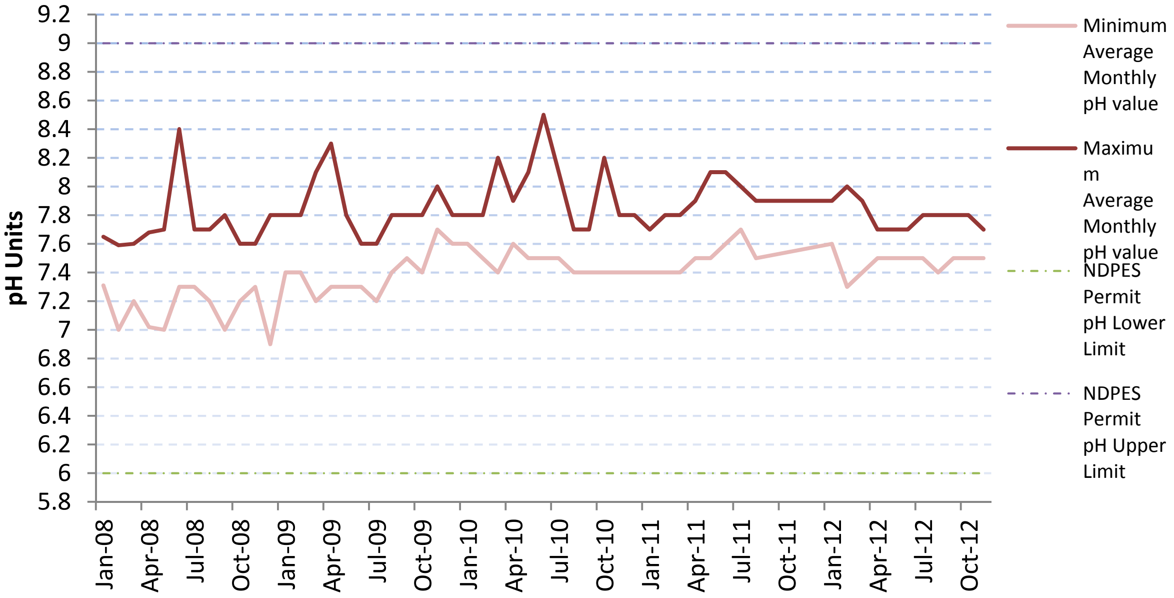
Figure 2.2.3-19. **Effluent *Enterococci* Concentrations at Agingan Wastewater Treatment Plant**



The elevated *Enterococci* levels in the effluent did not appear to have an impact on receiving waters as there were no reported spikes in *Enterococci* levels in the receiving water. Just as with the Sadog Tasi WWTP, bacterial concentrations in receiving waters are not regulated by the NPDES permit.

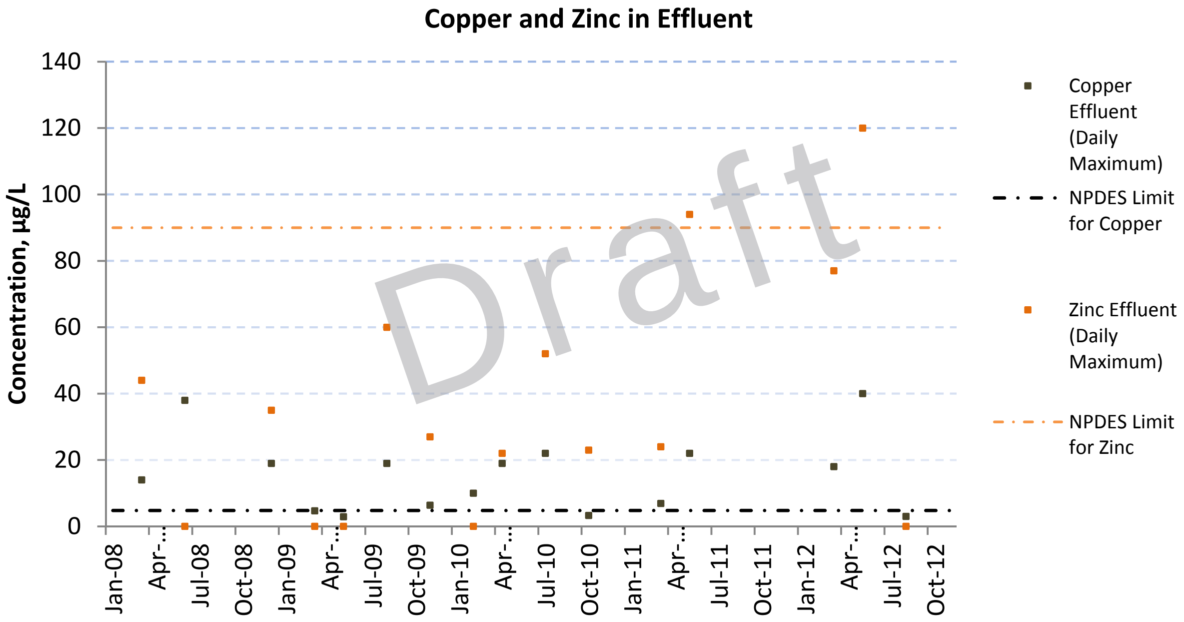
Effluent pH at the Agingan WWTP has been compliant with NPDES limits, with a pH range of 7.36 (minimum monthly average) and 7.86 (maximum monthly average) over the sampling period from January 2008 to November 2012 (Figure 2.2.3-20). The lower and upper limits for effluent pH per the NPDES requirements are 6 and 9, respectively. This is a larger range for pH values when compared to the NPDES limits for the Sadog Tasi WWTP. There are no reported problems with effluent pH NPDES compliance at Agingan WWTP.

Figure 2.2.3-20. **Effluent pH at Agingan Wastewater Treatment Plant**



NPDES limits for effluent copper and zinc at the Agingan WWTP for monthly average readings are 4.8 µg/L and 90 µg/L, respectively; these are generally very stringent limits when compared to the limits imposed on the Sadog Tasi WWTP (double that of the Sadog Tasi WWTP limits). Like the Sadog Tasi WWTP, copper concentrations from the Agingan WWTP effluent have generally exceeded NPDES limits during the sampling period from January 2008 through November 2012, with an average of 14.4 µg/L during the sampling period. Effluent zinc concentrations have been within NPDES limits, averaging at 42 µg/L during the reporting period from January 2008 to November 2012. The two instances of noncompliance, May 2011 and May 2012, occurred when the monthly average zinc concentration spiked at 94 µg/L and 120 µg/L, respectively. It is thought that this spike could be due to the ongoing construction work at the plant. Similar to the discussion for Sadog Tasi's effluent copper and zinc concentrations, the WWTP processes are not designed for the removal of these metals, hence it is unlikely that these concentrations can be lowered through treatment alone. By allowing a mixing zone dilution factor for metals and other toxic pollutants, it is likely that the permit levels can be met. See Figure 2.2.3-21 for trending graph of effluent copper and zinc concentrations.

Figure 2.2.3-21. **Effluent Copper and Zinc Concentrations at Agingan Wastewater Treatment Plant**



Other effluent parameters for Agingan WWTP, including nitrogen, phosphorus, ammonia, turbidity, and nickel, are within limits with no major or continuous periods of noncompliance. It was observed that nitrogen and phosphorus levels spiked in April 2011 and zinc levels spiked in May 2011, which correspond to the ongoing construction work and clarifier breakdown. See Figures 2.2.3-22 and 2.2.3-23 for trending graphs for effluent nitrogen, phosphorus concentrations, and turbidity, respectively.

Figure 2.2.3-22. **Effluent Nitrogen and Phosphorus Concentrations at Agingan Wastewater Treatment Plant**

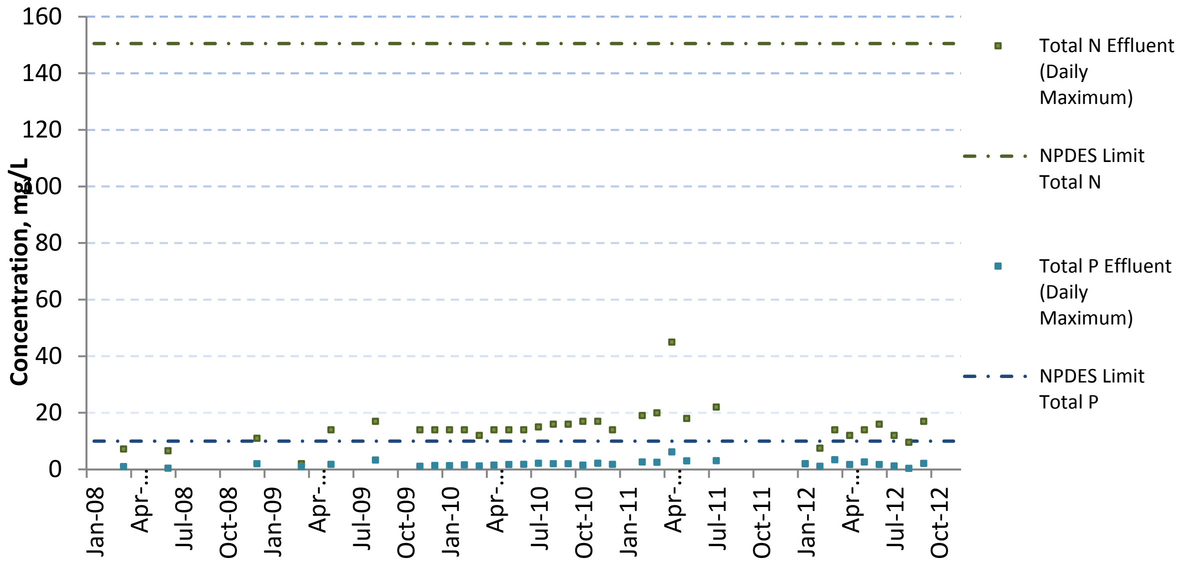
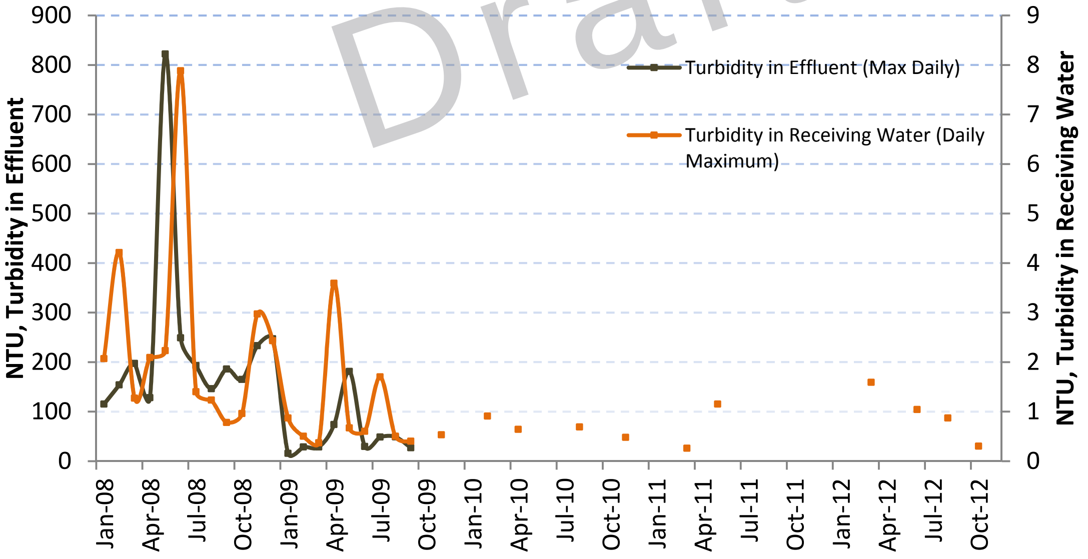


Figure 2.2.3-23. **Turbidity in Effluent and in Receiving Waters at Agingan Wastewater Treatment Plant**



There have been compliance issues with the WET testing for Agingan WWTP in the past; WET tests yielded negative (“fail”) results between 2007 and May 2009. However, since October 2009, after the NDPES permit was renewed, results have significantly improved. However, the renewed NPDES permit increased the number of species required for WET testing to two species, and increased testing to once every 6 months. See Table 2.2.3-6 below for WET testing results.

Table 2.2.3-6. **Whole Effluent Toxicity Testing Results for Agingan Wastewater Treatment Plant**

Date	Species: *Daphnia magna*	Species: *Hyalella azteca*
June 2007	Pass	Not required
August 2007	Fail	
October 26, 2007 (Follow-up #1 from Aug 2007)	Pass	
November 12, 2007 (Follow-up #2 from Aug 2007)	Pass	
November 26, 2007 (Follow-up #3 from Aug 2007)	Fail	
December 2007	Fail	
February 2008	Fail	
June 2008	Sample lost during shipping delay	
September 2008	Fail	
December 2008	Fail	
March 2009	Fail	
May 2009	Fail	
August 2009	Pass	
November 2009	Pass	Pass
April 2010	Pass	Pass
July 2010	Pass	Pass
March 2011	Pass	Pass
August 2011	Pass	Fail

The original species—*Daphnia magna*—is a freshwater species, which was used during the period when negative results were obtained. The second species—*Hyalella azteca*—is known to be more tolerant to salinity and, in the WET tests conducted so far, has shown a high “pass” rate. While these data do not clearly show the comparative advantage of using either species, based on its higher tolerance to salinity, it would appear that *Hyalella azteca* is a better choice for WET testing given that the receiving water is saline. The Sadog Tasi permit uses *Hyalella azteca* as the sole test species, and the same approach should be adopted for Agingan WWTP.

Similar to the observation for the Sadog Tasi WWTP, it is recommended that resources be allocated to collect and review operational data such as DO measurements, MLSS concentrations, sludge recycle and wasting rates, and sludge solids content. This information will aid plant operators in making process decisions in their day-to-day operational activities.

Similar to the Sadog Tasi WWTP, due to the low flows going through the plant, all standards at the edge of the mixing zones are easily achieved (see Section 2.2.5).

Receiving Water Quality

In general, the water quality parameters of the receiving waters at Agingan WWTP showed stable values (Figures 2.2.3-24 and 2.2.3-25). pH values of receiving waters were extremely stable, with few fluctuations occurring. No issues with fecal coliform concentrations in the Agingan WWTP receiving waters were found, with the last fecal coliform spike occurring in February 2008. Since then, fecal coliform readings have been stable. *Enterococci* concentrations have also been stable except for peaks in the December 2008 and April 2010 readings that cannot be clearly connected to any plant effluent quality issues.

Figure 2.2.3-24. **Receiving Waters *Enterococci* and Fecal Coliform Concentrations in Agingan Wastewater Treatment Plant**

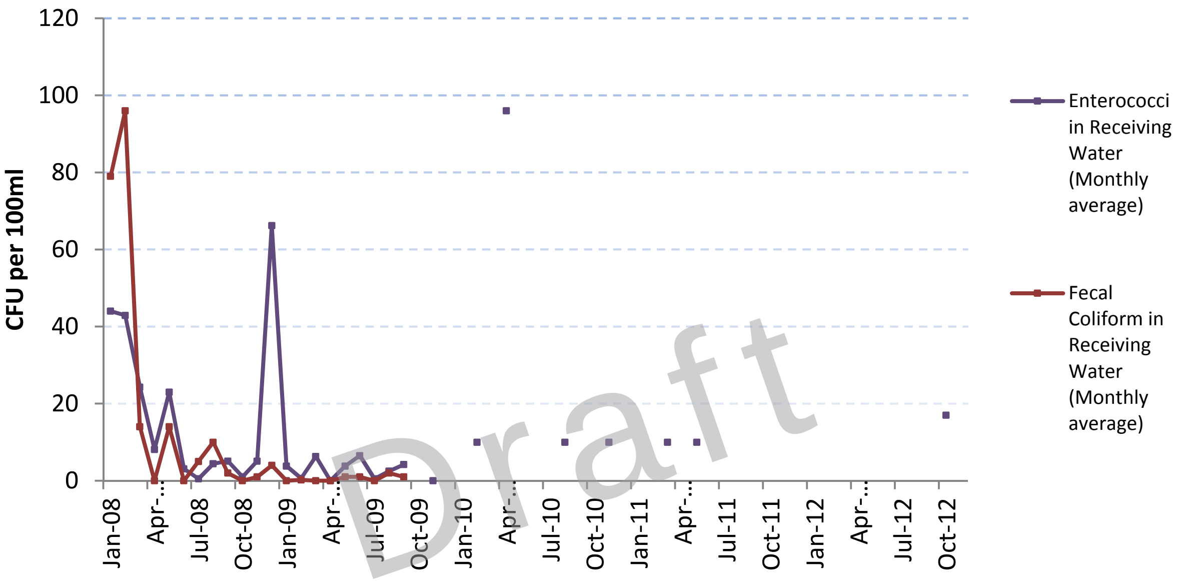
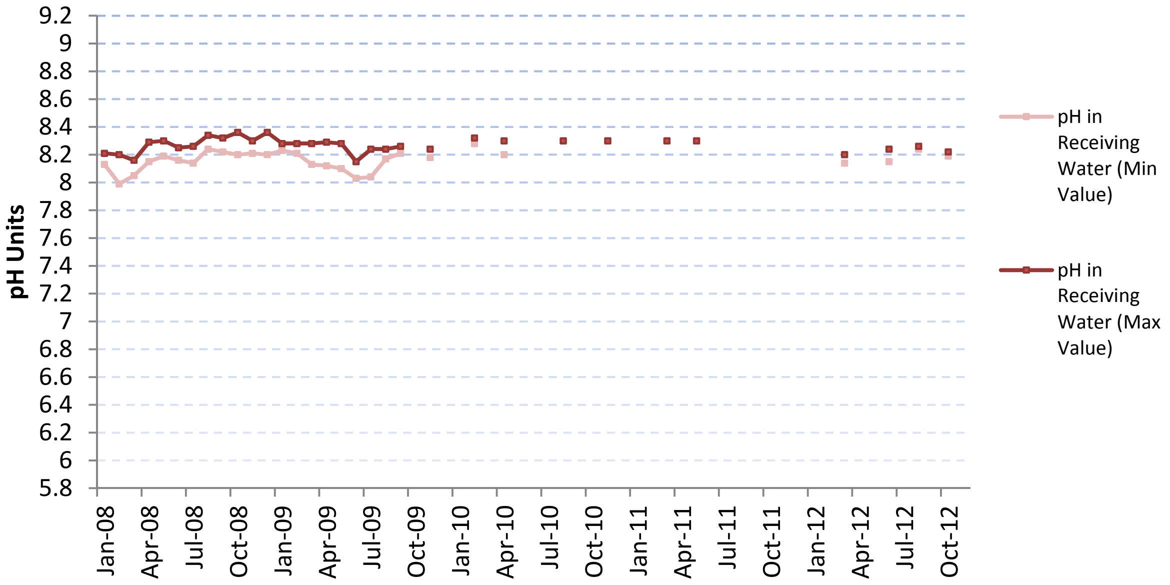
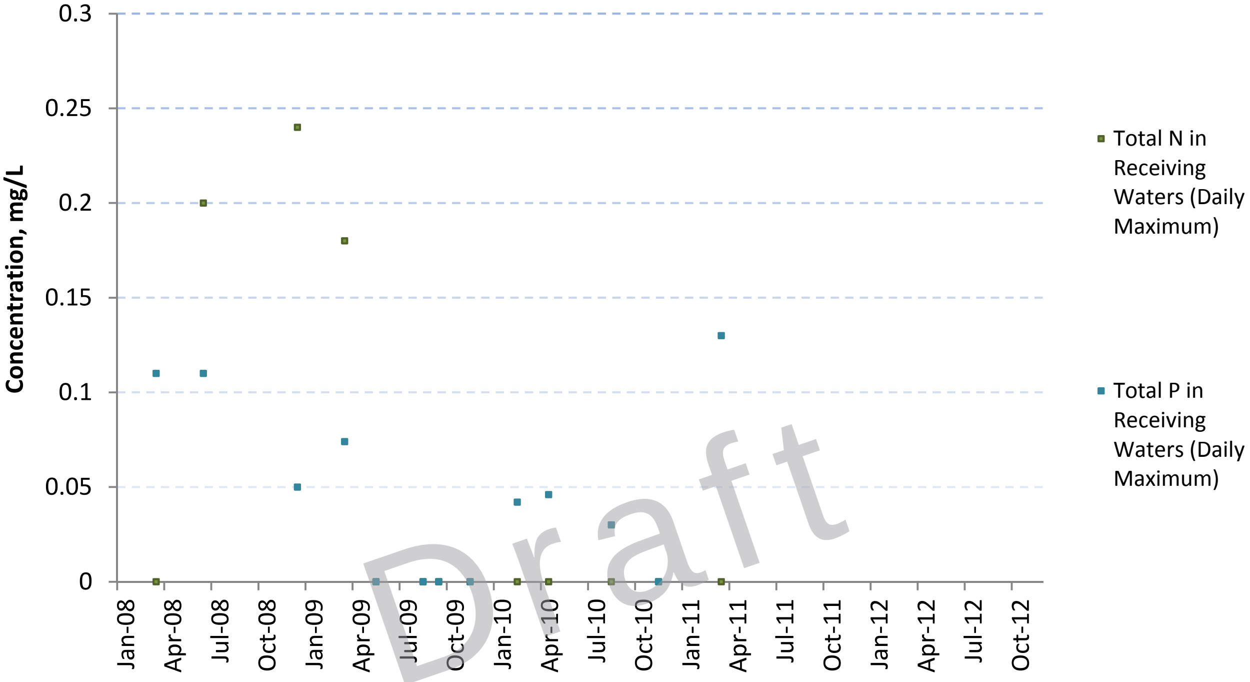


Figure 2.2.3-25. **pH of Receiving Waters at Agingan Wastewater Treatment Plant**



In terms of nitrogen and phosphorus concentrations in the receiving waters, there has been an observed decreasing trend in both nutrients (Figure 2.2.3-26). The concentration levels are much lower in the receiving waters of Agingan WWTP than those measured in the receiving waters of Sadog Tasi WWTP.

Figure 2.2.3-26. **Receiving Waters Nitrogen and Phosphorus Concentrations at Agingan Wastewater Treatment Plant**



Other Operational Observations for Agingan WWTP

The Agingan WWTP is currently undergoing retrofitting construction; operational performance is expected to improve once the construction work is done. Operational observations from the Agingan WWTP are as follows:

- Influent flow monitoring does not occur at the plant; it occurs at Pump Station A-16 where readings are taken from one flow meter. Flows are diverted to Pump Station A-1 (which has no flow meter) should Pump Station A-16 fail or need to be taken offline. When that happens or if the Pump Station A-16 flow meter fails, no flow measurements will be available to the plant for an extended period of time.
- Currently, Agingan WWTP is unable to meet effluent TSS and BOD standards during the construction phase. FOG was noted to be a potential cause of problems in the future; it may reduce the lifespan and functionality of sensitive downstream treatment equipment via the formation of grease balls that may damage pumps and other sensitive equipment. A long-term solution is to identify major sources of FOG, such as restaurants, and require the use of grease traps. FOG waste is then removed from these grease traps regularly for treatment at a digestion facility.

- Influent coming into Agingan WWTP has been noted by the operator to be brackish, indicating high concentrations of total dissolved solids (TDS) passing through the treatment process. The high TDS influent is most likely due to infiltration into the sewer collection system. High concentrations of TDS will impact the durability of equipment and ultimately create maintenance issues.
- Similar to the O&M manual for Sadog Tasi WWTP, the manual for the Agingan WWTP provides stepwise instructions for the basic operations of the treatment plant, but does not document information on the operating range of key process parameters based on past or current operating experience.
- Agingan WWTP previously had a mechanical screen installed at the headworks, but that apparently failed due to maintenance issues and has since been taken out of service. No fine screens or grit removal equipment are currently installed at the WWTP.

Review and Modification of NPDES Permits

The effluent discharges for each plant are to comply with each WWTP's respective NPDES discharge permits (Table 2.2.3-2, Sadog Tasi WWTP [Permit No. MP0020010]) and Table 2.2.3-5, Agingan WWTP [Permit No. MP0020028]). The Sadog Tasi and Agingan WWTPs generally comply with their respective NPDES permits except for the following parameters listed in Table 2.2.3-7.

Table 2.2.3-7. **Summary of Parameters in Non-compliance for Sadog Tasi and Agingan WWTPs**

NPDES Parameter	Non-compliance to NPDES Permit	
	Sadog Tasi WWTP	**Agingan WWTP**
BOD & TSS	Non-compliance of both BOD and TSS from February 2010 to September 2010 and one instance in September 2009 for BOD. The 2010 period of non-compliance coincided with the plant construction being performed at Sadog Tasi WWTP when the clarifier was out of service.	-
Enterococci	Effluent *Enterococci* values have consistently exceeded the NPDES permit levels of 2,230 CFU/ 100 ml for monthly average readings and 4,474 CFU/100 ml for daily maximum readings.	Effluent *Enterococci* values have consistently exceeded the NPDES permit levels of 5,746 CFU/ 100 ml for monthly average readings and 11,529 CFU/100 ml for daily maximum readings.
pH	pH has been noncompliant with NPDES limits, with an average pH of 7.24 to 7.63 over the sampling period (January 2008 to November 2012.	-
Copper and Zinc	Effluent copper and zinc have generally exceeded NPDES limits during the sampling period, averaging 18 µg/L and 50 µg/L over the sampling period respectively.	Effluent copper concentrations from the Agingan WWTP effluent have generally exceeded NPDES limits during the sampling period from January 2008 through November 2012, with an average of 14.4 µg/L during the sampling period.

Some non-compliant incidents were due to plant upgrade and re-construction work at both Sadog Tasi and Agingan. This is generally no longer an issue since the completion of these upgrades. Table 2.2.3-8 presents the reasons that support the review and revision of other specific parameters in the NPDES permit.

Table 2.2.3-8. **Summary of Proposed NPDES Parameters for Review**

NPDES Parameter	Sadog Tasi WWTP	Agingan WWTP
Enterococci	The latest outfall dilution study supports the use of a higher dilution factor that could be considered when reviewing the NPDES permit requirements. In addition, it is observed from the available monitoring data that the receiving waters are not adversely impacted by the effluent.	
pH	The band of pH values allowed in the NPDES limit for Sadog Tasi WWTP appears to be very narrow (7.6 – 7.8), especially compared to that for Agingan WWTP (an allowable range from 6 to 9).	NA
Copper and Zinc	Low permit limits are due to current CNMI water quality standards that do not allow the application of a zone of mixing dilution factor for any toxic pollutant such as metals. The proposed inclusion of a mixing zone dilution factor for metals and other toxic pollutants, as is the practice elsewhere, would increase the permit limit allowing the toxic metal values to meet the permit requirements.	

Additionally, a comparison of the NPDES discharge permits for Sadog Tasi and Agingan has shown that certain parameters have different limiting values as well as monitoring frequencies. The following table (Table 2.2.3-9, reproduced from Section 2.2.3) provides a side-by side-comparison of the Sadog Tasi and Agingan NPDES permit requirements. Red and blue are used to identify the differences between the two permits. Red is used to indicate where concentration limits are more stringent, and blue to indicate where limits are less stringent. Mass limits are based on flow and are thus not compared across both plants. Therefore, any revision of the NPDES permits for both plants should also consider the benefit of rationalizing these values.

Wastewater Treatment Process Modeling

The Professional Process Design (Pro2D) Model is CH2M's proprietary tool for evaluating wastewater treatment process design. This section provides background of the Pro2D model and its use, discussing how the model is beneficially used to evaluate and assess the adequacy and capability of the current treatment process for both WWTPs on Saipan.

Objectives of Process Modeling

For this assessment, Pro2D was used to achieve the following objectives:

- Assess each WWTP's existing treatment process to identify deficiencies.
- Identify how the treatment process can be optimized.
- Identify the potential issues for plant operation based on relevant scenarios.

Modeling Basis and Assumptions

The Pro2D model for each WWTP was based on information and data obtained from the as-built drawings and O&M manuals for the WWTPs. Sizing information for each of the plant components were mainly taken from as-built drawings, while relevant parameters such as flow rates, loading rates, and number of units were obtained from the O&M manuals. Changes to the treatment process and equipment were cataloged as markups within the O&M manuals and were incorporated into the Pro2D model as necessary. Physical conditions of the various equipment and treatment components, however, were not considered within the model, which focuses on the treatment process rather than the physical condition of the plant.

Table 2.2.3-9. **Summary Table of National Discharge Pollutant Elimination System Permit Requirements**

Section A: Effluent Limitations and Monitoring Requirements

	Sadog Tasi WWTP (Permit No. MP0020010) (Based on Average Daily Design Flow of 4.8 MGD)								Agingan WWTP (Permit No. MP0020028) (Based on Average Daily Design Flow of 3.0 MGD)							
	Mass Limits (lbs/day)			Concentration Limits			Monitoring Frequency	Sample Type	Mass Limits (lb/day)			Concentration Limits			Monitoring Frequency	Sample Type
	Monthly Average	Weekly Average	Daily Maximum	Monthly Average	Weekly Average	Daily Maximum			Monthly Average	Weekly Average	Daily Maximum	Monthly Average	Weekly Average	Daily Maximum		
Flow	N.A.	N.A.	N.A.	Monitoring and Reporting Required			Continuous	Continuous	N.A.	N.A.	N.A.	Monitoring and Reporting Required			Continuous	Continuous
Biochemical Oxygen Demand (5-day)[1]	1,201	1,801	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite	751	1,126	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite
Total Suspended Solids[1]	1,201	1,801	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite	751	1,126	N.A.	30 mg/L	45 mg/L	N.A.	3 days/ week	8-hour Composite
Settleable Solids	N.A.	N.A.	N.A.	1 ml/L	N.A.	2 ml/L	Once/day	Discrete	Not Regulated							
Oil and Grease	Monitoring and Reporting Required						Quarterly	Discrete	Monitoring and Reporting Required						Quarterly	Discrete
Whole Effluent Toxicity[2]	N.A.	N.A.	0.26	N.A.	N.A.	Pass	Semi-Annually	24-hour Composite	N.A.	N.A.	N.A.	N.A.	N.A.	Pass	Semi-Annually	24-hour Composite
Enterococci	N.A.	N.A.	N.A.	2,230 CFU/ 100mL	N.A.	4,474 CFU/100mL	Weekly	Discrete	N.A.	N.A.	N.A.	5,746 CFU/ 100mL	N.A.	11,529 CFU/ 100mL	Weekly	Discrete
Total Cl Residual	0.25	N.A.	0.5	6.2 μg/L	N.A.	12.4 μg/L	3 days/ week	Discrete	0.3	N.A.	0.3	N.A.	N.A.	12.4 μg/L	3 days/ week	Discrete
pH	Not more than 0.5 units from a value of 8.1						3 days/ week	Discrete	Within range of 6-9 standard units						3 days/ week	Discrete
Nitrate-Nitrogen	760	N.A.	1,600	19 mg/L	N.A.	39 mg/L	Quarterly	24-hour Composite	1,252	N.A.	2,503	50 mg/L	N.A.	100 mg/L	Monthly	24-hour Composite
Total Nitrogen	1,200	N.A.	2,300	29 mg/L	N.A.	58 mg/L	Quarterly	24-hour Composite	1,878	N.A.	3,768	75 mg/L	N.A.	150.5 mg/L	Monthly	24-hour Composite
Ortho-phosphate	80	N.A.	200	2 mg/L	N.A.	4 mg/L	Quarterly	24-hour Composite	125	N.A.	250	5 mg/L	N.A.	10 mg/L	Monthly	24-hour Composite
Total Phosphorus	80	N.A.	200	2 mg/L	N.A.	4 mg/L	Quarterly	24-hour Composite	125	N.A.	250	5 mg/L	N.A.	10 mg/L	Monthly	24-hour Composite
Unionized Ammonia	30	N.A.	80	0.8 mg/L	N.A.	2 mg/L	Quarterly	24-hour Composite	50	N.A.	100	2 mg/L	N.A.	4 mg/L	Monthly	24-hour Composite
Copper	0.1	N.A.	0.2	2.4 μg/L	N.A.	4.8 μg/L	Quarterly	24-hour Composite	0.12	N.A.	0.12	N.A.	N.A.	4.8 μg/L	Quarterly	24-hour Composite
Lead	Not Regulated								0.33	N.A.	0.33	N.A.	N.A.	13.3 μg/L	Quarterly	24-hour Composite
Nickel	0.3	N.A.	0.5	6.7 μg/L	N.A.	13.4 μg/L	Quarterly	24-hour Composite	0.35	N.A.	0.35	N.A.	N.A.	13.4 μg/L	Quarterly	24-hour Composite
Silver	0.04	N.A.	0.08	0.9 μg/L	N.A.	1.9 μg/L	Quarterly	24-hour Composite	0.05	N.A.	0.05	N.A.	N.A.	1.9 μg/L	Quarterly	24-hour Composite
Zinc	1.8	N.A.	3.8	45 μg/L	N.A.	90 μg/L	Quarterly	24-hour Composite	2.2	N.A.	2.2	N.A.	N.A.	90 μg/L	Quarterly	24-hour Composite
Radioactive Material	The discharge of radioactive materials at any level to the receiving waters is strictly prohibited.								The discharge of radioactive materials at any level to the receiving waters is strictly prohibited.							
Other Priority Toxic Pollutants (except Asbestos)[3]	Monitoring and Reporting Required						Oct 2007/ Oct 2010		Monitoring and Reporting Required						Oct 2009 Oct 2012	
Others Requirements:	***Discharge to be free from*** 1. Materials that will settle to form objectionable sludge or bottom deposits. 2. Floating debris, oil, grease, scum, or other floating materials. 3. Substances in amounts sufficient to produce taste or odor in the water or detectable from the flavor in the flesh of fish, or in amounts sufficient to produce objectionable odor, turbidity, or other conditions in the receiving water. 4. High temperatures; biocides; pathogenic organisms; toxic, corrosive, or other deleterious substances at levels or in combinations sufficient to be toxic or harmful to human health or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water. 5. Substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life. 6. Toxic pollutants in concentrations that are lethal to, or that produce detrimental physiological responses in human, plant, or animal life. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species and/or significant alterations in population or community ecology or receiving water biota. ***Discharge shall not cause:*** 1. The fecal coliform concentration in the receiving waters to exceed a geometric mean of 200 CFU/100 mL in not less than five samples equally spaced over a 30-day period, nor any single sample to exceed 400 CFU/100 mL at any time. 2. The concentration of DO in the receiving waters to be less than 75 percent saturation. 3. The concentrations of total filterable suspended solids in the receiving waters to be increased from ambient conditions at any time, or to exceed 40 mg/L except when due to natural conditions. 4. The salinity of the receiving waters to be altered more than 10 percent of the ambient conditions, or more than that which would otherwise adversely affect the sedimentary patterns and indigenous biota, except when due to natural causes. 5. The temperature of the receiving waters to vary by more than 1.0°C from ambient conditions. 6. The turbidity at any point in the receiving waters, as measured by nephelometric turbidity units (NTUs), to exceed 1.0 NTU over ambient conditions except when due to natural conditions. 7. The concentration of suspended matter at any point in the receiving waters shall not be increased from ambient conditions at any time, and should not exceed 40 mg/L except when due to natural conditions. 8. The health and life history characteristics of aquatic organisms in receiving waters affected by the discharge to differ substantially from those for the same receiving waters in areas unaffected by the discharge. Also, the discharge shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life in the receiving waters.								***Discharge to be free from:*** 1. Materials that will settle to form objectionable sludge or bottom deposits. 2. Floating debris, oil, grease, scum, or other floating materials. 3. Substances in amounts sufficient to produce taste or odor in the water or detectable from the flavor in the flesh of fish, or in amounts sufficient to produce objectionable odor, turbidity, or other conditions in the receiving water. 4. High temperatures; biocides; pathogenic organisms; toxic, corrosive, or other deleterious substances at levels or in combinations sufficient to be toxic of harmful to human health or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water. 5. Substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life. 6. Toxic pollutants in concentrations that are lethal to, or that produce detrimental physiological responses in human, plant, or animal life. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species and/or significant alterations in population or community ecology or receiving water biota. ***Discharge shall not cause:*** 1. The concentration of DO in the receiving waters to be less than 75 percent saturation. 2. The concentrations of total filterable suspended solids in the receiving waters to be increased from ambient conditions at any time, or to exceed 40 mg/L except when due to natural conditions. 3. The salinity of the receiving waters to be altered more than 10 percent of the ambient conditions, or more than that which would otherwise adversely affect the sedimentary patterns and indigenous biota, except when due to natural causes. 4. The temperature of the receiving waters to vary by more than 1.0°C from ambient conditions. 5. The turbidity at any point in the receiving waters, as measured by nephelometric turbidity units (NTUs), to exceed 1.0 NTU over ambient conditions except when due to natural conditions. 6. The health and life history characteristics of aquatic organisms in receiving waters to differ substantially from those for the same receiving waters in areas unaffected by the discharge. Also, the discharge shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life in the receiving waters.							

[1] The arithmetic mean of the BOD$_5$ and TSS values, by concentration, for effluent samples over a calendar month shall not exceed 15 percent of the arithmetic mean, by concentration, for influent samples.

[2] Based on the fifth edition of Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms (EPA-821-$-02-012, October 2002; Table IA, 40 CFR Part 136) ("Acute Toxicity TMM") Manual.

[3] Priority toxic pollutants are listed in 40 CFR 131.36 (b) (1). Permittee shall collect 24-hour composite samples for metals, 2,3,7,8-TCDD (dioxin), pesticides, base-neutral extractables, and acid-extractables. The permittee shall collect discrete samples for cyanide, total phenolic compounds and volatile organics.

Numerous model simulation runs were conducted to compare and contrast various possible operating conditions identified based on analysis of historical data. The simulation runs included scenarios to assess the robustness of the treatment process under both design and existing conditions. Plant performance under scenarios where one or more process units are offline were also evaluated to simulate either a maintenance configuration or a potential alternate operating mode.

The model simulation runs performed in Pro2D for both the Sadog Tasi and Agingan WWTPs are as follows:

- Run 1: Based on Average Design Flows and Loadings with One Aeration Basin Online
- Run 2: Based on Average Design Flows and Loadings with Two Aeration Basins Online
- Run 3: Push Capacity Test using Average Design Loadings with All Aeration Basins Online
- Run 4: Push Capacity Test using Current Loadings with All Aeration Basins Online
- Run 5: Based on Current Flows and Loadings with One Aeration Basin Online

There were data limitations on some parameters, primarily for information relating to the equipment used, with other data gaps from process control parameters. The following assumptions were made for process modeling:

- Ammonia and phosphorus concentrations in the influent were unknown and assumed based on the type of wastewater received.
- Alkalinity and hydrogen sulfide concentrations were unknown and assumed based on the type of wastewater received.
- The design SRT for Sadog Tasi WWTP aeration basins was unknown.
- The RAS rate for both WWTPs was unknown and assumed based on acceptable operation norms.
  - Sludge Volume Index (SVI) values for both WWTPS were not provided and had to be assumed based on acceptable operation norms.
  - Temperature was assumed to be 30°C and constant throughout the treatment process at both WWTPs.
  - Dewatering equipment performance data for both WWTPS (e.g., the sludge cake concentration and solids capture) were not provided and were based on standard operating values.
  - All equipment was assumed to be fully functional and in working order.
  - The models are based on a steady-state condition of treatment process, i.e., they do not account for performance of plant during start-up or unscheduled operational down-time.
  - Peaking factors applied in the model were adopted from the design. Average flows and loadings were used to stress-test the treatment process.
  - Minor operations, such as spray-washing, were not considered within the model.

Process Modeling Observations for Sadog Tasi WWTP

Table 2.2.3-10 summarizes the process modeling results for the various modeling scenarios for the Sadog Tasi WWTP that were performed as part of this evaluation. These results include influent and effluent parameters, as well as key process parameters arising from the completed model runs. Where applicable, parameters from the relevant 10-States Standards (for design) are also appended for reference.

Table 2.2.3-10. **Pro2D Run Results Summary for Sadog Tasi Wastewater Treatment Plant**

	Run 1	**Run 2**	**Run 3**	**Run 4**	**Run 5**	
Modeling Objective	**Evaluate Design Conditions - Flow And WW Characteristics - With Aeration Basin Stress Test (1 Basin)**	**Evaluate Design Conditions - Flow and WW Characteristics - with Aeration Basin Stress Test (2 Basins)**	**Evaluate Maximum Plant Capacity Under Design Conditions (WW Characteristics)**	**Evaluate Maximum Plant Capacity Under Current Conditions (WW Characteristics)**	**Evaluate Operating Regime Under Current Conditions (Flow and WW Characteristics)**	**Relevant 10 States Standards**
Flow Basis	Design Flow	Design Flow	Max Capacity	Max Capacity	Current Flow	
Water Quality Characteristics	Design Characteristics	Design Characteristics	Design Characteristics	Current Characteristics	Current Characteristics	
No. of Aeration Basins	1	2	3	3	1	At least two units, if more than 100,000 gpd
Influent Parameters						
Average Flow (MGD)	2.9	2.9	4.8	5	1.5	
Influent TSS (mg/L)	200	200	200	160	160	
Influent BOD (mg/L)	200	200	200	167	167	< 640 mg/L per MGD
Influent P (assumed, mg/L)	8	8	8	8	8	
Influent NH_3 (assumed, mg/L)	14	14	14	14	14	
Influent TKN (mg/L)	20	20	20	20	20	
Process Parameters						
SVI (mL/g)	125	125	125	125	125	
Aeration SRT (days)	5	10	8	10	10	
Aeration Basin AOR (lb O_2/day)	5,863	3,170	3,361	3,381	3,030	Design for 3068 lb O_2/mgd
MLSS in Aeration Tanks (mg/L)	2,757	3,158	2,904	3,078	2,075	Between 1000 – 3000 mg/L and < 5000mg/L
Solids Loading Rate (lb/day-sq. ft.)	13	17	24	25	5	< 50 lb/day = sqft
WAS Concentration (mg/L)	7,932	7,076	7,350	8,852	5,979	
RAS (%)	50	75	60	50	50	Between 15-100%
WAS Flow (GPD)	55,263	72,122	120,279	82,597	26,212	< 25% of flow
Digester HRT (days)	18.1	13.9	8.3	12.1	38.1	
Digester SRT (days)	19.0	29.4	14.0	39.0	39.0	
Digester AOR (lb O_2/day)	1,300	1,010	1,612	1,524	369	
% VSS reduction in digester	23.7	23.5	21.6	25.7	24.5	

Table 2.2.3-10. **Pro2D Run Results Summary for Sadog Tasi Wastewater Treatment Plant**

	Run 1	Run 2	Run 3	Run 4	Run 5	
Modeling Objective	**Evaluate Design Conditions - Flow And WW Characteristics - With Aeration Basin Stress Test (1 Basin)**	**Evaluate Design Conditions - Flow and WW Characteristics - with Aeration Basin Stress Test (2 Basins)**	**Evaluate Maximum Plant Capacity Under Design Conditions (WW Characteristics)**	**Evaluate Maximum Plant Capacity Under Current Conditions (WW Characteristics)**	**Evaluate Operating Regime Under Current Conditions (Flow and WW Characteristics)**	**Relevant 10 States Standards**
Decant rate (GPD)	2,833	39,838	51,458	58,356	638	
BFP solids capture (%)	85%	85%	85%	85%	85%	
Dewatered Sludge concentration (%)	20%	20%	20%	20%	20%	
Biosolids disposal (kg/d)	2685	2873	5280	5280	1013	
Effluent Parameters						
Effluent TSS (mg/L)	30	30	20	20	20	
Effluent BOD (mg/L)	11	3	4	3	4	
Effluent NH_3-N (mg/L)	3	0	1	0	0	
Effluent NO_3-N (mg/L)	9	4	2	4	11	
Process Units						
Aeration Basin Dimensions	54 ft (w) by 41.3 ft (l) by 18 ft (d)	54 ft (w) by 41.3 ft (l) by 18 ft (d)	54 ft (w) by 41.3 ft (l) by 18 ft (d)	54 ft (w) by 41.3 ft (l) by 18 ft (d)	54 ft (w) by 41.3 ft (l) by 18 ft (d)	
Clarifier Dimensions	100 ft (dia), 16 ft (d)	100 ft (dia), 16 ft (d)	100 ft (dia), 16 ft (d)	100 ft (dia), 16 ft (d)	100 ft (dia), 16 ft (d)	
Aerobic Digester Dimensions	54 ft (w) by 123.77 ft (l) by 20 ft (d)	54 ft (w) by 123.77 ft (l) by 20 ft (d)	54 ft (w) by 123.77 ft (l) by 20 ft (d)	54 ft (w) by 123.77 ft (l) by 20 ft (d)	54 ft (w) by 123.77 ft (l) by 20 ft (d)	
BFP capacity (gpm)	60	60	60	60	60	

Run 1 was set up to stress-test the plant process with one aeration basin operating when design loadings and flows are received. The results of this run showed that the aerators in the aeration basin become limiting and are not able to provide the DO level of 2 mg/L in the water for the biological process. The required AOR of 5,832 lb O_2/day is more than the provided AOR of 2,880 lb O_2/day. At an SRT of 5 days, treatment goals are met. However, the operator has to waste 20 percent of the MLSS inventory each day and has to be cautious not to over-waste such that it draws down the MLSS concentration and affects the stability of the biological process. Hence, there are added responsibilities for operation.

Run 2 was set up to increase the number of aeration basins by one as compared to **Run 1**. With two out of three aeration basins in operation, as shown in Table 2.2.3-11, the aerators can attain DO levels of 2 mg/L in the water. At an SRT of 10 days, less wasting will be needed. The clarifier is not overloaded and treatment goals are met. This is a more desirable plant configuration to operate under design flow and loading conditions as compared to **Run 1**.

Run 3 indicated that the plant can handle an average flow of 4.8 MGD under design loading conditions when all three aeration basins are in operation. **Run 4** was performed to demonstrate that the plant can handle an average flow of 5 MGD under current loading conditions. The comparison of these two run results indicated that the model is showing a correct trend and is correctly set up. The current wastewater received is weaker in strength compared to the wastewater for which the plant is designed, hence it is expected to be able to treat more flow at lower loadings. Hydraulically, the plant can manage the diurnal peak flow, which is obtained by multiplying the average flow by the peaking factor of 1.79 used in the plant's original design criteria. The clarifier becomes limiting under this pushed capacity test. Flows beyond 5 MGD under current loading conditions may cause settling sludge in the clarifier to wash out, impacting effluent quality. Additional runs to further stress test the clarifier by increasing flows beyond 5 MGD may not be necessary as, according to the "Saipan Wastewater Facilities Master Plan" (Dueñas & Associates/ CH2M, 1993), the recommended flow for the Sadog Tasi plant is 5.0 MGD. The primary concern is that more than 5.0 MGD effluent discharge may pollute the harbor.

Run 5 was set up similarly to **Run 1** except that it was subjected to current flow and loadings. The results show that the plant can cope with the flow and loading under this plant configuration. This is a reasonable alternative operating mode that can potentially save on energy costs while still meeting treatment goals. The parameters listed in Table 2.2.3-7 can be used as a guide for operating under these conditions, though actual performance is dependent on various factors such as process mechanical equipment performance. The assumptions described earlier that were used for this modeling work should also be noted and validated where possible.

Process Modeling Observations for Agingan WWTP

Table 2.2.3-11 summarizes the process modeling results for the various modeling scenarios for the Agingan WWTP that were performed as part of this evaluation. This includes influent and effluent parameters, as well as key process parameters arising from the completed model runs. Where applicable, parameters from the relevant 10-States Standards (for design) are also appended to Table 2.2.3-11 for reference.

Table 2.2.3-11. **Pro2D Run Results Summary for Agingan Wastewater Treatment Plant**

	Run 1	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Relevant 10-States Standards**
Modeling objective	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (1 Basin)**	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (2 Basins)**	**Evaluate Maximum Plant Capacity Under <u>Design</u> Conditions (WW Characteristics)**	**Evaluate Maximum Plant Capacity Under <u>Current</u> Conditions (WW Characteristics)**	**Evaluate Operating Regime Under <u>Current</u> Conditions (Flow & WW Characteristics)**	
Flow Basis	Design Flow	Design Flow	Max Capacity	Max Capacity	Current Flow	
Water Quality Characteristics	Design Characteristics	Design Characteristics	Design Characteristics	Current Characteristics	Current Characteristics	
No. of Basins	1	2	2	2	1	At least 2 units, if more than 100,000 gpd
Influent Parameters						
Average Flow (MGD)	3	3	3	3.7	1.24	
Influent TSS (mg/L)	200	200	200	110	110	
Influent BOD (mg/L)	155	155	155	120	120	< 640 mg/L per MGD
Influent P (assumed, mg/L)	8	8	8	8	8	

Table 2.2.3-11. **Pro2D Run Results Summary for Agingan Wastewater Treatment Plant**

	Run 1	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Relevant 10-States Standards**
Modeling objective	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (1 Basin)**	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (2 Basins)**	**Evaluate Maximum Plant Capacity Under <u>Design</u> Conditions (WW Characteristics)**	**Evaluate Maximum Plant Capacity Under <u>Current</u> Conditions (WW Characteristics)**	**Evaluate Operating Regime Under <u>Current</u> Conditions (Flow & WW Characteristics)**	
Influent NH3 (assumed, mg/L)	14	14	14	14	14	
Influent TKN (mg/L)	20	20	20	20	20	
% VSS reduction in digester	28.4	24.1	21.7	25.0	38	
Process Parameters						
SVI (mL/g)	120	120	120	120	120	
Aeration SRT (days)	5	7	9	9	11.5	
Total AOR (lb O2/day)	3,000	5,701	5732	5,800	1,384	Design for 3068 lb O_2/mgd
MLSS in Aeration Tanks (mg/L)	4,556	2,558	3813	3,231	3,603	Between 1000 – 3000 mg/L and < 5000mg/L
Solids Loading Rate (lb/day-sq. ft.)	28	16	23	24	9	< 50 lb/day=sqft
WAS concentration (mg/L)	10,800	5,984	9,013	7,675	8,531	
RAS (%)	70	70	70	70	70	Between 15-100%
WAS Flow (GPD)	45,910	70,195	50,699	47,419	19,502	< 25% of flow
Digester HRT (days)	13.3	8.7	12.0	12.9	31.3	
Digester SRT (days)	20.0	8.7	20.0	20.0	31.28	
Digester AOR (lb O2/day)	1,200	946	832	758	645	
BFP Solids Capture (%)	95%	95%	95%	95%	95%	
Dewatered Sludge Concentration (%)	17%	17%	17%	17%	17%	
Biosolids disposal (kg/d)	3287	3032	3194	2426	796	
Effluent Parameters						
Effluent TSS (mg/L)	20	20	20	20	20	
Effluent BOD (mg/L)	5	5	4	5	7	
Effluent NH3-N (mg/L)	2	1	2	2	5	

Table 2.2.3-11. **Pro2D Run Results Summary for Agingan Wastewater Treatment Plant**

	Run 1	Run 2	Run 3	Run 4	Run 5	Relevant 10-States Standards
Modeling objective	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (1 Basin)**	**Evaluate Design Conditions - Flow & WW Characteristics - with Aeration Basin Stress Test (2 Basins)**	**Evaluate Maximum Plant Capacity Under Design Conditions (WW Characteristics)**	**Evaluate Maximum Plant Capacity Under Current Conditions (WW Characteristics)**	**Evaluate Operating Regime Under Current Conditions (Flow & WW Characteristics)**	
Effluent NO3-N (mg/L)	0	1	0	0	0	
Process Units (include quantities)						
Aeration Basin dimensions	0.6 MG	0.6 MG	0.6 MG	0.6 MG	0.6 MG	
Clarifier Dimensions	47.5 ft (dia)	47.5 ft (dia)	47.5 ft (dia)	47.5 ft (dia)	47.5 ft (dia)	
Aerobic Digester Dimensions	0.6 MG	0.6 MG	0.6 MG	0.6 MG	0.6 MG	
BFP Capacity (gpm)	Not available	Not available	Not available	Not available	Not available	

Run 1 indicated that an SRT of 5 days and a high MLSS concentration of 4556 mg/L are required to be sustained in the aeration basin. These requirements add stress to the clarifier with a solids loading rate of 28 lb/day-sq ft, which is high and can lead to poor settling. WAS is at a high concentration of 10.8 percent. Although treatment goals are achieved, wasting 20 percent of the MLSS inventory each day and sustaining a high solids loading rate in the clarifier can result in operational instability and cause process upset when higher flows enter the plant.

Run 2 was set up with an additional aeration basin in operation compared to **Run 1**. With all basins in operation under design flow and loadings, the run result indicated that the plant copes well in terms of moderate MLSS concentrations, solids loading rate for the clarifier, and achievement of treatment goals.

Run 3 and **Run 4** were set up to determine the maximum average flows that the plant can cope with for both design and current loadings into the plant, respectively, while meeting treatment goals. It was observed that, at an SRT of 9 days, the plant can treat a maximum flow of 3 MGD under design loading conditions and 3.7 MGD under current loading conditions. The MLSS concentrations exceeded 3,000 mg/L and the clarifier becomes limiting, with solids loading rates bordering at the high end of an acceptable range for stable operation. Hydraulically, the plant copes well. Aeration capacity is also at its limit with the DO level in the last two basins of the aeration basin at almost zero, indicating that the DO is nearly depleted. It is recommended that a DO of 1 mg/L is maintained in the last basin before going into the clarifier so that denitrification does not occur in the clarifier, causing a rising sludge blanket. As there are no adjustable weirs in the basin to adjust the submergence level of the aerators, aeration capacity cannot be increased under the current configuration.

Run 5 adopted the lower flow and weaker wastewater loading that the plant is currently experiencing. The run indicates that the plant is able to cope even with a one aeration basin configuration, but requires 11.5-day SRT for the treatment goals to be met. The parameters listed in Table 2.2.3-8 can be used as a guide for operating under these conditions, though actual performance is dependent on various factors such as process mechanical equipment performance. The assumptions described earlier that were used for this modeling work should also be noted and validated where possible.

Final Recommendations

Based on the condition assessment and process modeling performed for both WWTPs, this section presents some final recommendations for the WWTPs.

General Recommendations for Sadog Tasi and Agingan Wastewater Treatment Plants

- Review the permit requirement to achieve 85 percent or more reduction in influent BOD and TSS concentrations. It is currently framed as being a concurrent requirement on top of the limit on average monthly effluent BOD and TSS concentrations to 30 mg/L. The requirement to achieve 85 percent reduction could be re-stated to come into effect when the absolute values for average monthly effluent concentrations cannot be met, or the requirement could be removed entirely.
- Incorporate an appropriate mixing dilution factor (supported by the outfall mixing analysis) to be more representative of the field conditions and make the permit requirements more consistent with standard EPA guidance. Currently, both permits for Sadog Tasi and Agingan WWTPs currently do not allow the application of a zone of mixing dilution factor for any toxic pollutants such as metals, making it very difficult for the WWTPs to meet permit levels even though concentrations are not excessively high. See the Sections 2.2.4 and 2.2.5 for further information.
- Document plant operating experience by logging key operational information and process parameters to aid future operators in terms of understanding and operating the system. Records of operating parameters such as HRT, SRT, sludge recycle (RAS) and wasting (WAS) rates, and polymer dosing values in the O&M manual will provide continuing operations guidance and a basis for future adjustments.
- Develop a training program for plant operators and implement changes to the personnel system to recognize and reward staff who reach specified education and certification milestones.
- Improve the inventory and tracking system for tools and equipment, and build a stock of required tools to facilitate regular and efficient maintenance work.
- Ensure nameplates for equipment are correctly labeled.

Preliminary Treatment Alternatives for Sadog Tasi and Agingan Wastewater Treatment Plants

As noted in the earlier sections, for both WWTPs there are only bar screens provided before the influent reaches the aeration basins. These are located upstream at the last pump station to remove debris from the raw sewage before it enters the plant. It is usually a good practice to consider fine screens of 6 to 8 mm and grit removal to protect the mechanical equipment in the downstream processes. For fine screens, the main challenge is that both WWTPs receive influent that has significant saline water influence, which creates maintenance and durability issues for any equipment type. Implementing fine screens will also add to the O&M efforts required to operate the plant and increase operational costs.

Table 2.2.3-12 below gives a review of the various screen technologies available.

Table 2.2.3-12. **Summary of Various Screen Technologies**

Possible Equipment Types	Advantages / Disadvantages
Mechanically Cleaned (Chain) Bar Screens	Multiple cleaning elements, low O&M costs, potential for jamming, requires greater operator attention
Reciprocating (Chain and Rake) Bar Screens	No submerged mechanical parts, limited capacity for heavy solids handling
Catenary Bar Screens	Requires large area for installation, expensive to maintain, no submerged mechanical parts
Self-Cleaning Rotary Drum Screens	Suitable for high flows, enhanced removal of solids
Continuous Belt Screens	Continuous, expensive to maintain and replace components, enhanced removal of solids

Conclusion

The reciprocating bar screen system has no submerged mechanical parts and is a relatively low maintenance system that can be considered in Saipan's context. Flows and solids loadings in both WWTPs are also not expected to be high.

Additional Observation

Currently, the wasted sludge is aerobically digested, decanted, and sent to a BFP, requiring minimal sludge pumps and no centrifuge equipment. Sludge pumps and centrifuge equipment typically require special protection against wear from grit. Hence, the addition of grit removal equipment is not deemed critical to plant operations.

Treatment Process Recommendations - Sadog Tasi WWTP

- Review and revise the water column monitoring frequency in the NPDES permit. Implement a quarterly water column monitoring frequency at Sadog Tasi WWTP, similar to that carried out at Agingan WWTP, to reduce logistical needs in light of the limited resources available.
- Review and revise pH limits in NPDES permit. Widen the existing range of pH limit values (7.4 to 8.6) to be more consistent with that for Agingan, which has an allowable range of 6 to 9. A wider and more practical range of allowable pH values will more closely reflect receiving water pH levels.
- Operate with one aeration basin under current conditions. The model runs demonstrate that, at the current raw wastewater influent flows that the WWTP accepts, it is possible to operate just one aeration basin and still meet treatment goals.

- Configure sludge transfer from the aerobic digester to the BFP. The existing settling basin serves to provide some thickening capability before sending the sludge for dewatering. However, this causes occasional operational problems, such as clogging of the transfer pump intake. The sludge feed pump is also configured to allow sludge to move directly from the digester to the BFP. The feed sludge will be more dilute in this case, the corresponding dewatered sludge concentration is generally expected to be lower (slightly more sludge volume to handle), and polymer consumption will be higher (increased operating costs). It is recommended to continue thickening the digested sludge as long as the operational issues with sludge pumping can be overcome (e.g., by drilling more holes into the suction pipe).

Treatment Process Recommendations - Agingan WWTP

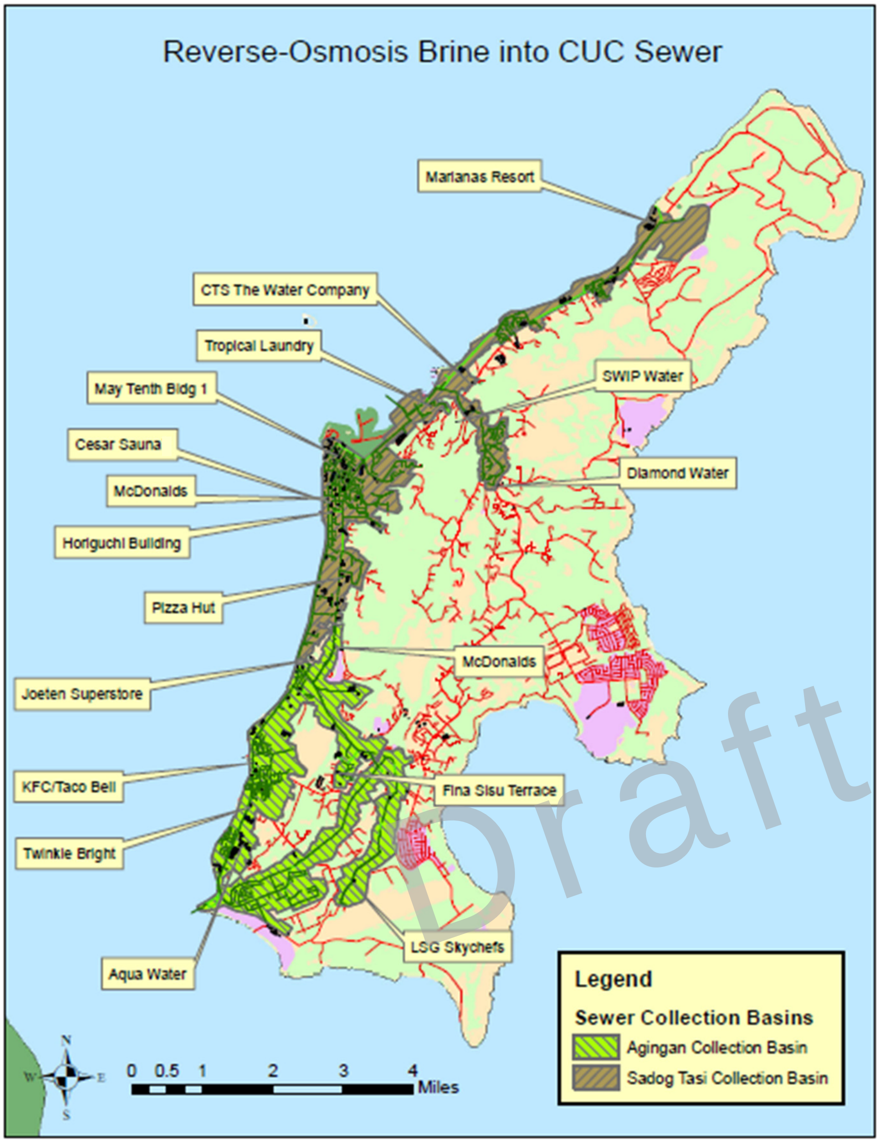
- Review and revise the choice of WET test species in NPDES permit. Propose the use of *Hyalella azteca* as the only species for WET testing, as *Daphnia magna* is a freshwater species not suitable for a saline environment.
- Install a flow meter within the plant to record total plant flow. A new flow meter before the headworks within the WWTP or at the plant effluent pipe will serve as a backup flow meter when the Pump Station A-16 flow meter fails or when Pump Station A-1 is in operation instead of Pump Station A-16. It will also serve as a countercheck against the upstream flow readings under normal circumstances.
- Operate with one aeration basin under current conditions. Similar to Sadog Tasi WWTP and based on Model Run 5 with the current raw wastewater influent flows that the WWTP accepts, it is possible to operate just one aeration basin and still meet treatment goals by operating under a longer SRT.

Impact of Reverse Osmosis Brine Discharge into the Wastewater System

A number of hotels and large bottled water companies in Saipan produce a concentrated brine stream from their reverse osmosis (RO) desalination systems (see Figure 2.2.3-27). These systems are either currently discharging brine into the sewer system or will potentially discharge to the sewer in the future. Some of the old asbestos-cement sewer pipes in the system may be susceptible to corrosion and may deteriorate under the high salinity environment if brine is discharged into the sewer regularly.

Widely varying salinity concentrations of a great enough magnitude can negatively affect nitrification in the WWTP. If TDS levels fluctuate drastically (e.g., a hotel RO system starts up or shuts down), it is possible for biomass cells to lyse. The biological processes may not suffer if daily variations in TDS do not exceed 20 percent of a long-term average TDS value; the allowable variation could be higher if average TDS is low. To avoid upsetting the biological processes it is critical for the WWTPs to receive influent at relatively steady salinity concentrations without wide daily variations so that the microorganisms can acclimatize. If high TDS brine is to be discharged into the system, the timing and rate of discharge of the sources at different locations should be controlled such that the influent salinity concentration entering the WWTPs is actively managed (e.g., staggering discharges from separate RO systems to control the impact on WWTP influent salinity). Further safeguards such as the provision of a 24-hour detention time in process or equalization basins to allow for attenuation of peak concentrations will also help to minimize process upsets.

Figure 2.2.3-27. **Location of Hotels and Companies that Dispose Concentrated Brine in CUC Sewers** *(Source: DEQ)*



However, such controls can be very difficult to implement as CUC has no control over private RO system operations, startups, and shutdowns. Another factor that makes it challenging to control the impact from brine discharge is the actual received flows at each of the WWTPs. Each WWTP treats a relatively small average flow (approximately 1.5 MGD for Sadog Tasi and approximately 1.2 MGD for Agingan) and the potential discharge from hotels can be as much as 0.2 MGD. Assuming WWTP influent TDS is 1,000 mg/L without suspected brine impacts and typical RO brine TDS is 50,000 mg/L, just having half the 0.2 mgd hotel RO plant startup will push WWTP influent TDS up three-fold. This magnitude of salinity change would have an adverse impact on the biological processes and could negatively impact plant performance for extended periods.

It is recommended that brine discharge into the sewage system be controlled and monitored. This is less capital intensive than constructing large equalization tanks to accommodate salinity fluctuations. It is also a more sustainable approach as it protects CUC's sewerage infrastructure and minimizes unnecessary operational and maintenance costs as well as potential permit violations. As an initial step, CUC or another agency can conduct long-term monitoring at the different sites to collect data on flow and concentration. The data can then be used in future studies or in formulating policies to control the brine discharge.

Sludge Handling Alternatives for Sadog Tasi and Agingan Wastewater Treatment Plants

Currently, both WWTPs are equipped with an aerobic digester and a 2-meter BFP. Agingan WWTP does not perform any decanting/ thickening step prior to sending the digested sludge to the BFP, while Sadog Tasi WWTP does. The dewatered sludge from the BFP at both WWTPs is then sent to the landfill at Marpi for final disposal. From the Pro2D run results, the amount of solids produced per day at Sadog Tasi WWTP ranges between 1,000 kg/day under current flow conditions to 5,300 kg/day under maximum flow conditions, while Agingan WWTP solids production ranges between 800 kg/day under current flow conditions to 3,300 kg/day under maximum flow conditions. The percent reduction for volatile solids (degree of stabilization) achieved by the digesters is between 21 to 26 percent for Sadog Tasi WWTP and 21 to 38 percent for Agingan WWTP.

Assessment of the WWTP's sludge-handling processes is largely based on final disposal requirements. CUC does not have a specific permit for landfill disposal of sludge. In an EPA technical support document titled "Landfilling of Sewage Sludge" (1988), it is documented that the minimum solids content in the sludge disposed and landfilled should be 20 percent (or 15 percent for narrow trench landfills). In the CNMI DEQ permit for the Marpi Landfill, the disposal of sewage sludge is specifically authorized, with the main requirement for sludge disposal being the free liquid content must be measured by means of a "Paint Filter Liquids Test" (EPA Test Method 9095).

This wastewater systems assessment recognizes that both Sadog Tasi and Agingan WWTPs have adequate sludge-handling facilities in the current context of final disposal at the Marpi Landfill. The following segment provides a review of the sludge-handling alternatives available to CUC from thickening and stabilization (digestion) to dewatering. Potential alternatives are considered in order of benefit to CUC in terms of reduced capital investment, operating (energy) cost, and O&M requirements in the local context.

Thickening Alternatives

During the design stage, it is common to consider thickening as a potential unit process to reduce the volume of WAS from the secondary clarifiers to allow for a smaller digester. In this case the digesters are already operational, hence there is no need to introduce additional thickening before the digesters if they continue to operate in the current configuration.

Stabilization Alternatives

There are currently no requirements for sludge stabilization to dispose dewatered sludge at the Marpi Landfill. However, other than sludge stabilization, digestion also helps to reduce sludge solids loading for downstream dewatering operations. As a result of volatile solids reduction, total solids reduction is estimated to be between 18 and 20 percent for Sadog Tasi WWTP and about 19 to 21 percent for Agingan WWTP. This reduces the loading to the BFPs and improves performance compared to dewatering un-stabilized sludge. Hence, the current aerobic digestion process still provides benefits for plant operations.

Comparison of Aerobic and Anaerobic Digesters. The use of aerobic digesters as compared to anaerobic digesters is as follows:

- Aerobic Digesters
  - The aerobic digester generally has a higher operating cost compared to the anaerobic digester due to the aeration system.
  - For small WWTPs such as Agingan and Sadog Tasi, the aerobic digester is easy to operate, reliable, and effectively reduces the biodegradable organic fraction in the sludge.
- Anaerobic Digesters
  - For small WWTPs, anaerobic digesters typically incur higher capital costs than can be recovered through energy savings/recovery from biogas production and in general perform better when the treatment process includes primary sedimentation that provides an organics-rich sludge feed.
  - Anaerobic digesters also tend to utilize more complex mechanical and instrumentation systems and require greater degree of operation and maintenance effort in comparison to aerobic digesters.

Because the lifecycle costs for anaerobic digestion is not necessarily lower, and in view of the existing O&M environment, it is recommended that aerobic digestion continue to be the stabilization process for both WWTPs.

Additional Comments. Although aerobic digestion is currently an appropriate stabilization process for CUC, this Master Plan aims to address the potential for a low-energy alternative for sludge stabilization using ponds or lagoons. As energy costs remain high, causing the aerobic digesters to be a relatively high O&M expense, it may be viable to identify land that can be used to create ponds to provide stabilization before dewatering and drying of sludge.

As there appear to be no specific stabilization criteria for landfill disposal, stabilization ponds are likely to be an adequate solution. If stabilization ponds are constructed near the WWTP, the existing digesters could be used as an intermediate thickening basin before sending thickened sludge for stabilization.

For the Sadog Tasi WWTP, where there are external discharges directly into the aerobic digesters such as private septage, FOG, and dairy waste, there may be a need to retain the aerobic digester function to provide additional stabilization capability when these waste streams are introduced.

Dewatering Alternatives

Sludge dewatering alternatives were identified based on what is practiced in Guam. Sludge handling in Guam is accomplished either by aerobic/anaerobic digestion followed by dewatering using BFPs or dewatering centrifuges before final disposal at a landfill or by the use of stabilization ponds/lagoons with bottom sludge removed to drying beds. The efficacy of the dewatering alternatives is as described below:

- Belt Filter Press
  - Solids content 15 to 20 percent for BFPs.
  - Both WWTPs currently utilize BFPs that are not energy intensive, are relatively easy to operate, and produce dewatered sludge at 17 to 20 percent solids.
  - The BFPs are currently able to meet the primary landfill criterion of 20 percent solids content.

- Dewatering Centrifuge
  - Improves dewatering in terms of achieving higher solids content (20 to 25 percent).
  - Increased power consumption, which increases overall operating costs.
- Sludge Drying Beds
  - It is a low energy, low maintenance method of achieving sludge dewatering compared to the current BFPs.
  - Achieving the necessary dewatering performance under the frequent wet weather conditions in Saipan will be challenging. To overcome this, capital expenditure would be needed to construct a shelter over the entire drying bed. The existing BFPs can be retained and kept in operation before the drying beds are placed in operation.
  - At Sadog Tasi WWTP, the existing Japanese Tank can potentially be converted for use as a drying bed. However, there will be additional costs involved in dredging the current sediments accumulated from years of deposition in the tank.

Hence, conversion to centrifuges or other more efficient, but more energy intensive, equipment is not deemed beneficial and not recommended for CUC.

High-Level Assessment of WWTPs, Abandonment of Sadog Tasi WWTP, and Redirection of Flow to Agingan WWTP

The Stipulated Order requires the Master Plan to include (1) a high-level look at placement and needs of existing or new plants, consolidation, and expansion capabilities; (2) evaluation of expansion capabilities at Agingan WWTP, the potential abandonment of Sadog Tasi WWTP, and redirection of flows to Agingan WWTP; and (3) evaluation of the Kagman WWTP and an alternative collection and conveyance system to transport wastewater from Kagman WWTP to Agingan WWTP. Items 1 and 2 are evaluated in this section. Item 3 is discussed in Section 2.2.7.

High-Level Look at Placement and Needs of the Existing or New Plants, Consolidation, and Expansion Capabilities

Sadog Tasi WWTP. Sadog Tasi WWTP is well placed to handle sewage for the northern part of Saipan. Based on the evaluation of existing data, it is able to handle the dry and wet weather flows that it receives. It generally complies with its NPDES permit levels except for *Enterococci*, pH, copper, zinc, and phosphorus.

As mentioned previously, a disinfection step prior to discharge to the outfall would be recommended to achieve the *Enterococci* limits in the permit based on the current plant treatment processes alone. Alternatively, a revision of the NPDES permit that accounted for dilution at the outfall would allow for consistency with standard EPA guidance and place the plant into compliance.

There is currently available land space surrounding the plant for the expansion of the Sadog Tasi WWTP. However as the plant is receiving less flow than its design capacity, expansion is not expected in the foreseeable future.

Agingan WWTP. Agingan WWTP is well placed to handle sewage from the southern part of Saipan. Based on the evaluation of existing data, it is able to handle the dry and wet weather flows that it receives. It generally complies with its NPDES permit except for *Enterococci* and copper. Similar to Sadog Tasi WWTP, a disinfection step would be necessary to comply with the NPDES permit. Alternatively, a revision of the NPDES permit that accounted for dilution at the outfall for allow for both consistency with standard EPA guidance and place the plant into compliance.

There is currently limited land space available at Agingan WWTP for expansion purposes. Any future expansion plans would have to consider a treatment technology that does not require large land space.

Evaluation of Expansion Capabilities of Agingan WWTP, Abandonment of Sadog Tasi WWTP, and Redirection of Flow to Agingan WWTP

The Stipulated Order requires the assessment of the expansion capabilities of Agingan WWTP, the potential abandonment of Sadog Tasi WWTP, and the redirection of Sadog Tasi flows to Agingan. The following discussion assesses the feasibility, advantages, and disadvantages of this strategy.

Expansion capabilities of Agingan WWTP. The Agingan WWTP was designed for an average flow of 3 MGD and is currently treating an average flow of 1.3 MGD. The process modeling estimated that the plant can handle up to an average flow of 3.7 MGD; this difference is primarily due to the fact that the wastewater currently being treated at Agingan WWTP is lower strength (i.e., TSS and BOD loads) than what the plant was designed to treat. However, for the purpose of master planning, the design wastewater characteristics are used and the plant capacity is assumed to be 3 MGD for this discussion.

An expansion of Agingan WWTP will be at a considerable capital expenditure that must be evaluated thoroughly, especially as CUC has recently completed significant upgrades at the plant, as described in the earlier sections of the Master Plan. Key considerations for a potential expansion of wastewater treatment are land availability, and plant configuration, as described below.

Land Availability. Limited land is available at the Agingan WWTP site. It is currently surrounded by public land, but with the following existing uses: a communications transmission (broadcasting) company to the north on leased public land, a private golf course (Coral Ocean Point golf course) on leased public land to the east, and public beaches to the south and west. Any expansion via the construction of a new module will be challenging and may involve encroaching into the adjacent leased public land parcels.

Plant Configuration. The configuration of the existing wastewater treatment process at Agingan WWTP has the treatment tanks above the equipment room, integrated as one compact structure. This configuration is very space efficient on its own but would be difficult to upgrade by modifying the existing structure. Thus, a separate module is likely to be necessary if the WWTP needs to handle additional flow above its design capacity.

The construction of an additional conventional wastewater treatment plant at Agingan WWTP would be limited by space constraints. The adoption of a space-saving technology such as membrane bioreactors would be very costly from a capital expenditure perspective as well as from an O&M perspective. If expansion at the Agingan WWTP were to become a prioritized project for CUC, different wastewater technologies should be evaluated (e.g., MBR and SBR) to determine if the space-saving technologies will provide a footprint small enough to allow expansion to occur at the Agingan site.

Abandonment of Sadog Tasi WWTP and Redirection of Flow to the Agingan WWTP. The Sadog Tasi WWTP has also been recently upgraded and has experienced much better performance since the upgrades.

The redirection of flow from Sadog Tasi WWTP (currently receiving an average flow of 1.5 MGD) appears to be within the treatment capacity at Agingan WWTP (3 MGD) for the current situation. The total average flow to both WWTPs is currently 2.8 MGD. However, as population grows and flow increases, the existing Agingan WWTP will not be able to handle future flows and overloading it will affect its ability to comply with its NPDES permit. Thus, an expansion of the plant would be needed to handle flows from both the Agingan and Sadog Tasi sewersheds. The potential limitations for a plant expansion at Agingan were discussed in the previous section.

The existing sewer network is split into the northern and southern parts of Saipan, and the sewers convey sewage flow to Sadog Tasi and Agingan WWTP, respectively. The redirection of the Sadog Tasi flows to Agingan WWTP would mean the conveyance of sewage flow from the Northern part to the Southern part of Saipan. Thus, major modifications to the existing sewer network will be needed as discussed below.

Description of Sewer Network. The existing sewer networks for the northern and southern parts of Saipan connects to their respective WWTPs via a network of branch and trunk sewers. Low-elevation sewage networks have lift stations to pump up the sewage to higher elevation downstream networks. No pipeline connects the two networks together.

If the Sadog Tasi WWTP is to be abandoned and flow is redirected to the Agingan WWTP, a method to convey the sewage from the northern part of Saipan to the Agingan WWTP located at the southern-most part of Saipan must be implemented.

Based on our preliminary evaluation and understanding of the situation at Saipan, three options are proposed. It should be noted that variations of these options are possible and should be investigated further to determine the most cost-effective and optimal operational alternative.

Option 1 – Convey all Sadog Tasi Service Area Flow Directly to Agingan WWTP via a New Gravity Line. Option 1 has two variations, both involving the construction of a gravity line to convey Sadog Tasi service area flows directly to Agingan WWTP.

Option 1a: Gravity Flow all Sadog Tasi Service Area Flow Directly to Agingan WWTP Area from S-3 via new Gravity Line. The first option is to lay a new, large-DIA gravity trunk sewer along Beach Road that is sized to handle the peak future projected flow from the entire sewage network for the Sadog Tasi sewer service area. It will take the sewage from the final Sadog Tasi service area collection point (Lift Station S-3) upstream of the Sadog Tasi WWTP and convey it via gravity flow to the Agingan WWTP. There will be a new final lift station at the end of the gravity pipe to lift the sewage into the Agingan WWTP. This option would require the gravity line to be buried very deeply to achieve gravity flow and be located below the water table (i.e., potentially 30 to 40 feet below ground surface).

Option 1b: Gravity Flow all Sadog Tasi Service Area Flow Directly to the Agingan WWTP area via New Interceptor from Sadog Tasi WWTP to Agingan WWTP, Intercepting Flows for Southern Sadog Tasi Sewershed Lift Stations. This option is very similar to Option 1a in that a new gravity trunk sewer would be used to convey sewage from the Sadog Tasi sewer service area to the Agingan WWTP. The main differences between Options 1a and 1b is that with Option 1b:

- A new gravity trunk will connect to the existing Sadog Tasi trunk sewer to collect the flows from sewage network north of the Sadog Tasi WWTP.
- The Sadog Tasi lift stations south of the Sadog Tasi WWTP will be decommissioned and flows just upstream of lift stations will be intercepted into the new trunk sewer. This gravity trunk sewer will convey wastewater flows directly to Agingan WWTP, where a new lift station at the end of the gravity line will pump the sewage to the Agingan WWTP.

Option 2 – Convey all Sadog Tasi Service Area Flow Directly to Agingan WWTP via New Force Main. This option is similar to Option 1b, with the exception that a force main, rather than a gravity line, would be used to convey flow from the Sadog Tasi service area to the Agingan WWTP. This option would require the construction of a new large DIA trunk force main that would convey flow from the final Sadog Tasi collection point (Lift Station S-3) to the Agingan WWTP. All flow north of the Sadog Tasi WWTP would be collected at the upstream end of the new force main, while all existing force mains south of the Sadog Tasi WWTP would be reconfigured to pump directly into the new force main, eliminating the existing lift stations in the southern Sadog Tasi service area. The new force main would follow Beach Road and would not need to be buried nearly as deep as the gravity pipe discussed in Options 1a and 1b.

Option 3 – Convey all Sadog Tasi Service Area Flow to Agingan WWTP via Force Main to the East Sewer System. This option will involve the redirection of Sadog Tasi flows to a new lift station at the junction of Beach Road and Chalan Monsignor Guerrero Road, and construction of a new force main to lift the collected Sadog Tasi sewage flows to the East Sewage Collection System at As Lito, which connects to the Agingan WWTP. The East Collection System has sufficient existing capacity to accommodate the Sadog Tasi sewage flows. Reversal of existing Sadog Tasi WWTP bound flows and upgrade of the lift stations south of and including Lift Station S-3 will be required.

Comparison of Potential Options. Table 2.2.3-13 summarizes the comparison of the options for the potential abandonment of Sadog Tasi WWTP and redirection of sewage flow to Agingan WWTP.

Due to feasibility of construction and associated construction costs, Option 3 is considered the most feasible option for abandoning the Sadog Tasi WWTP and redirecting all flows to the Agingan WWTP. The major disadvantage to Option 3 is the use of existing capacity in the East Sewage Collection System that may be reserved to accept future sewage flows from the Kagman and other unsewered areas. There will also be significant additional costs associated with the additional pumping needed to convey wastewater flows from the Sadog Tasi service area to the Agingan WWTP via the East Sewage Collection System. All three basic options represent a significant capital investment for CUC as well as additional O&M burden in its sewage collection system. Further study of the potential variations in each basic option is recommended prior to any final recommendations being made for centralization of wastewater treatment.

In terms of treatment plant capacities, while the abandonment of Sadog Tasi WWTP will free up land for other developments and allow the decommissioning of the Sadog Tasi Outfall, another large capital investment is required to build a completely new treatment plant module at Agingan WWTP. The land constraints and potential mitigation measures to minimize impacts on historic resources at the Agingan site are also likely to introduce additional construction costs.

Table 2.2.3-13. **Comparison of Options for Potential WWTP Centralization**

Key Consideration	Option 1a Transfer Sewer, Gravity Line	Option 1b Interceptor Sewer, Gravity Line	Option 2 New Force Main Along Beach Road	Option 3 New Force Main Via East Collection System
Impact on Existing Agingan Sewer Network	Bypasses it; will not exceed existing capacities or complicate future developments	Bypasses it; will not exceed existing capacities or complicate future developments	Bypasses it; will not exceed existing capacities or complicate future developments	Bypasses it; will not exceed existing capacities; will create capacity issues if Kagman flows are included in the future
Impact on Existing Sadog Tasi Sewer Network	Not impacted; continue to operate and maintain existing sewers and lift stations	Lift stations south of Lift Station S-3 would be decommissioned as flows are intercepted into the new interceptor sewer	Lift stations south of Lift Station S-3 would be decommissioned as flows are intercepted into the new force main	Redirection of flows and upgrading of lift stations south of and including Lift Station S-3 will be required.
New Lift Station	New lift station required at the end of the new trunk sewer to pump to Agingan WWTP	New lift station required at the end of the new trunk sewer to pump to Agingan WWTP	New lift station or upgrades to existing Lift Station S-3 required at the upstream end of the new force main to pump to Agingan WWTP	A new lift station at junction of Beach Road and Chalan Monsignor Guerrero Road will be required
New Gravity Trunk Sewer	New trunk sewer sized to covey total Sadog Tasi flows; construction may not be feasible due to the depth requirements to provide for gravity flow	New trunk sewer sized to match flows that it intercepts along the way in Southern Sadog Tasi service area; construction may not be feasible due to the depth requirements to provide for gravity flow	No new gravity line needed	No new gravity lines needed until (and if) Kagman sewage flows are routed to East Collection System
New Force Main Sewer	No force main needed	No force main needed	New force main sized to match flows intercepted along Beach Road	New force main to the East Sewage Collection System at As Lito
New Link Sewers	Not needed	Link sewers will need to be built to intercept flows upstream of individual lift stations into the new trunk sewer	Existing force mains will need to be reconfigured to intercept flows upstream of individual lift stations into the new force main	Not needed

Table 2.2.3-13. **Comparison of Options for Potential WWTP Centralization**

Key Consideration	Option 1a Transfer Sewer, Gravity Line	Option 1b Interceptor Sewer, Gravity Line	Option 2 New Force Main Along Beach Road	Option 3 New Force Main Via East Collection System
Capital Expenditure	Large capital expenditure for building the long, large-DIA trunk sewer from Sadog Tasi to Agingan WWTP; additional cost for new lift station at Agingan WWTP	Large capital expenditure for building the long, large-DIA trunk sewer from Sadog Tasi to Agingan WWTP; additional cost for new lift station at Agingan WWTP; more complicated construction for link sewers	Large capital expenditure for building the long, large DIA force main from Sadog Tasi to Agingan WWTP, though less costly than Options 1a and 1b due to depth requirements; additional cost for new/upgraded Lift Station S-3; new, larger pumps may be required at the southern Sadog Tasi lift stations	Modest capital expenditure for building the large DIA force main along Chalan Monsignor Guerrero, from the new lift station at Beach Road to As Lito, which would be less costly than Options 1a, 1b, and 2 due to depth requirements and length of improvements; additional costs for upgrading of lift stations including and south of Lift Station S-3
O&M Costs	New lift station at Agingan WWTP will be a significant additional O&M cost; Additional O&M associated with new gravity line; Reduction in operating costs for power, tools, materials, parts, and staff	New lift station at Agingan WWTP will be a significant additional O&M cost; additional O&M associated with new gravity line' reduced energy and other O&M costs for decommissioned southern Sadog Tasi lift stations; reduction in operating costs for power, tools, materials, parts, and staff	New/additional pumping at the S-3 lift station will be a significant additional O&M cost; additional O&M associated with new force main; additional pumping costs to intercept all flows south of S-3 into the new force main; reduction in operating costs for power, tools, materials, parts, and staff	New/additional pumping at Beach Road-Chalan Monsignor Guerrero Road lift station will be a significant additional O&M cost; additional O&M associated with new force main additional cost to redirect flows and upgrade existing lift stations; reduction in operating costs for power, tools, materials, parts, and staff

Conclusions

The abandonment of Sadog Tasi WWTP and redirection of sewage flow to the Agingan WWTP has both advantages and disadvantages that are summarized below.

- Advantages
  - Free up the land for other developmental use.
  - Result in the decommissioning of the Sadog Tasi Outfall.
  - Elimination of the source of frequent odor complaints from neighbors in the Sadog Tasi area.
  - Elimination of the pollutant loading to the Saipan lagoon, which may improve water quality in an area that is heavily used by the tourism industry and that also contains important coral reef resources and a marine protected area. It may also improve water clarity, which would be an aesthetic improvement, at a minimum, in this important tourist area.
- Disadvantages
  - Expected high cost for the expansion of Agingan WWTP as well as the upgrades to the collection system.
  - Limited land space at Agingan WWTP for expansion that would require either the use of land-saving technology, which has high capital and O&M expenses, or the purchase of adjacent land to Agingan WWTP, which is highly improbable and could be very costly.
  - Additional O&M costs for redirection of flow to Agingan WWTP associated with new/upgraded lift stations and new sewer pipe.

The centralization of the sewerage system to the Agingan WWTP in the most southern portion of Saipan would be an expensive program to implement. The program would have some benefits, as outlined above. However, without a very large source of funding for this capital investment in addition to all other necessary capital investments for both water and wastewater system improvements, this may not be a feasible project.

Sadog Tasi WWTP, based on available land, would be a more feasible option for wastewater treatment centralization as it is underutilized and has more land space for further expansion. The feasibility of this alternative would be difficult to implement because of the concern with additional flow being released through the Sadog Tasi outfall near a recreational area and in much shallower water.

Because the two WWTPs have been recently upgraded and are producing a reliable quality effluent, centralization is a very low priority for the wastewater system in Saipan. The higher priorities include upgrading deteriorated infrastructure and connecting existing unsewered areas that are impacting groundwater quality to the system to the sewer.

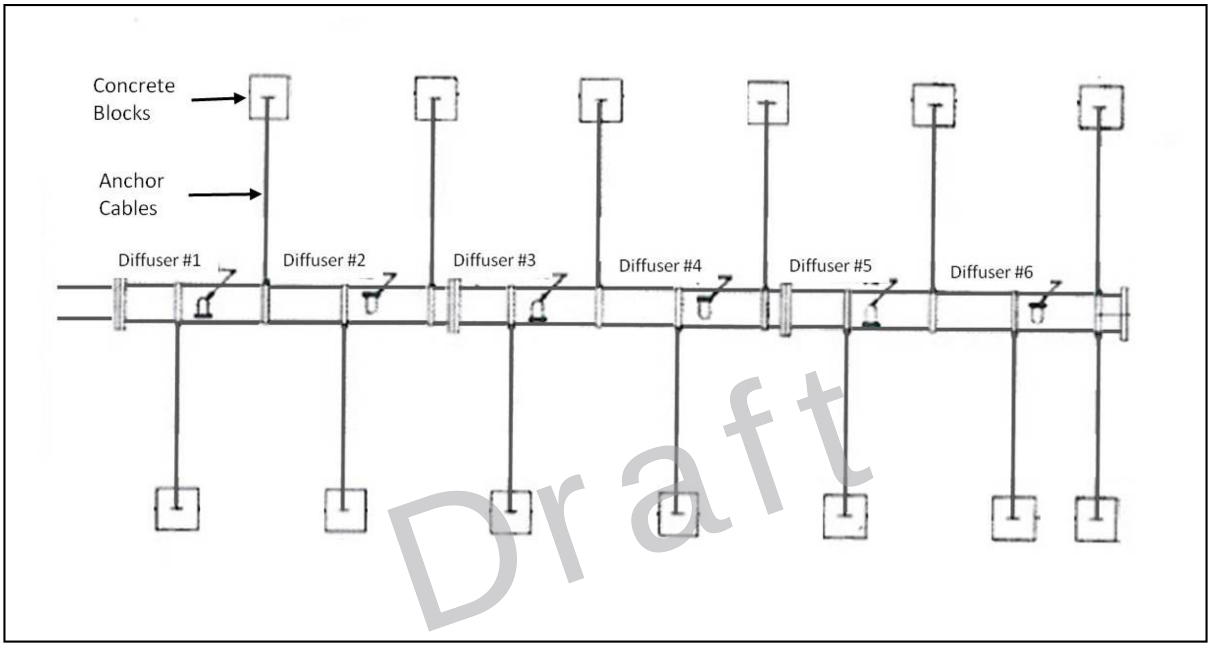
2.2.4 Saipan Harbor Outfall Dilution Study

The 2001 mixing zone analysis (see Appendix F) established a critical initial dilution of 77:1 for the outfall. The dilution study documented in this section updates the previous mixing zone analysis based on additional information about ambient conditions and operation of the outfall, and evaluates potential improvements in the achievable initial dilution due to changes to the diffuser configuration and assumed flow conditions. The results of initial dilution calculations show that this critical dilution is currently being met even with three diffuser ports blocked off and that additional dilution can be achieved with changes to the diffuser configuration and operations as described below.

Background

The Sadog Tasi WWTP outfall was originally permitted in 1985 to discharge up to 1.63 mgd of primary treated wastewater into Tanapag Harbor. The treatment plant was upgraded and expanded in 1995 to discharge up to 4.8 mgd of secondary treated wastewater through the outfall. The outfall extends approximately 1200 feet into the harbor and consists of 20-inch DIA high-density polyethylene (HDPE) pipe anchored to the bottom with concrete blocks, terminating in an approximately 100-foot long diffuser section that rests on the bottom of the harbor in about 49 feet of water. The diffuser section is anchored laterally by 13 cables attached to concrete blocks as shown in Figure 2.2.4-1.

Figure 2.2.4-1. **Plan of Sadog Tasi WWTP Outfall Diffuser**



The diffuser section contains six 6-inch DIA risers spaced 19.68 feet apart. The risers extend from the top of the outfall pipe with a 90 degree bend at the top of the riser so that effluent is discharged horizontally. The discharge is directed 90 degrees from the axis of the outfall with ports oriented such that adjacent ports discharge in opposite directions with the first port discharging off the north side of the outfall, the second off the south side, etc.

Outfall Condition

The critical initial dilution based on the previous mixing zone analysis of 77:1 assumed that effluent was discharged from the first three ports nearest land and that the three outboard ports were closed off based on notes in the as-built drawings. A recent diver inspection showed that all six ports were open; however, the first three ports were either partially or totally plugged by marine growth or other material. Ports 1 and 3 showed no signs of flow and were clogged inside the neck of the risers.

Port 2 had a significant amount of material and growth extending out the port and appeared to have a small amount of effluent flow seeping out around the blockage.

The three outboard ports were open and appeared to be flowing unimpeded.

Based on the diver inspection, the condition of the rest of the outfall was generally good. Divers inspected each concrete anchor/support along the portion of the pipeline between the shoreline and the diffuser section. A single clamping strap holding the pipe to one of the concrete anchor blocks was broken. All other anchor/support assemblies were in good condition. For the diffuser section, one of the outermost anchor cables had almost corroded through at a point close to where it was connected to the diffuser. All other anchor cables appeared sound. No other damage to the outfall was noted.

An internal inspection of the outfall was not conducted. However, due to the riser locations at the crest of the diffuser pipe and low historic flow rates, which can both allow sediment delivered from the plant to settle in the diffuser and allow recirculation of seawater into the risers, it is likely that some sediment has accumulated in the diffuser section.

Approach to Dilution Study

This dilution study uses input from the 2001 mixing zone analysis as presented in Appendix A to the December 2007 Fact Sheet for the renewed NPDES permit (EPA Region 9, 2007) as a basis for the calculations; however, the study has been updated as supported by more recent additional data. In addition, effects of potential changes in outfall operations and potential modifications were evaluated, including:

- Operating at lower effluent flow rates more consistent with what demand may be in the near term
- Reducing the port size
- Adding Tideflex Diffuser Valves to the ports
- Adding an extra port to the endgate of the diffuser as a means of reducing sediment buildup in the diffuser

Consistent with the 2001 mixing zone analysis, Visual Plumes mixing zone modeling software was used to evaluate the initial dilution achievable from the Sadog Tasi outfall. Visual Plumes provides a graphical user interface for a number of EPA-approved plume dilution models. The documentation for the 2001 mixing zone analysis that was included with the 2007 Fact Sheet indicates that Visual Plumes was used to evaluate initial dilution of the outfall, but does not indicate the model that was used. Runs were made using the models UDKW and UM3 within Visual Plumes using input from the 2001 mixing zone analysis, and the results were compared with dilutions calculated in the 2001 analysis. The results indicate that the model UM3 was likely the model used in the previous calculations and was selected for use in this dilution study both for consistency with the previous analysis and because it provides a conservative estimate of dilutions compared to the other model results.

The remainder of this section is divided into three sections:

- **Model Input** includes input from the 2001 mixing zone study that were used as a basis for the dilution calculations as well as parameters that were changed as part of this dilution study.
- **Results** presents model results of dilutions for the cases addressed.
- **Discussion** summarizes the results and presents potential flow-based effluent limits for nickel, copper, silver, and zinc.

Model Input

Model input used for the dilution study is presented below. 2001 Mixing Zone Input is based on information from the December 2007 Fact Sheet (EPA, 2007) and provides the basis for the analysis. The Revised Inputs present changes made to the 2001 mixing zone study input based on more recently collected data, potential changes to the diffuser section, and potential reduced flow rates.

2001 Mixing Zone Input

Dilution model inputs used in the previous mixing zone analysis are as follows:

- Diffuser Configuration
  - Port DIA: 6 inches
  - Number of Ports: 6 and 3
  - Port Spacing: 19.68 feet
  - Vertical Angle: 90 degrees
  - Port Depth: 49 feet
- Effluent Characteristics
  - Effluent Flow: 4.8 and 3.0 mgd (representing average plant design and 1998 average flow)
  - Effluent Salinity: 4.5 ppt
  - Effluent Temperature: 30 °C
- Receiving Water
  - Current Speed: 0 ft/s
  - Ambient Salinity: 36 ppt
  - Ambient Temperature: 30 °C

Ambient receiving water salinity and temperature used were not documented in the appendices to December 2007 Fact Sheet (EPA, 2007); however, ranges for these parameters were provided in email exchanges between EPA and CH2M related to the 2001 mixing zone study, and the most conservative combinations of these were used.

Although no flow limitation is set in the NPDES permit, flow rates must be monitored and mass limits are specified for a list of water quality constituents. Effluent flow rates in the mixing zone study were based on an average plant design flow rate of 4.8 mgd and an average flow rate for 1998 of 3.0 mgd. The December 2007 Fact Sheet indicates that the average daily flow for 2005 was 2.9 mgd, similar to the 1998 value. Although both 4.8 and 3.0 mgd effluent flow rates were considered, the more conservative design flow rate was used for determining the critical initial dilution.

EPA (1994) allows up to a 10-percentile current speed for calculating critical initial dilution from an outfall. Insufficient data were available to characterize the currents for the previous analysis, thus a zero current speed was assumed as a conservative value.

Revised Inputs

Changes the initial mixing zone study inputs were limited to:

- Current speed
- Effluent flow rate
- Port size (both fixed ports and variable port sizes associated with Tideflex Diffuser Valves)
- Addition of a port to the end gate

Current Speed

As part of an oceanographic and shoreline mapping survey of Saipan Lagoon from April to June 2010 that was designed to support development of a numerical model of circulation in the lagoon, the Pacific Islands Applied Geoscience Commission (SOPAC) collected current profile data at a number of locations within the lagoon, including one at the location of the Sadog Tasi WWTP outfall (Krüger, et al., 2010). Data were collected between May 3 and June 10, 2010 and recorded 2-minute average current speed and direction profiles every 10 minutes with data grouped into 1-meter vertical bins along the profile between the bottom-mounted Acoustic Doppler Current Profiler (ADCP) and the surface.

Current profile time series data were obtained in a Microsoft® Excel® file. The data were processed to remove bins that extended above the water surface and those that were close enough to the water surface to be subject to side-lobe interference from the acoustic signals. Tenth-percentile current speeds were calculated for each bin. The overall current speeds were fairly consistent from the bottom to the top of the profile with tenth-percentile speeds ranging from 2.74 centimeters per second (cm/s) at the bottom-most bin to 2.37 cm/s at the upper-most bin in the profile and an overall (depth-averaged) speed of 2.50 cm/s.

For the purposes of this study, a 2.5 cm/s current speed was selected as a conservative estimate for the 10-percentile current speed. The depth averaged value should be conservative in that it will underestimate the impact of current near the diffuser where it has the greatest impact on enhancing mixing of the plume with ambient water. It will also tend to overestimate the rate at which the wastefield at the surface is transported to the edge of the zone of initial dilution (ZID), limiting the amount of additional mixing that could occur within the ZID. Although using a depth averaged current will tend give conservative results, the differences are expected to be small.

Effluent Flow Rate

As indicated above, there is no set limitation on flow rate, but there are limitations on concentrations and mass loading of various water quality constituents in the effluent. Although the plant is designed for an average flow of 4.8 mgd, demand is not expected to reach the plant design for another 20 years and is expected to remain flat or even decrease over the next 10 years. Because the plant design flow is not representative of present conditions and could underestimate the amount of dilution that is achievable with lower flows, flows ranging from 2 to 4.8 mgd were evaluated to assess the sensitivity of dilution on flow rate with the idea that interim limits could be negotiated based on lower flow rates in the near-term.

Port Size

Port size was varied for two scenarios: 1) reduction in size of the ports, and 2) retrofitting the existing ports with Tideflex Diffuser Valves that effectively provides a variable-sized port which opens up as flow is increased. For the fixed-size ports, port size was varied between 4 and 6 inches to assess the potential effect of smaller DIA ports and greater initial discharge velocities on dilution.

The Tideflex Diffuser Valves effectively provide a variable-sized orifice with the valve closed at zero flow and progressively opening as flow is increased. Hydraulic data that included effective port area and head loss for a range of flows were obtained from Tideflex Technologies for two 6-inch diffuser valves: one designed for a comparable jet velocity and head loss to the existing outfall diffuser ports with the outfall operating at 4.8 mgd, and one designed for the same jet velocity, but at total flow of 2.4 mgd, resulting in smaller effective port sizes. These data sheets are included as Appendix G.

Potential impacts that changes in port size would have on head loss through the outfall for both the fixed and retrofitted ports are discussed.

Added Port

The possibility of adding a seventh riser off the bottom of the end gate could be considered as a means of reducing sediment buildup in the bottom of the diffuser section. The benefit to dilution of adding a port was evaluated by adding a seventh port to the dilution model. For the purposes of this assessment, it was assumed that all seven ports were fitted with the Tideflex Diffuser Valves described above designed for the outfall operating at 4.8 mgd.

Results

Table 2.2.4-1 presents initial results comparing results of Visual Plumes runs of the UM3 and UDKW models with results from the 2001 Mixing Zone Study presented in EPA (2007). Both models were run assuming zero current consistent with assumptions in the 2001 study. As noted in the Model Input section above, ambient receiving water temperature and salinity that was used was not documented in EPA (2007). Representative ranges were assumed based on emails obtained related to the 2001 study and the values that resulted in the most conservative (lowest) dilutions were used. The UM3 model results were close to those from the 2001 study, but did not match exactly. While the source of the discrepancy was unclear, the values were sufficiently close to be considered representative of critical achievable dilutions consistent with the previous analysis.

Table 2.2.4-1. **Comparison of Visual Plume Models with 2001 Mixing Zone Study Results**

	Dilution		
Effluent Flow (mgd)/# Ports	**2001 Mixing Zone Study**	**UM3**	**UDKW**
3.0 / 6	102:1	107:1	131:1
3.0 / 3	82:1	85:1	94:1
4.8 / 6	87:1	90:1	108:1
4.8 / 3	77:1	78:1	84:1

Note: Zero ambient current assumed.

It is noted that UDKW results were significantly larger, with predicted dilutions on the order of 20 to 30 percent greater than those from the previous study for the cases with all six ports operating. Both UM3 and UDKW are EPA-approved initial dilution models that have been validated with empirical data. UM3 was selected for use in further calculations as a more conservative approach and consistent with the previous analysis. All runs were made using the Brooks far-field solution to calculate subsequent mixing following the end of initial dilution as the plume is carried by currents to the edge of the mixing zone.

Table 2.2.4-2 presents model results showing the effect of a tenth-percentile current on the achievable dilution for the four cases considered in the previous study. As shown, there was a moderate increase in dilution with increases on the order of 2 to 5 percent for the cases considered.

Table 2.2.4-2. **Effect of Ambient Current on Calculated Dilution**

	Dilution	
Effluent Flow (mgd)/# Ports	**Zero Current**	**Tenth-Percentile Current**[a]
3.0 / 6	107:1	112:1
3.0 / 3	85:1	88:1
4.8 / 6	90:1	92:1
4.8 / 3	78:1	80:1

[a] Tenth-percentile current = 2.5 cm/s

Table 2.2.4-3 and Figure 2.2.4-2 show the changes in calculated dilution for effluent flow rates ranging from 2.0 to 4.8 mgd. The modeled scenarios assumed that the outfall was operating with all six 6-inch DIA diffuser ports open and a tenth-percentile current. The critical dilution of 77:1 used in the existing permit is based on zero current, 4.8 mgd effluent flow (based on the design flow of the WWTP) and only three ports open. The increased dilution of 92:1 shown in Table 2.2.4-3 for the 4.8 mgd flow is largely due to the assumption that all six ports are open and, to a lesser extent, small differences in model predictions.

As shown in Table 2.2.4-3, operating at lower flows, and particularly reducing flows for each port, can have a significant effect on the dilution achievable. As shown in last two rows of Table 2.2.4-2, reducing the flow per port by half resulted in an increase in dilution from 80:1 to 92:1. Decreasing the total flow through the six ports from 4.8 to 3.0 mgd (the approximate average daily flow reported for 1998 and 2005) resulted in an increase in dilution to 112:1.

Reducing the port size for a given flow results in greater exit velocities. The reduced size results in greater dilution from greater turbulent mixing due to shear and greater entrainment of ambient water into the plume. The greater discharge velocities will also result in greater head losses through the ports, which could affect the hydraulic performance of the system.

Table 2.2.4-3. **Effect of Discharge Flow Rate on Calculated Dilution**

Flow (mgd)	Dilution
2.0	139:1
2.5	124:1
3.0	112:1
3.5	105:1
4.0	99:1
4.5	96:1
4.8	92:1

Note: Assumes existing diffuser with six 6-inch ports operating.

Figure 2.2.4-2. **Effect of Discharge Flow Rate on Calculated Dilution**

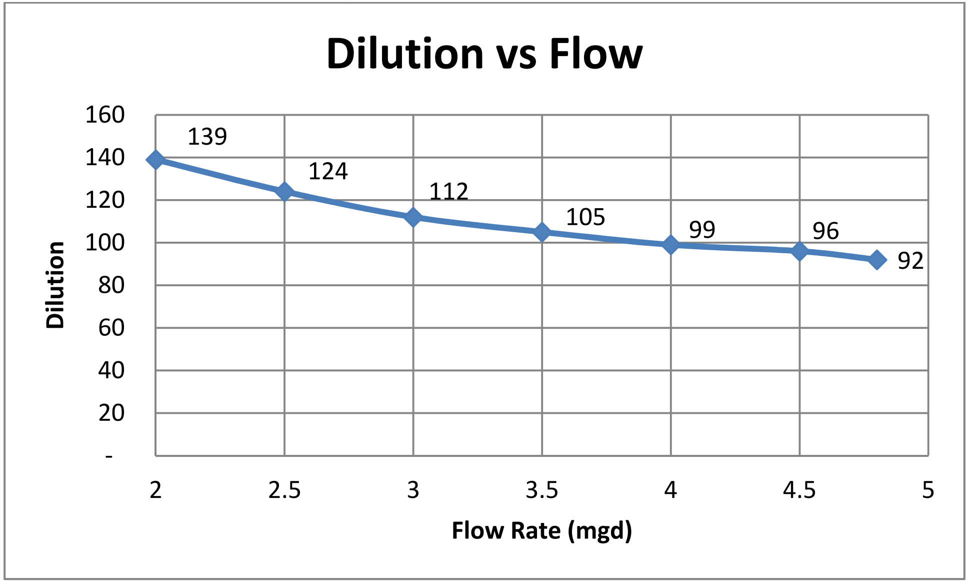


Table 2.2.4-4 and Figure 2.2.4-3 show results for model runs with port DIAs varied between 4 and 6 inches. Additionally, results for two Tideflex Diffuser Valve designs are presented. “Tideflex (high)” refers to a Wide-Bill Diffuser valve designed to have approximately the same jet exit velocity as the 6-inch fixed port with a total outfall discharge flow of 4.8 mgd. “Tideflex (low)” refers to a valve designed for a similar jet exit velocity, but when operating at half the flow. Results are shown for total effluent discharge rates of 1.0, 2.0, 3.0, 4.0, and 4.8 mgd.

Table 2.2.4-4. **Effect of Port Size on Calculated Dilution**

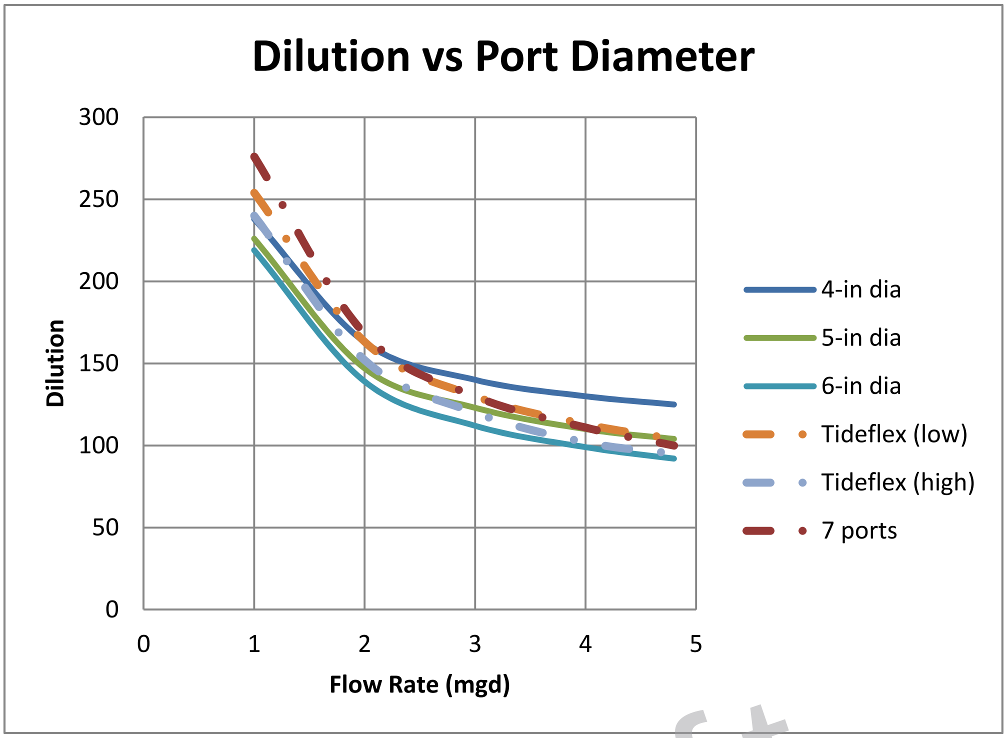
	Dilution for specified discharge flow				
Port Size (inches)	**1.0 mgd**	**2.0 mgd**	**3.0 mgd**	**4.0 mgd**	**4.8 mgd**
4.0	238:1	163:1	140:1	130:1	125:1
4.5	235:1	154:1	130:1	119:1	114:1
5.0	226:1	147:1	123:1	110:1	104:1
5.5	224:1	143:1	117:1	105:1	99:1
6.0	219:1	139:1	112:1	99:1	92:1
Tideflex (low)[a]	254:1	163:1	130:1	113:1	104:1
Tideflex (high)[b]	240:1	152:1	120:1	102:1	95:1
7 ports[c]	276:1	168:1	130:1	111:1	100:1

[a] Tideflex (low) indicates Wide Bill Tideflex Diffuser, Hydraulic Code 454, sized for 6.3 feet per second jet velocity at 2.4 mgd outfall flow

[b] Tideflex (high) indicates Wide Bill Tideflex Diffuser, Hydraulic Code 926, sized for 6.3 feet per second jet velocity at 4.8 mgd outfall flow

[c] Values interpolated from Tideflex (high) values to account for reduced per-port flow

Figure 2.2.4-3. **Effect of Port Size on Calculated Dilution**



As seen in Table 2.2.4-4, additional increases in dilution can be achieved through decreasing the port size with an increase in dilution from 92:1 to 125:1 for 4.8 mgd of effluent flow achieved by decreasing the port size from 6 to 4 inches; however, these increases come at the cost of increased head loss in the system. Table 2.2.4-5 and Figure 2.2.4-4 show impacts these changes have on the head loss in the system. The gain in dilution from decreasing the port size from 6 to 4 inches results in an increase in head loss by a factor of 5 from 0.62 feet to 3.12 feet of effluent when operating at 4.8 mgd.

Table 2.2.4-5. **Effect of Port Size on Head Loss**

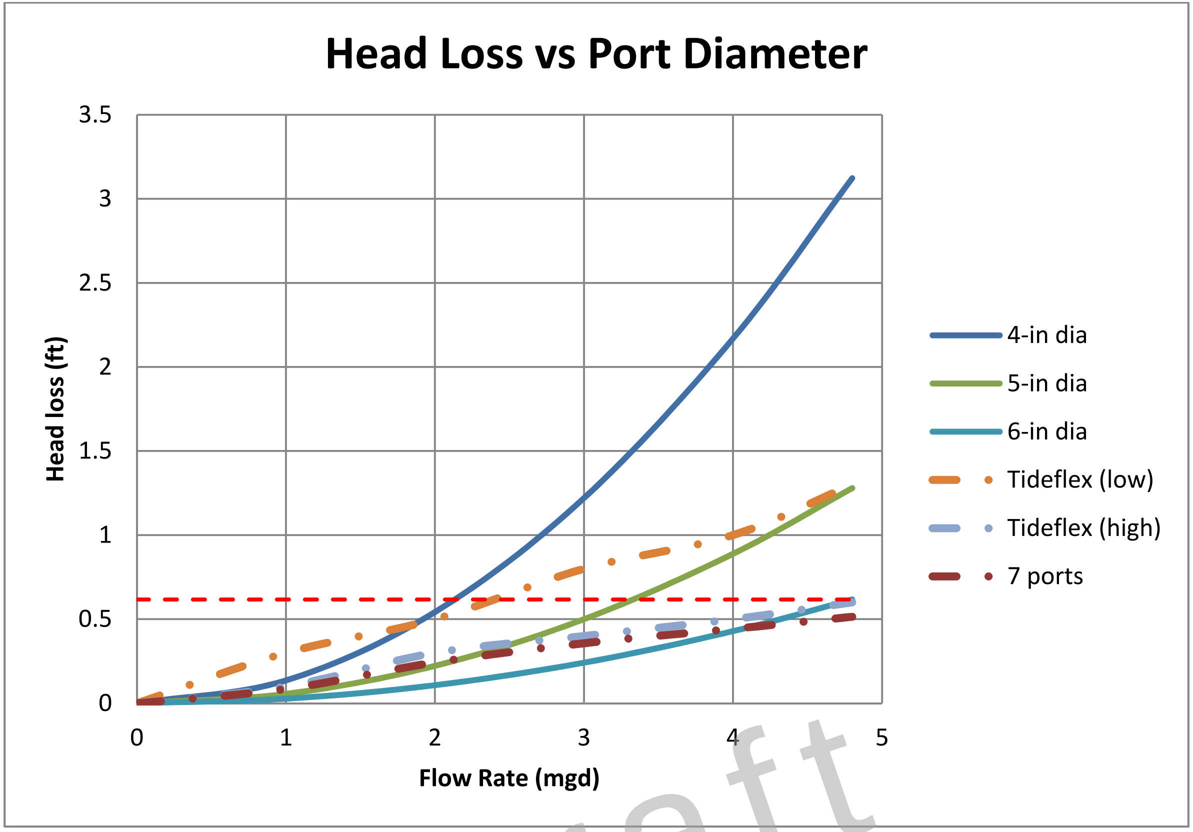
	Head Loss through Port for Specified Discharge Flow				
Port Size (inches)	**1.0 mgd**	**2.0 mgd**	**3.0 mgd**	**4.0 mgd**	**4.8 mgd**
4.0	0.14	0.54	1.22	2.17	3.12
4.5	0.08	0.34	0.76	1.35	1.95
5.0	0.06	0.22	0.50	0.89	1.28
5.5	0.04	0.15	0.34	0.61	0.87
6.0	0.03	0.11	0.24	0.43	0.62
Tideflex (low)[a]	0.3	0.5	0.8	1.0	1.3
Tideflex (high)[b]	0.1	0.3	0.4	0.5	0.6
7 ports[c]	0.09	0.24	0.36	0.44	0.51

[a] Tideflex (low) indicates Wide Bill Tideflex Diffuser, Hydraulic Code 454, sized for 6.3 feet per second jet velocity at 2.4 mgd outfall flow.

[b] Tideflex (high) indicates Wide Bill Tideflex Diffuser, Hydraulic Code 926, sized for 6.3 feet per second jet velocity at 4.8 mgd outfall flow.

[c] Values interpolated from Tideflex (high) values to account for reduced per-port flow.

Figure 2.2.4-4. **Effect of Port Size on Head Loss**



The horizontal red dashed line in Figure 2.2.4-4 represents the head loss of approximately 0.6 feet across the diffuser ports for the outfall operating at 4.8 mgd with six 6-inch ports discharging effluent. This shows that if the discharge was limited to 4 mgd, the ports could be decreased to 5.5 inches without increasing the head at the plant. Similarly, the port size could be reduced to about 4.75 inches if flows were limited to 3 mgd or 4 inches if flow was limited to about 2 mgd.

By closing down at lower flows, Tideflex Diffuser Valves can achieve greater dilutions while limiting head loss at peak flow rates. Table 2.2.4.5 and Figure 2.2.4-4 show that the valve design designated "Tideflex (high)" is comparable, both in terms of hydraulic and dilution performance, to a 6-inch port at a peak outfall flow of 4.8 mgd, however at 3.0 mgd it is approximately equivalent to a 5-inch port, and at 1.0 mgd is equivalent to a 4-inch port. The "Tideflex (low)" valve is equivalent to a 5-inch port at 4.8 mgd, a 4.5-inch port at 3.0 mgd, and a 4-inch port at 2.0 mgd while exceeding the dilution performance of a 4-inch port at 1.0 mgd.

Finally, comparison of the "Tideflex (high)" results with the results labeled "7 ports" demonstrates the additional dilution that can be achieved through reducing the per-port flow that could be expected if a seventh port was added at the end of the diffuser section to help reduce the accumulation of sediment in the diffuser section.

Discussion

The dilution calculations show that dilution will increase with an increase in the number of operating ports and/or a decrease in the effluent flow rate. Increasing the number of ports operating from three to six and assuming a tenth-percentile ambient current of 2.5 cm/s can increase the critical dilution for the plant operating at 4.8 mgd from 77:1 to 92:1.

Operating at reduced flows will increase the dilution further, with a 99:1 dilution calculated for a 4.0 mgd flow, 112:1 for 3.0 mgd, and 139 for 2.0 mgd. Further increases could be obtained by modifying the diffuser by decreasing the port size. Potential increases are shown in Table 2.2.4-4 and Figure 2.2.4-2. However, these increases come at the cost of increased head in the system, and the feasibility of reducing port sizes would depend on the hydraulic capacity of the system.

Retrofitting the diffuser with Tideflex Diffuser Valves can provide gains in dilution at lower flows without increasing the head loss through the diffuser at peak flows. The magnitude of increase is dependent on the design parameters of the valves. For a valve that is sized such that the hydraulic capacity of the system is not affected at peak design flows, there is essentially no improvement in dilution at the peak flow of 4.8 mgd and progressively increasing up to an approximately 10 percent increase as the system flow is reduced to 1 mgd. Tideflex Diffuser Valves also have the advantage of reducing or eliminating seawater intrusion into the outfall during times that the outfall is shut down or operating at low flow (less than about 0.5 mgd for the outfall operating with six 6-inch ports).

Given that the WWTP is not operating at capacity and will likely not in the near term, negotiation of flow-based limits or negotiation of interim limits based on lower effluent flows are possible ways of obtaining greater dilution credits for constituents in the receiving water. Water quality-based effluent limits were calculated for nickel, copper, silver, and zinc for dilution factors calculated for the existing diffuser with all six ports operating with flows ranging from 4.8 to 1.0 mgd. Results for these calculations are presented in Table 2.2.4-6. Calculations are based on procedures in the EPA *Technical Support Document for Water Quality-based Toxics Control* (EPA, 1991) and receiving water quality criteria from EPA's National Recommended Water Quality Criteria Table (EPA, 2012).

For comparison, Table 2.2.4-7 provides comparable results for the case in which the existing diffuser was fitted with Tideflex Diffuser Valves.

Table 2.2.4-6. **Potential Flow-Based Effluent Limits – Existing Diffuser with Six Open Ports**

	Dilution Factor/ Effluent Flow Rate					
	77:1[a] (Previous Permit)	**92:1 4.8 MGD**	**99:1 4.0 MGD**	**112:1 3.0 MGD**	**139:1 2.0 MGD**	**219:1 1.0 MGD**
Nickel						
Maximum Daily Limit (mg/L)	1.05	1.25	1.34	1.52	1.88	2.96
Average Monthly Limit (mg/L)	0.52	0.62	0.67	0.76	0.94	1.47
Copper						
Maximum Daily Limit (mg/L)	0.38	0.45	0.48	0.54	0.67	1.05
Average Monthly Limit (mg/L)	0.19	0.22	0.24	0.27	0.33	0.53
Silver						
Maximum Daily Limit (mg/L)	0.14	0.18	0.19	0.21	0.27	0.42
Average Monthly Limit (mg/L)	0.071	0.088	0.095	0.11	0.13	1.21
Zinc						
Maximum Daily Limit (mg/L)	7.01	8.36	8.98	10.15	12.58	19.77
Average Monthly Limit (mg/L)	3.49	4.16	4.48	5.06	6.27	9.85

Table 2.2.4-7. **Potential Flow-Based Effluent Limits – Existing Diffuser Fitted with Tideflex Diffuser Valves**

	Dilution Factor/ Effluent flow rate					
	77:1 (Previous permit)	**95:1 4.8 mgd**	**102:1 4.0 mgd**	**120:1 3.0 mgd**	**152:1 2.0 mgd**	**240:1 1.0 mgd**
Nickel						
Maximum Daily Limit (mg/L)	1.05	1.29	1.38	1.63	2.06	3.24
Average Monthly Limit (mg/L)	0.52	0.64	0.69	0.81	1.02	1.61
Copper						
Maximum Daily Limit (mg/L)	0.38	0.46	0.49	0.58	0.73	1.15
Average Monthly Limit (mg/L)	0.19	0.24	0.25	0.29	0.37	0.58
Silver						
Maximum Daily Limit (mg/L)	0.14	0.18	0.20	0.23	0.29	0.46
Average Monthly Limit (mg/L)	0.071	0.091	0.097	0.114	0.145	0.228
Zinc						
Maximum Daily Limit (mg/L)	7.01	8.63	9.25	10.87	13.75	21.65
Average Monthly Limit (mg/L)	3.49	4.61	4.61	5.42	6.85	10.79

Conclusions

- The 2001 mixing zone study established a critical initial dilution for the Sadog Tasi WWTP outfall of 77.1:1 based on an effluent flow rate of 4.8 mgd and the diffuser section operating with three of the six risers closed off.
- A diver inspection of the outfall showed the outfall generally in good condition with the exception of a broken clamping strap holding the pipe to one of the concrete anchor blocks and a corroded anchor cable on the diffuser section.
- It was also noted that three of the six ports on the diffuser were blocked with debris and marine growth, such that the outfall was discharging out of three ports only.
- Although the plant is designed for an average flow of 4.8 mgd, demand is not expected to reach the plant design for another 20 years and is expected to remain flat or even decrease over the next 10 years. The plant design flow is not representative of present conditions and the model underestimates the amount of dilution that is achievable with lower flows.
- It is likely that sediment has accumulated in the diffuser section due to the riser locations at the crest of the diffuser pipe and low historic flow rates, both of which can allow sediment delivered from the plant to settle in the diffuser and allow recirculation of seawater into the risers.
- Refitting the diffuser risers with Tideflex check valves can serve to prevent recirculation of seawater into the diffuser section as well as increase dilution at low flows.
- Additional increased dilution can be achieved by reducing the per-port flow rate by opening all ports.
- Addition of a seventh port fitted with a Tideflex check valve at the bottom of the endgate would result in further additional dilution and allow flushing of sediment that may accumulate in the bottom of the diffuser.

Recommendations

- Perform maintenance on the outfall and diffuser section, which should include replacement of the broken clamping strap, replacement of the corroded anchor cable on the diffuser section, and clearing all marine growth and other debris from the diffuser risers.
- Fit all six riser ports with Tideflex check valves.
- Install a seventh port fitted with a Tideflex check valve on the diffuser endgate to provide additional flow capacity as well as prevent buildup of sediment in the diffuser section.

2.2.5 Agingan Outfall Assessment

The Agingan Ocean outfall discharges secondary treated wastewater from the Agingan WWTP off Agingan Point into the Philippine Sea. At present, the Agingan WWTP is operating well below the current capacity and is expected to remain at that level for many years. Calculations documented in this section were performed to determine the potential for improved dilution for the outfall operating at reduced discharge rates. No additional studies were determined to be necessary at this point in time.

Approach

UM3, an EPA-approved initial dilution model that is part of the Visual Plumes model, was used to calculate dilutions for effluent flows ranging from 1 to 6 mgd.

Definition of the outfall and ambient conditions used as input to the model come primarily from information presented in the August 2009 Fact Sheet for the Agingan WWTP National Pollutant Discharge Elimination System (NPDES) discharge permit (EPA, 2009), previous dilution calculations performed during the design of the outfall (CH2M, 2001), and outfall design drawings and specifications.

Outfall and Receiving Water Characteristics

The August 2009 NPDES Fact Sheet (EPA) indicates that Water Quality-Based Effluent Limitations (WQBELs) used a critical dilution value of 200:1 based on an average flow of 3 MGD and a peak flow of 6.75 MGD. Details of the mixing zone calculations that support this critical dilution value have not been obtained.

Design drawings show the horizontal directional-drilled (HDD) outfall pipe to daylight in 100 feet of water with a port angle of 10 degrees above horizontal; however, as-built drawings were unavailable. The NPDES Fact Sheet indicates that the outfall discharges in 94 feet of water with the discharge angled 30 degrees above horizontal, discharging perpendicular to the current, and it is assumed that this better represents the as-built condition of the diffuser.

The 24-inch DIA outfall is fitted with a Tideflex Diffuser Valve, which is an elastomeric check valve that is closed at no-flow conditions, but progressively opens as the flow increases. As a result, the valve effectively provides a variable DIA port size with the size of the port increasing with an increase in the discharge flow rate. A hydraulic performance data sheet was provided by Tideflex Technologies (2012) for a valve that met the valve specifications in the Agingan Outfall design specifications (included as Appendix G to this Master Plan). Head loss and effective port DIA are presented in Table 2.2.5-1 for this valve for flow rates ranging from 1 to 6 MGD.

Table 2.2.5-1. **Tideflex Diffuser Valve Characteristics (24-inch, hydraulic code 2584)**

Tideflex Technologies, 2012

Discharge Flow (MGD)	Head Loss (feet)	Effective Diameter (inches)
1	0.3	8.2
2	0.6	9.8
3	0.8	10.8
4	1.1	11.5
5	1.4	12.1
6	1.7	12.7

Data presented in the previous dilution calculations (CH2M, 2001) were used to define effluent temperature and receiving water characteristics. An effluent temperature of 27°C was defined in the previous calculations based on data presented in the 1993 Facilities Master Plan.

Ambient density was defined based on conductivity, temperature, and a depth (CTD) profile measured at the site in July 2001. Table 2.2.5-2 presents this profile data as presented in CH2M (2001). A current speed of 0.1 m/s was specified based on results of current drogue studies conducted in the area.

Table 2.2.5-2. **Receiving Water Profile Characteristics Used for Dilution Modeling of the Agingan WWTP Outfall**

Measured July 17, 2001

Depth (feet)	Temperature (ºC)	Salinity (ppt)
Surface	30.0	34.2
10	30.0	34.2
20	30.0	34.2
30	30.0	34.2
40	30.0	34.2
50	30.0	34.2
60	30.0	34.2
70	30.0	34.4
80	30.0	34.4
90	30.0	34.4
100	30.0	34.4
110	29.5	34.4
120	29.5	34.4
130	29.5	35.0
140	29.5	35.0
150	29.5	35.0
160	29.5	35.0

Salinity of the effluent was set at 4.5 ppt based on estimates of effluent salinity used in similar calculations for the Sadog Tasi WWTP outfall (CH2M, 2012).

Table 2.2.5-3 summarizes the outfall and receiving water conditions used in the model runs. Additional model runs to look at sensitivity of the results to current speed were made for ambient current speeds of 0.05 and 0.15 m/s.

Table 2.2.5-3. **Agingan Wastewater Treatment Plant Outfall and Receiving Water Definitions Used in Dilution Modeling**

Parameter	Value	Source
Receiving water density	Profile in Table 2	CH2M, 2001
Ambient receiving water current speed	0.1 m/s	CH2M, 2001
Receiving water current direction	Perpendicular to discharge	EPA, 2009
Effluent Temperature	27°C	CH2M, 2001
Effluent Salinity	4.5 ppt	CH2M, 2012
Effluent flow rate	1, 2, 3, 4, 5, and 6 MGD	Defined
Diffuser water depth	94 feet	EPA, 2009
Diffuser angle to horizontal	30 degrees	EPA, 2009
Diffuser port DIA (associated effluent flow rate)	8.2 inches (1 MGD) 9.8 inches(2 MGD) 10.8 inches (3 MGD) 11.5 inches (4 MGD) 12.1 inches (5 MGD) 12.7 inches (6 MGD)	Tideflex data sheet (included as Appendix G)

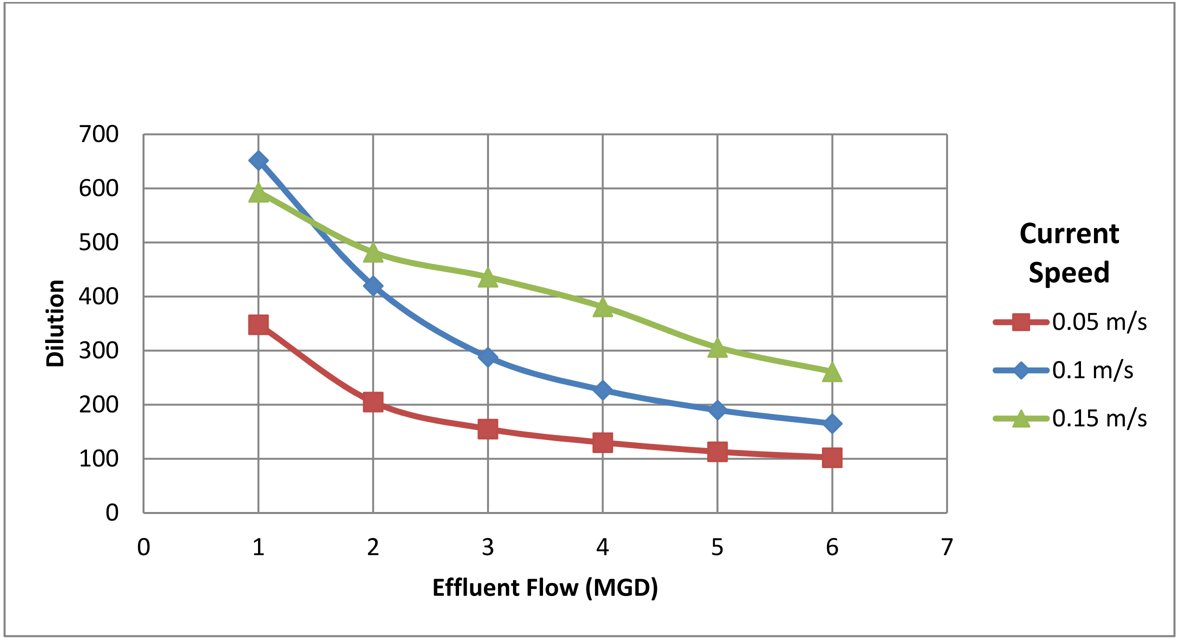
Results

Model results are summarized in Table 2.2.5-4 and presented graphically in Figure 2.2.5-1.

Table 2.2.5-4. **UM3 Dilution Model Results, Agingan Wastewater Treatment Outfall**

Flow	Dilution		
	0.05 m/s Ambient Current	0.10 m/s Ambient Current	0.15 m/s Ambient Current
1 MGD	348	652	593
2 MGD	205	420	482
3 MGD	155	288	436
4 MGD	130	227	381
5 MGD	113	190	306
6 MGD	102	165	261

Figure 2.2.5-1. **UM3 Dilution Model Results, Agingan Wastewater Treatment Outfall**



Discussion

As can be seen in the model results, both the effluent flow rate and the ambient current speed will have significant effects on dilution of the wastewater plume.

For an assumed current speed of 0.1 m/s, the dilution for an effluent flow of 2 MGD was calculated to be 46 percent greater than that for a 3 MGD flow. Dilution increased by 126 percent for a flow of 1 MGD compared with a 3 MGD discharge. For a current speed of 0.05 m/s, results were similar, but with smaller increases, with dilution calculated for 1 and 2 MGD of effluent flow increasing by 125 percent and 32 percent over the value calculated for 3 MGD, respectively.

Less significant increases are predicted at low flow for the 0.15 m/s current scenario. For this case, the 2 and 3 MGD cases resulted in the plume being carried out of the mixing zone before the plume surfaced, limiting the amount of initial dilution occurring inside the mixing zone. For the 1 MGD case, although the water column profile was only slightly stratified, sufficient dilution occurred initially in the denser water at depth near the discharge to increase the density of the plume sufficiently so that it became trapped below the surface before being carried out of the mixing zone by ambient currents. In any event, all dilutions calculated assuming a 0.15 m/s current are above the critical initial dilution of 200:1 used in the NPDES permit.

Typically, a tenth-percentile current speed is used for calculating the critical initial dilution value. A 0.1 m/s current was assumed based on the analysis performed by CH2M (2001). Sufficient data were not available to calculate a tenth-percentile current. The 0.1 m/s current was the lowest current measured during drogue studies near the site and was assumed to be representative of a low current. Average currents measured at a National Oceanic and Atmospheric Administration (NOAA) monitoring site approximately one nautical mile south of the outfall were on the order of 0.5 m/s.

The current values assumed in the mixing zone study performed in support of the NPDES permit for the Agingan WWTP outfall were not obtained. Assuming the critical initial dilution was determined for an average flow of 3 MGD, the current magnitude can be assumed to be between about 0.05 and 0.1 m/s and dilutions achievable bounded by the two lower curves in Figure 2.2.5-1. If the critical initial dilution was based on the peak flow of 6.75 MGD, assumed current velocities and associated achievable dilutions would be higher. However, without additional information on model inputs used as a basis for the NPDES permit mixing zone study, more precise dilution values cannot be determined, and the results from this study should be considered to be representative of potential for increases in dilution only.

2.2.6 Wastewater Collection System Hydraulic Model

The Stipulated Order requires a wastewater hydraulic assessment of the CUC wastewater system to determine the capability of the wastewater system to collect, convey, and treat peak dry-weather and peak wet-weather flows under current conditions and at future population projections over the next 20 years. The following elements must be addressed in this assessment:

- Flow measurements under dry and wet weather conditions
- Infiltration and inflow (I/I) in the collection/conveyance system
- Cost effectiveness analysis comparing the cost of I/I control and cost to convey and treat peak wet weather flows
- Identification of flow bottlenecks in the collection and treatment systems (bottlenecks in the treatment plants are discussed as part of Section 2.2.3.

This section of the Master Plan presents the wastewater system model software, uses, and development; development and results of the flow metering; existing wastewater collection system hydraulic and capacity analysis; wastewater lift station review with regard to capacity; force main capacity analysis; identification of bottlenecks; and recommendations to improve the hydraulics, operations, and capacity of the wastewater system.

Model Software

Innovyze H2OMap Sewer (formerly MWH Soft) was the chosen wastewater model software. CUC does not currently have an active wastewater model or licensed software. H2OMap Sewer is a simple, steady-state model that can run extended period simulations and simulate unsteady flow conditions. The software is user-friendly and easy to follow for those who have a basic understanding of open channel hydraulic principles. Input requirements are as follows:

- Manhole location, top elevation and size (i.e., DIA)
- Gravity line upstream and downstream inverts, size (i.e., DIA) and friction coefficient
- Lift station capacity, elevation, and pump control settings
- Diurnal patterns for each manhole, which are used to estimate wastewater loading at each manhole for extended period simulations

The H2OMap Sewer model supports both CAD and GIS files. Both background types were used in model development.

Model Uses

The wastewater model was used to identify and evaluate the following:

- Bottlenecks in the collection system
- Remaining capacity estimates
- Hydraulic and capacity analysis on the lift station pumps and force mains
- Proposed collection system upgrades and modifications
- Illustrate existing and future system operations

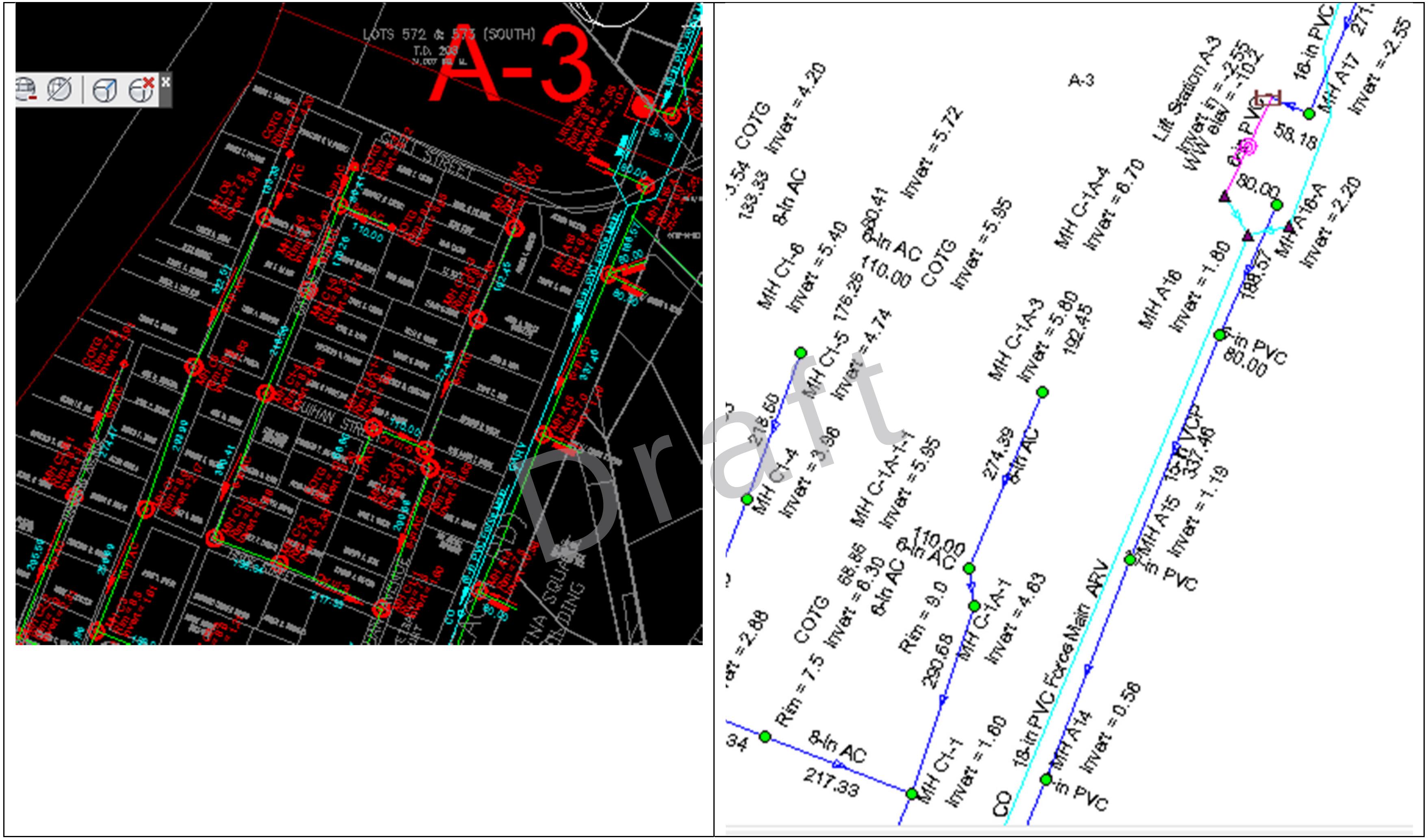
It is important to note that the model should not be used as a substitute for field evaluations. Results presented in this Master Plan are for planning purposes only. Establishing proper design criteria (i.e., flow and head) must be done when designing new, or upgrades to, lift stations.

Model Development

CUC has maintained a wastewater base-map for Saipan in AutoCAD format. An excerpt of this base map is shown in Figure 2.2.6-1. This base map includes critical information such as manhole locations, pipe inverts, pipe DIAs, and pipe lengths. This information is provided in the CUC base map for all locations except for the following areas:

- **Capitol Hill.** The project team located an as-built print that contained the needed sewer line information and incorporated this information into the model.
- **As-Matuis.** Data collected as part of the GIS effort were used to establish the location of the manholes. Gravity line slopes were estimated by using spot depths to inverts collected in the field and existing terrain slopes.
- **Koblerville.** No information on the pipe size and slopes were readily available. Some locations within Koblerville are not connected to any sewer. (Further discussion of Koblerville sewers is provided in Section 2.2.7 of the Master Plan.) No sewer model was generated for the Koblerville subdivision; the collection main adjacent to Koblerville was modeled using results from a flow meter placed at downstream section of the Koblerville collection system (see Figure 2.2.6-1).

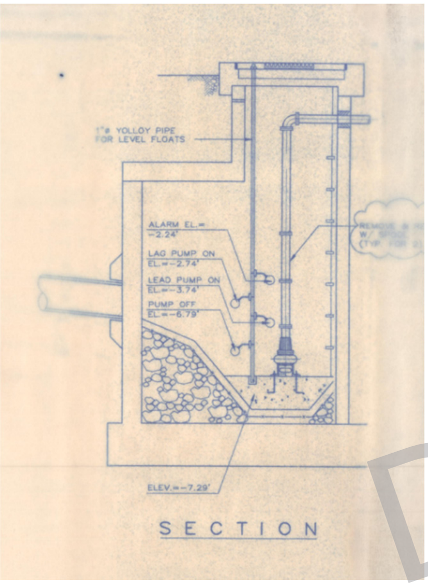
Figure 2.2.6-1**. CUC Base Map and Wastewater Model**

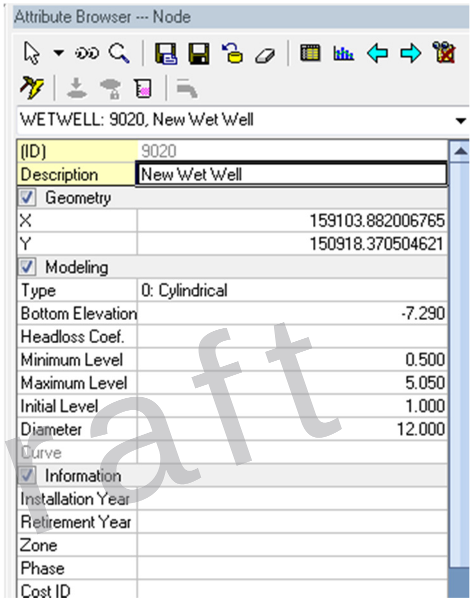


A review of the CUC as-builts (Figure 2.2.6-2) was performed to ascertain any and all information available for the lift stations that is needed for the hydraulic model, including:

- Pump level settings (as designed).
- Wet well capacity (i.e., volume). In most cases, the wet wells are configured with two circular chambers; for ease of modeling, the wet wells are configured with one circular chamber in the model using an equation for equivalent DIA to ensure hydraulics could be properly mimicked.
- Pump size (i.e., pumping capacity [gpm]). In most cases no information on pump size was provided in any of the as-builts or plans reviewed. See the pump size estimation in Section 2.2.2 for further discussion on this data gap.

Figure 2.2.6-2**. Excerpt from the CUC As-builts and the Modeled Input for the Wet Well**

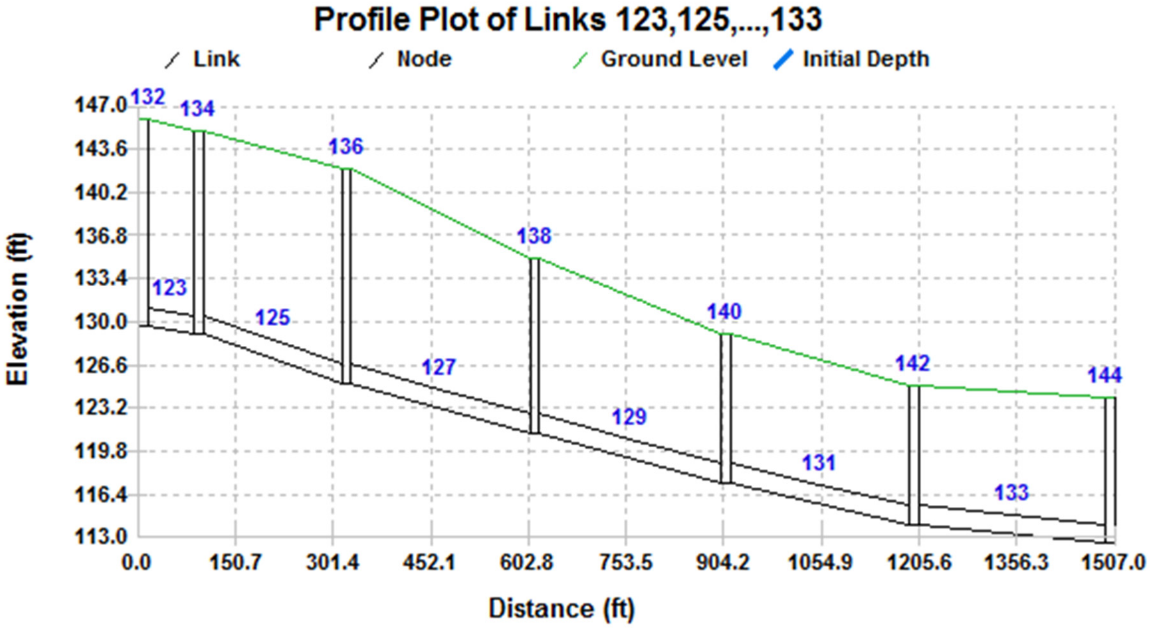




(ID)	9020
Description	New Wet Well
☑ Geometry	
X	159103.882006765
Y	150918.370504621
☑ Modeling	
Type	0: Cylindrical
Bottom Elevation	-7.290
Headloss Coef.	
Minimum Level	0.500
Maximum Level	5.050
Initial Level	1.000
Diameter	12.000
Curve	
☑ Information	
Installation Year	
Retirement Year	
Zone	
Phase	
Cost ID	

Using a consistent base elevation for the top of manholes is critical in setting up the model elevations. In most cases, the top elevation shown on the CUC base map was either missing or based on different benchmarks. To ensure a consistent base elevation was being utilized in the hydraulic model, elevation data from Google Earth was used for the top elevations of the manholes. The elevation used is for planning purposes and not intended for design of detailed modeling. Of interest for master planning was the carrying capacity of the existing collection system. This is a function of slope. Pipe invert and slope information from CUC available as-built or record drawings were used where available. Pipe profiles were generated by the model software and reviewed. Figure 2.2.6-3 presents an example of the pipe profiles generated in the model.

Figure 2.2.6-3. **Pipe Profiles Generated in the Model**



Model Assumptions

The following assumptions were used in development of the model:

- A Manning value of n=0.009 was used for all PVC (polyvinyl chloride, also referred to as plastic pipe) pipe and a value of n=0.013 was used for the remaining cement and clay pipes. These are the suggested values for the H2O Map Sewer model and are in line with industry standards. Appendix A includes maps that show the location of these pipe types. These values are commonly used for open channel flow design.
- A friction value of C=100 was used for all force mains. This is the suggested value for the H2O Map Sewer model and is in line with industry standards.
- Wastewater flow estimates within each sewershed are theoretical and are categorized as residential, commercial, hotel, airport, government or a combination thereof. When a sewershed was identified as having a combination of uses, the estimated wastewater flow (i.e., load) was based on the larger use within the sewershed. The model assumes that all customers in the service area are connected, even though it is known that many of the residential customers are not connected to available sewer and are still served by septic systems. The number of customers in each service area was determined using 2010 census data. Customer billing data was reviewed as an alternative means to estimating wastewater flows, but the data was found to be inconsistent and not readily available for use. The following demand assumptions were used in generating wastewater demands for the model (the “Wastewater Service Areas” section above provides additional discussion on how these values were used):
  - Residential: 90 gpd/capita
  - Commercial: 130 gpd/capita
  - Hotel: 130 gpd/capita
  - Government: 65 gpd/capita
  - Airport: 65 gpd/capita

- One large data gap for model development is the limited information available on the lift stations' flow and head values. Data provided by CUC engineering and operations were incomplete and, in most cases, conflicting. This data gap required the development of theoretical estimates for the existing pump sizes to be used for the hydraulic model. Further discussion on this assumption and data gap is provided in Section 2.2.2.

Wastewater Service Areas

Two wastewater service areas are located on Saipan: the Sadog Tasi WWTP service area and the Agingan WWTP service area. The Sadog Tasi WWTP is located in the village of Sadog Tasi and serves the central and northern areas of Saipan. The Agingan WWTP is located in Agingan and serves the southern area of Saipan as well as portions of Central Saipan. Figure 2.2.6-4 presents the locations of these two WWTPs and the associated wastewater service areas.

These two main service areas were further analyzed and geographical boundaries were created to identify a number of sewersheds within each of the service areas. The sewersheds were determined by the topography of the areas and/or locations of downstream lift stations. Figure 2.2.6-4 presents the sewershed boundaries.

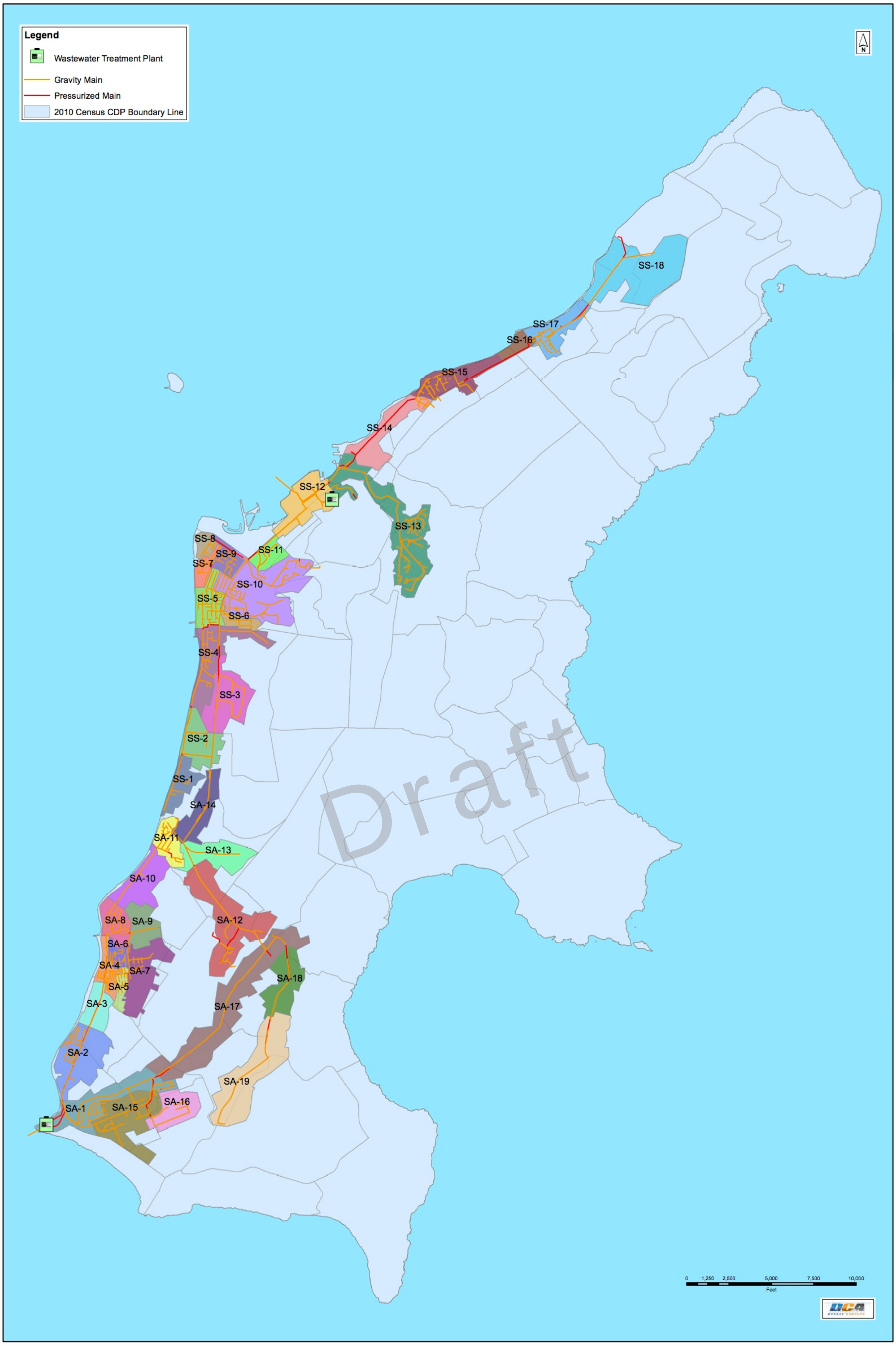
Both the Sadog Tasi and Agingan basins were split into two separate models. The Sadog Tasi basin discharges to Lift Station S-3. A northern collection system and a southern collection system both discharge to this lift station. The Agingan basin discharges to Lift Station A-16. An eastern collection system and a western collection system both discharge to this lift station. Tables 2.2.6-1 through 2.2.6-4 list the service areas as they were modeled and summarize important information pertaining to the wastewater service in each area.

The following nomenclature is used throughout this analysis and in the model for identification of the sewersheds on Saipan:

- SS-1: Sadog Tasi Service Area, first sewershed in series
- SA-1: Agingan Service Area, first sewershed in series

As a conservative measure, the sewer load (gpd/capita) that has the higher use in each sewershed was chosen for this analysis.

Figure 2.2.6-4. **Saipan Wastewater Sewersheds**



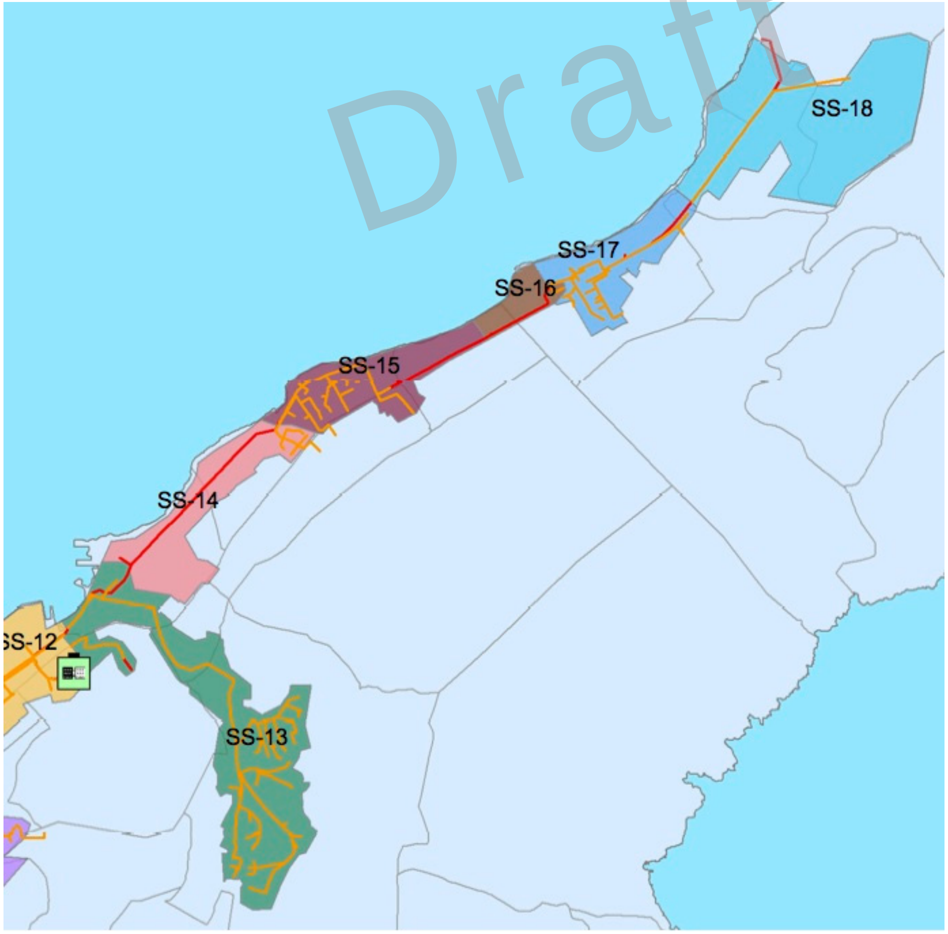
Northern Sadog Tasi Model

The Northern Sadog Tasi model includes sewersheds SS-13 to SS-18, which includes the villages of Marpi, As Matuis, Tanapag, San Roque, Lower Base, and Capitol Hill. Wastewater from these sewersheds ultimately discharges to Lift Station S-3, which is the final lift station in the Sadog Tasi service area located directly downstream of the Sadog Tasi WWTP. Table 2.2.6-1 summarizes the 2010 population, typical wastewater usage, loading and flows for the Northern Sadog Tasi sewersheds; Figure 2.2.6-5 shows the locations of the sewersheds.

Table 2.2.6-1**. Northern Sadog Tasi Sewersheds (Average Dry-Weather Flow)**

Sewershed	2010 Population	Use	Loading (GPD/Capita)	Average Dry Weather Flow (GPD)
SS-13	681	Residential/Government	90	61,290
SS-14	260	Commercial/Government	90	23,400
SS-15	695	Residential/Commercial	90	62,550
SS-16	76	Residential/Commercial	90	6,840
SS-17	521	Residential/Commercial	90	46,890
SS-18	103	Residential/Commercial	90	9,270
			Total Flow, Average Dry Weather (GPD)	**210,240**

Figure 2.2.6-5. Northern Sadog Tasi Sewersheds



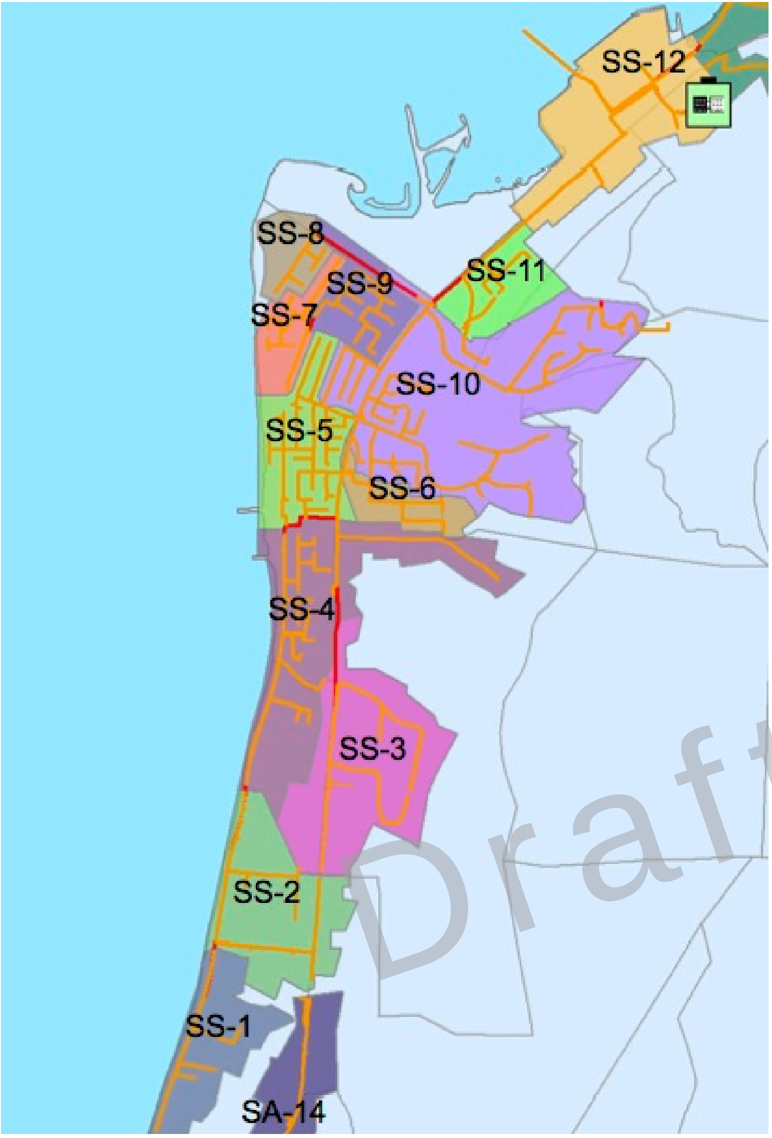
Southern Sadog Tasi Model

The Southern Sadog Tasi model includes sewersheds SS-1 to SS-12, which includes the villages of Garapan, Puerto Rico, Sadog Tasi, and Gualo Rai. Wastewater from these sewersheds ultimately discharge to Lift Station S-3, which is the final lift station in the Sadog Tasi service area located directly downstream of the Sadog Tasi WWTP. Table 2.2.6-2 summarizes the 2010 population, typical wastewater usage, loading, and flows for the Southern Sadog Tasi sewersheds; Figure 2.2.6-6 shows the locations of the sewersheds. The tables represent the average dry weather flows. Rain events and peak flows are discussed later in this report.

Table 2.2.6-2. **Southern Sadog Tasi Sewersheds (Average Dry Weather Flow)**

Sewershed	2010 Population	Use	Loading (GPD/Capita)	Average Dry Weather Flow (GPD)
SS-1	356	Residential/Commercial	130	46,280
SS-2	566	Residential/Commercial	130	73,580
SS-3	1,175	Residential/Commercial	130	152,750
SS-4	1,657	Residential/Commercial	130	215,410
SS-5	1,441	Commercial/Hotel	130	187,330
SS-6	709	Residential/Commercial	130	92,170
SS-7	329	Commercial/Hotel	130	42,770
SS-8	335	Commercial/Hotel	130	43,550
SS-9	584	Commercial	130	75,920
SS-10	2,234	Residential/Commercial	130	290,420
SS-11	455	Residential/Commercial	130	59,150
SS-12	61	Residential/Commercial	130	7,930
			Total Flow, Average Dry Weather (GPD)	**1,287,260**

Figure 2.2.6-6. **Southern Sadog Tasi Sewersheds**



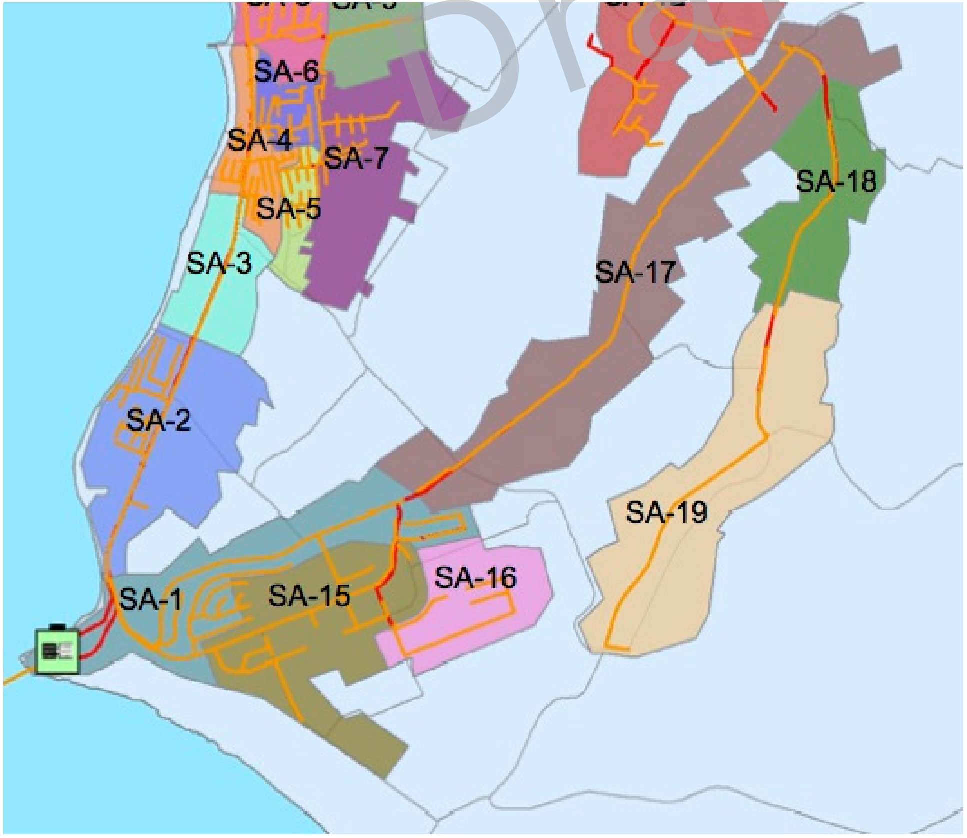
Eastern Agingan Model

The Eastern Agingan model includes sewersheds SA-1 and SA-15 to SA-19, which includes the areas along Airport Road (Chalan Tun Herman Pan) north to Dan Dan and south to Finasisu and Koblerville. These sewersheds ultimately discharge to sewer Lift Station A-16, which is the final lift station in the Agingan service area located directly downstream of the Agingan WWTP. Table 2.2.6-3 summarizes the 2010 population, typical wastewater usage, loading, and flow for the Eastern Agingan sewersheds. Figure 2.2.6-7 shows the locations of the sewersheds.

Table 2.2.6-3. **Eastern Agingan Sewersheds (Average Dry Weather Flow)**

Sewershed	2010 Population	Use	Loading (GPD/Capita)	Average Dry Weather Flow (GPD)
SA-1	1,604	Residential	65	104,260
SA-15	1,510	Residential	65	98,150
SA-16	32	Residential	65	2,080
SA-17	1,370	Residential/Commercial	65	89,050
SA-18	304	Residential/Commercial	65	19,760
SA-19	647	Residential/Commercial/Airport	65	42,055
			Total Flow, Average Dry Weather (GPD)	**355,355**

Figure 2.2.6-7. **Eastern Agingan Sewersheds**



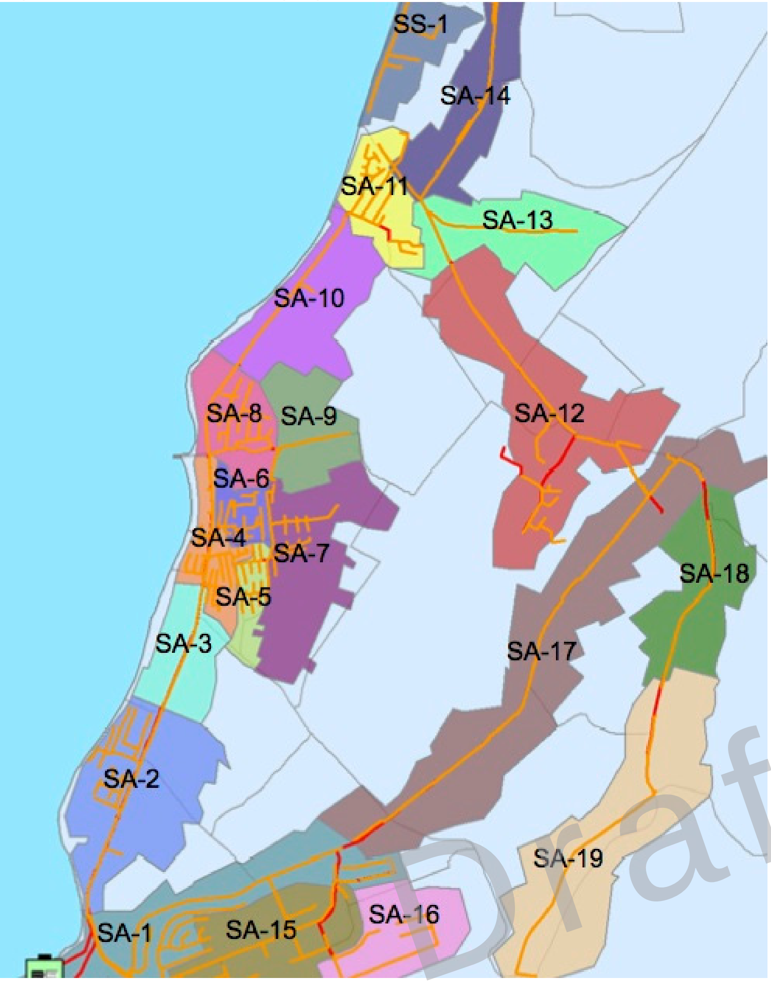
Western Agingan Model

The Western Agingan model includes sewersheds SA-2 to SA-14, which includes the following areas: Chalan Kiya, San Jose, Susupe, Chalan Kanoa and San Antonio. These sewersheds ultimately discharge to lift station A-16, which is the final lift station in the Agingan service area located directly downstream of the Agingan WWTP. Table 2.2.6-4 summarizes the 2010 population, typical wastewater usage, loading, and flow for the Western Agingan sewersheds. Figure 2.2.6-8 shows the locations of the sewersheds.

Table 2.2.6-4. **Western Agingan Sewersheds (Average Dry Weather Flow)**

Sewershed	2010 Population	Use	Loading (GPD/Capita)	Average Dry Weather Flow (GPD)
SA-2	2,216	Commercial/Hotel	65	144,040
SA-3	557	Commercial/Hotel	65	36,205
SA-4	858	Residential/Commercial	65	55,770
SA-5	750	Residential	65	48,750
SA-6	755	Residential	65	49,075
SA-7	927	Residential	65	60,255
SA-8	1,029	Residential/Commercial	65	66,885
SA-9	429	Residential	65	27,885
SA-10	667	Residential/Commercial	65	43,355
SA-11	980	Residential/Commercial	65	63,700
SA-12	1,262	Residential/Commercial	65	82,030
SA-13	483	Residential	65	31,395
SA-14	375	Residential/Commercial	65	24,375
		Total Flow, Average Dry Weather (GPD)		**733,720**

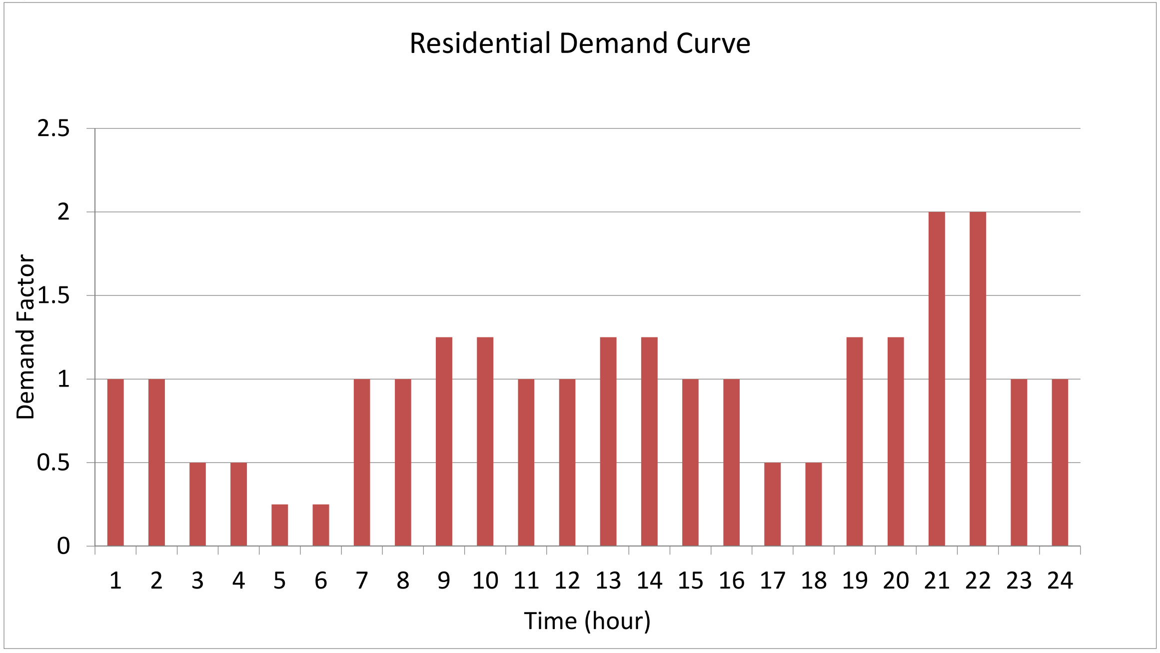
Figure 2.2.6-8. **Western Agingan Sewersheds**



Residential Diurnal Patterns

A flow meter was installed at Tottotville, a strictly residential area with 24-hour water service, to develop a diurnal pattern for residential wastewater flows. This diurnal pattern was used to estimate the 24-hour residential use, which is essential for developing extended period simulations. The diurnal pattern, shown in Figure 2.2.6-9 was multiplied by the average flows to develop the variation in daily loading. This pattern was applied for all residential uses.

Figure 2.2.6-9. **Residential Demand Curve**



A government diurnal pattern was evaluated from a flow meter placed in Capitol Hill. Capitol Hill is a mixture of residential and government use. There was little notable difference between the metered data at Tottotville and Capitol Hill except for the peak flow that occurs around 9 to 10 p.m. (i.e., hours 21 to 22). This is expected for residential use. As a result of this, government use was assumed to be similar to residential use patterns. The commercial, hotel, and airport uses were assumed to be the same as the residential use.

Model Calibration

Model calibration is an essential process to model development. Various levels of calibration are used, with the most basic being mass-balance calibration. The goal of a mass-balance calibration is for the loading placed into the model to be equal to the real-world loading. In other words, the amount of wastewater placed into the model should equal the amount of the wastewater collected at the WWTPs. The use of flow meters in the collection system provides valuable calibration information. Flow meters provide depth and flow data in real time. These data may be used to verify the loading and friction values were used in the model.

There are various type of models and levels of calibration. The model developed for the Master Plan is being used for planning and analysis purposes, and represents a high-level model.

Two data sets were used to calibrate the wastewater models. The first set of data was collected from existing flow meters located at the influent to both the Sadog Tasi WWTP and Agingan WWTP. The second data set included wastewater collection system flow meter data.

Calibration with Wastewater Treatment Plant Flow Data

For a hydraulic model to be considered calibrated, the amount of wastewater generated in each service area must be equal to the amount of wastewater treated at each treatment plant. Flows being conveyed and treated at the WWTPs include wastewater and I/I. Noticeable increases in WWTP influent flow were observed during rain events (see Figures 2.2.6-10 and 2.2.6-11), which is indicative of I/I in the collection system. Weather stations were deployed throughout Saipan to collect rainfall data; a series of rain events were captured during the data collection period. The rainfall stations located at Maui I and Maui IV were used due to their close proximity to the Agingan and Sadog Tasi wastewater treatment plants, respectively. Further discussion on the weather stations can be found in the GWUDI section of the Saipan Drinking Water Master Plan (DCA/CH2M, 2015). The rainfall data from the weather stations was compared to the WWTP influent flow meter data, as shown in Figures 2.2.6-10 and 2.2.6-11. Two important pieces of information were determined from the comparison of rainfall data and wastewater flow metering: the average dry weather wastewater flow and the peak wet weather flow for both service areas.

The data collected during October 2012 was used to characterize both dry and wet weather events. October 2012 had at least two significant rain events. The 2-inch rainfall event is considered a significant event. The flow data collected by the meters was reviewed and discussed with CUC Operations and Engineering. The average flow used for modeling was consistent with what was measured during dry weather events. Noticeable peaks were observed during the 2-inch plus rainfall events. Flows to both WWTP peaked during these rain events. These peaks were assumed to be the peak wet weather events. The flow metered during the significant rain event was divided by the average flow to generate a peaking factor.

Figure 2.2.6-10 shows an excerpt from the Sadog Tasi WWTP metered influent and rainfall data collected at the Maui well sites during the month of October 2012. Figure 2.2.6-11 shows the Agingan WWTP metered influent and rainfall data collected during the month of October 2012.

Figure 2.2.6-10. **Sadog Tasi Service Area Metered WWTP Influent and Rainfall Data for October 2012**

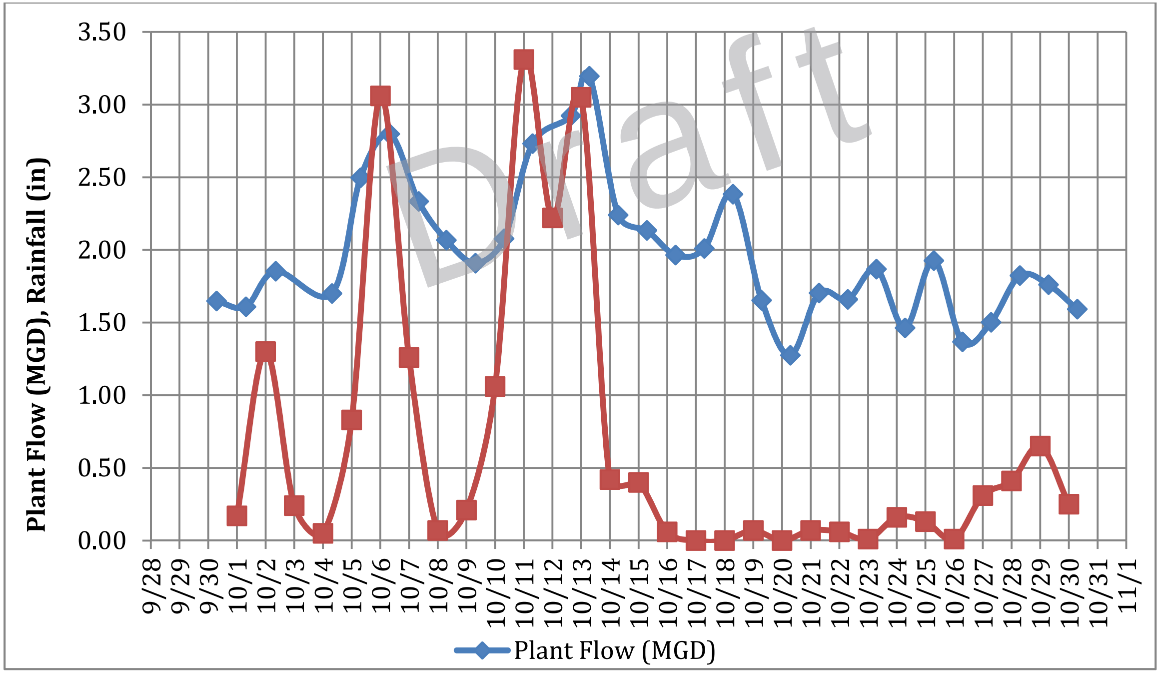


Figure 2.2.6-11. **Agingan Service Area Metered WWTP Influent and Rainfall Data for October 2012**

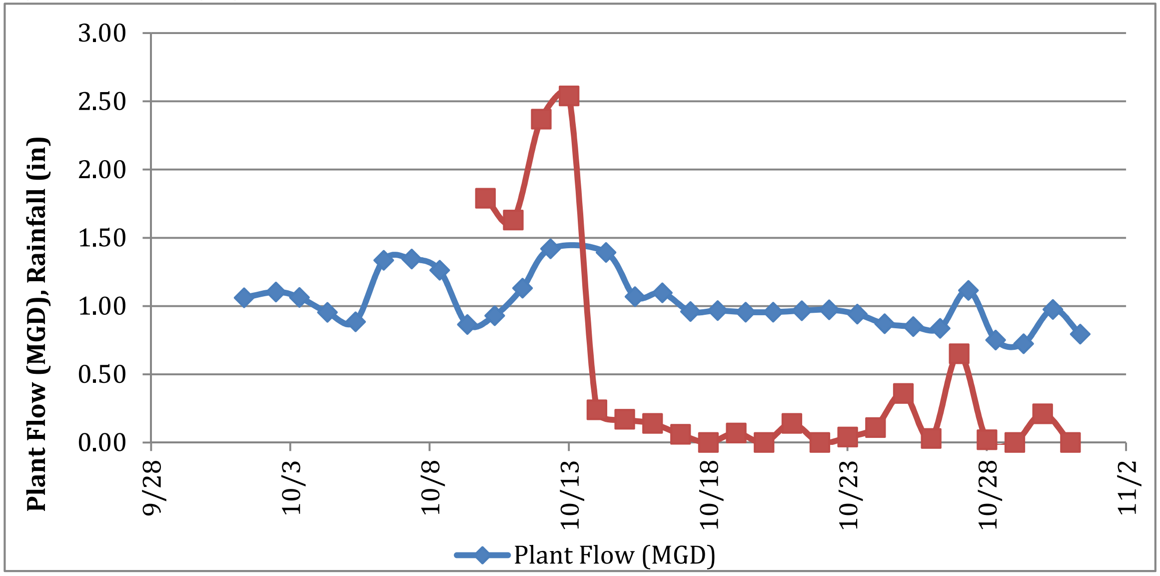


Table 2.2.6-5. **Sadog Tasi WWTP Influent Flows**

Sadog Tasi	Flow (MGD)
Northern Model Average Dry Weather Flow	0.21
Southern Model Average Dry Weather Flow	1.28
Northern Model Peak Wet Weather Flow	0.45
Southern Model Peak Wet Weather Flow	2.73
Average Daily Dry Weather Flow (Total)	**1.49**
Peak Wet Weather Flow (Total)	**3.18**
Peaking factor	**2.13**

Table 2.2.6-6. **Agingan WWTP Influent Flows**

Agingan	Flow (MGD)
Eastern Model Average Dry Weather Flow	0.33
Western Model Average Dry Weather Flow	0.68
Eastern Model Peak Wet Weather Flow	0.66
Western Model Peak Wet Weather Flow	1.36
Average Daily Dry Weather Flow (Total)	**1.01**
Peak Wet Weather Flow (Total)	**1.52**
Peaking factor	**2.00**

The month of October falls within the rainy season on Saipan. Three storms exceeding 2 inches per day were documented during October 2012. Direct correlations between rainfall and WWTP influent flow are observed in the datasets, as shown in Figures 2.2.6-10 and 2.2.6-11. Tables 2.2.6-5 and 2.2.6-6 present the estimated average flow, estimated peak flow, and estimated peaking factor used in the models for the Sadog Tasi and Agingan service areas. The Agingan peaking factor of 1.5 is lower than industry standards, so the peaking factor for Agingan was adjusted from 1.5 to 2 to present a more conservative view of the sewer collection system in Agingan sewershed. The estimated Sadog Tasi peaking factor of 2.13 is within the industry standard. For wastewater systems where contributions from I/I is significant, it is typical and within industry standards for peaking factors to range between 1.5 and 3.

For wet weather modeling, the wastewater flows used in the hydraulic model for the service areas was determined by multiplying the average daily dry weather flow by the peaking factors.

After developing and making slight adjustments to the hydraulic models, the total average flow going to the Sadog Tasi and Agingan WWTPs, as estimated by the model, was equal to the metered inflow. This demonstrates that the models are calibrated for dry weather conditions, based on the mass-balance calibration method. That is, the daily flow generated in the model is equal to the average flows measured in the field for dry weather.

The average daily dry weather flows and the peak wet weather flows placed into the models were all based on the values presented above. Flow data entered into the model matches the flow entering the WWTPs.

Calibration with Collection System Flow Metering Data

The distribution of daily wastewater flow throughout the nodes in the collection system hydraulic model is critical in evaluating how the collection system operates. To determine they ways in which the flows are distributed and the actual collection system is operating, flow meters were deployed throughout the collection system. Appendix H presents the locations where these flow meters were placed.

Where possible, flow meters were located upstream of lift stations and in areas where influence from a lift station was predicted to be minimal. Based on preliminary flow metering results, it was determined that the majority of the metered locations were influenced by lift station operations, which was evident by an abrupt rise and fall of the metered depth. This influence will be further discussed later in this section.

Two types of flow meters were deployed in the collection system: area-velocity meters and pressure transducers. The area-velocity meter collects actual depth data, which is converted to area and velocity data and used to calculate flow within the pipe. Unfortunately, the area-velocity meters used as part of this project were subject to ragging, which impacted the data collection. Ragging is a condition where rags and other material get lodged onto the sensor, which results in incomplete or inaccurate velocity and flow data. The area measurement remains accurate. Another problem encountered with the area-velocity meters was the observance of erroneous data collected during surcharge events. The depth data collected is considered accurate during both ragging and surcharging events, while the velocity data is considered inaccurate.

Two pressure-transducer flow meters were deployed in the collection system. These meters work by measuring pressure in the pipe, then flow is calculated based on the user-provided pipe slope, DIA, and pipe material type. As such, the flow data collected from these meters is not a direct measurement of flow. The pressure transducers are light and subject to failure if submerged. Both pressure transducer meters experienced surcharge events, resulting in failure.

Limited data was collected from the pressure transducer meters before failure; the area-velocity meters collected the majority of the data that were used for model calibration. Tables 2.2.6-7 and 2.2.6-8 summarize the dates and locations where the meters were placed in both sewer service areas. Meters were placed in the same location twice; this was an effort to ensure a rain event was captured by the flow meters.

The flow meters were set to collect data at 5-minute intervals, which is sufficient to pick up daily patterns and peaks in the flow.

Table 2.2.6-7. **Sadog Tasi Service Area Flow Meters**

Meter Name	Location (Sadog Tasi)	Install Date	Removal Date	Install Date	Removal Date
T-Church	Across from Tanapag Church	12/19/2011	1/19/2012	10/19/2012	11/2/2012
Capitol Hill	Downstream of Capitol Hill	1/27/2012	2/3/2012	10/19/2012	11/2/2012
Navy Hill	Immediately downstream of Navy Hill	12/9/2011	12/19/2011	11/2/12	11/16/12
S-5	Immediately upstream of S-5	2/15/2012	2/27/2012	11/2/12	11/16/12
China Town	Downstream of China Town system	2/15/2012	2/27/2012	11/2/2012	11/30/2012
S-9	Immediately upstream of Lift Station S-9	12/9/2011	12/19/2011	11/2/2012	11/30/2012
S-10 North	Immediately north of Lift Station S-10	11/29/2011	12/8/2011	11/30/2012	12/14/12
S-10 South	Immediately south of Lift Station S-10	11/29/2011	12/8/2011	11/30/2012	12/14/12
Gualo Rai	Northern Gualo Rai collection system	2/15/2012	2/28/2012	12/14/12	12/28/12

Table 2.2.6-8. **Agingan Service Area Flow Meters**

Meter Name	Location (Agingan)	Install Date	Removal Date	Install Date	Removal Date
Pale Arnold	Between W-5 and Pale Arnold collection system	2/4/2012	2/14/2012	12/14/12	12/28/12
San Jose	Downstream of Lift Station W-6	1/27/2012	2/3/2012	12/28/12	1/11/13
College	Top of As Terlaje Hill	2/27/2012	2/29/2012	12/28/12	1/11/13
A-9	Immediately upstream of Lift Station A-9	12/19/2011	1/19/2012	1/25/13	2/8/13
A-15	Immediately upstream of Lift Station A-15	1/20/2012	1/27/2012	1/11/13	1/25/13
Tottot	Immediately upstream of Tottotville lift station	1/20/2012	1/27/2012	1/11/13	1/25/13
Koblerville	Downstream of Koblerville Homestead	2/3/2012	2/14/2012	1/25/13	2/8/13

Flow Meter Results

The following section provides excerpts from the flow metering results; complete meter data are provided in Appendix I. The flow meter results are presented as a side-by-side comparison with extended period model results taken from the same locations as the flow meter data. The data periods shown below are for 2 days at 5-minute intervals.

Tanapag Church (T-Church)

This location experiences an abrupt rise and fall in water level, indicating that this location is influenced by the upstream lift station, SR-2. Meter depths range between 0.5 inches to 3 inches (Figure 2.2.6-12). The model was calibrated to match this lift station influence condition (Figure 2.2.6-13).

Figure 2.2.6-12. **T-Church Meter Results**

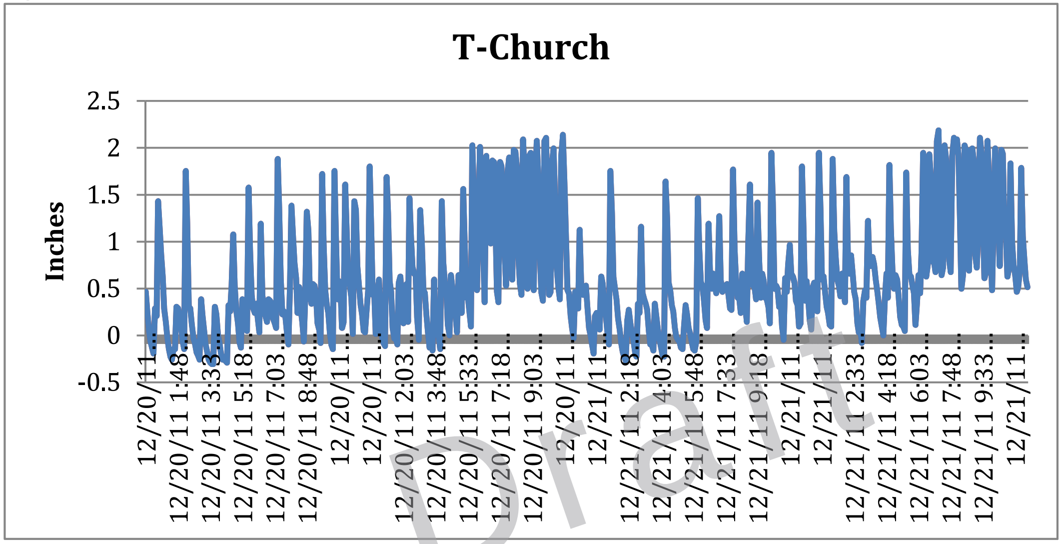
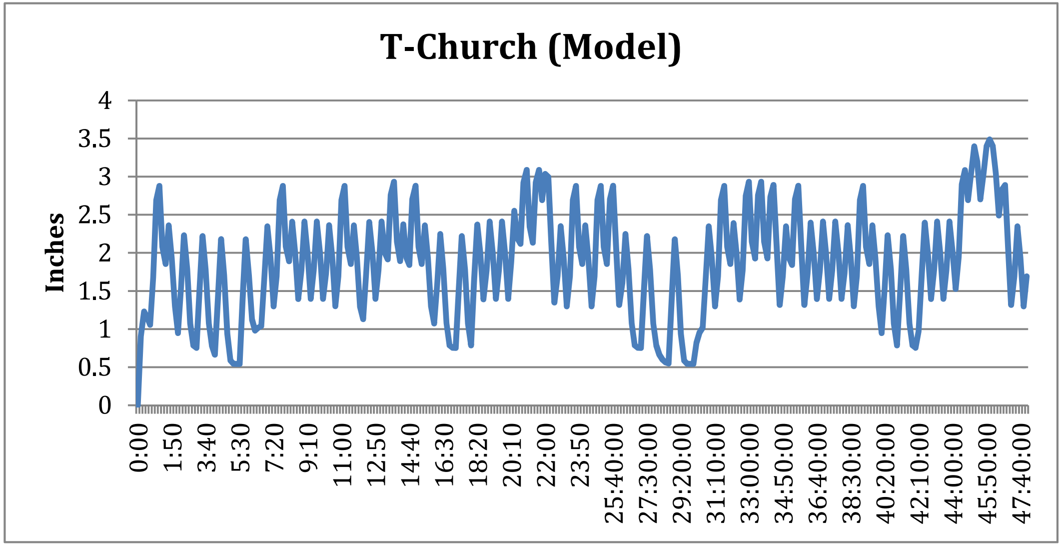


Figure 2.2.6-13**. T-Church Model Results**



S-9 (Garapan)

This flow meter was installed immediately upstream of Lift Station S-9. The results (shown in Figures 2.2.6-14 and 2.2.6-15) indicate that the water level exceeded the crown of the sewer line, which indicates that collection system is surcharged. The DIA of the sewer line at this location is 12 inches. The metered water level in the surcharged manhole reached between 25 to 30 inches consistently. This level is the result of the pump controls at Lift Station S-9 being set above the invert and crown of the sewer line. As a result, the collection line experiences backwater effects each time the lift station wet well is filled. A backwater effect occurs when an event downstream (blockage or wet well backup) affects the upstream water level. A quick drop was observed in the flow metering data each time the lift station pump engaged.

Figure 2.2.6-14. **S-9 Meter Results**

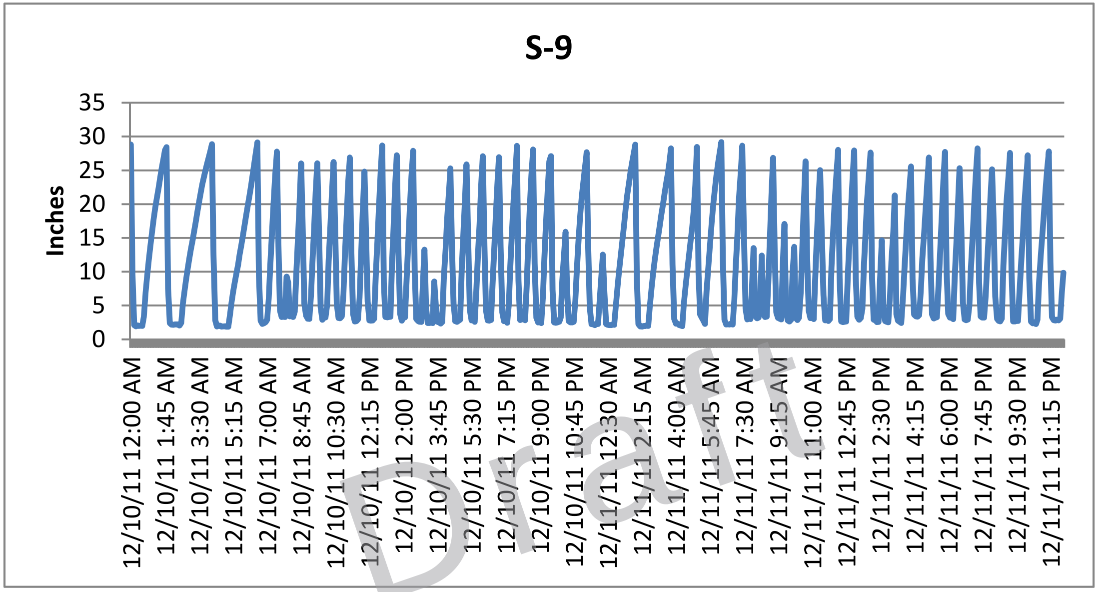
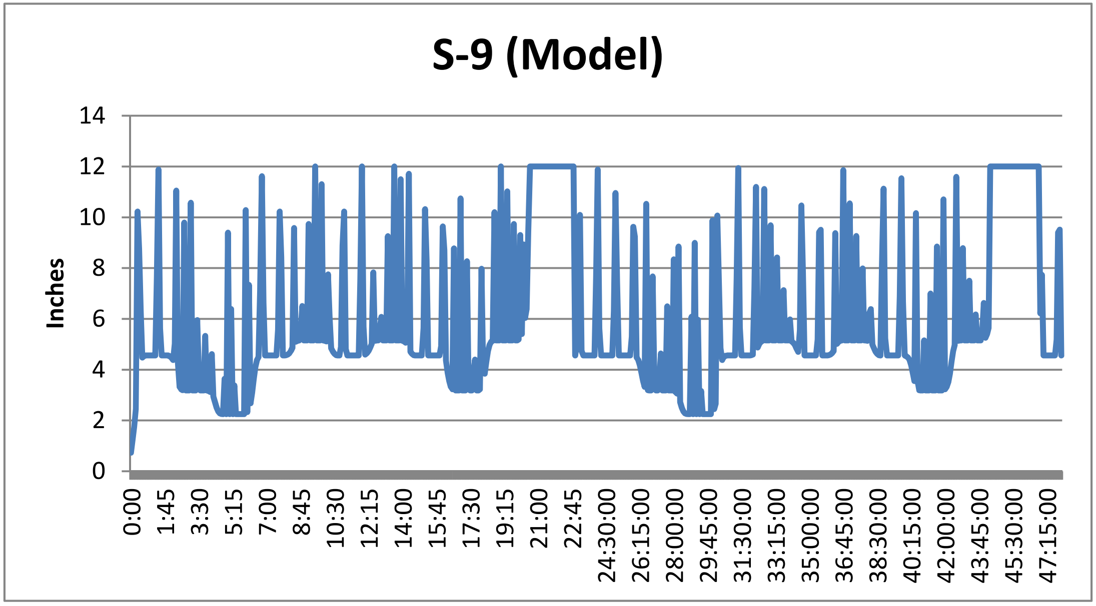


Figure 2.2.6-15. **S-9 Model Results**



Similar conditions were observed at Lift Stations A-2 and A-3. The backwater condition at these lift stations may also be the result of clogging on bar screens. This backwater condition prohibits proper metering of velocity, though depth can still be accurately metered.

Note in Figure 2.2.6-15 that the model results stop at 12 inches. This occurs because the model is not set up to model flows past the crown of the pipe. In any event, flow past the crown of the sewer is considered a failure of the collection system and should be corrected. This type of failure is labeled as a bottleneck in the system. In this case, the correction is to reset the pump controls.

A-15

The flow meter results show a water level depth ranging between 1 to 3 inches (Figure 2.2.6-16). The abrupt rise and fall indicate that this meter is influenced by the upstream Lift Station A-14. The model was calibrated to the metered levels to match real world conditions (see Figure 2.2.6-17).

Figure 2.2.6-16. **A-15 Meter Results**

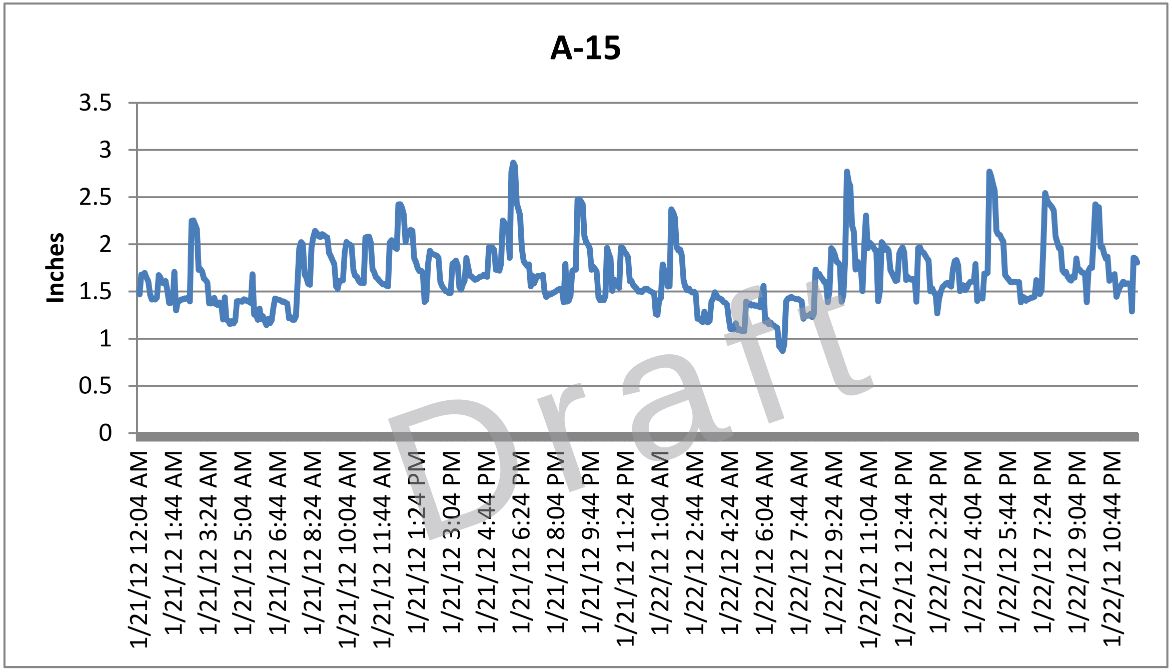
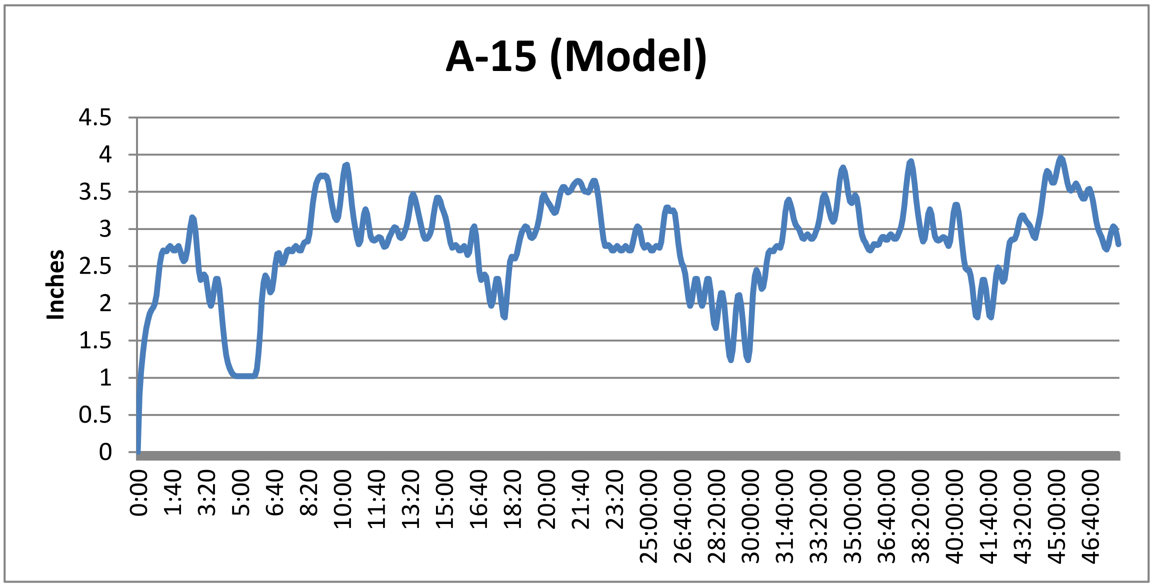


Figure 2.2.6-17. **A-15 Model Results**



NMC College

Noticeable peaks were onserved at this location, both in the metered data and the hydraulic model (Figures 2.2.6-18 and 2.2.6-19). Subsequent discussion with CUC Engineering revealed that there is a hotel that discharges upstream of this metered location as well as a laundry. The metered peaks do not seem to follow a pattern, but do occur daily. Smaller peaks were observed in the metered data. The model results reflect the daily peaks observed in the metered data. During the calibration process, these peaks were slightly increased to account for the more frequent smaller peaks that occur during the day, as observed in the metered data. The large metered peaks impact the downsterm collection system, which is of importance and discussed in more detail in "Hydraulic Model and Capacity Assessment Results" later in this section.

Figure 2.2.6-18. **Northern Marianas College Meter Results**

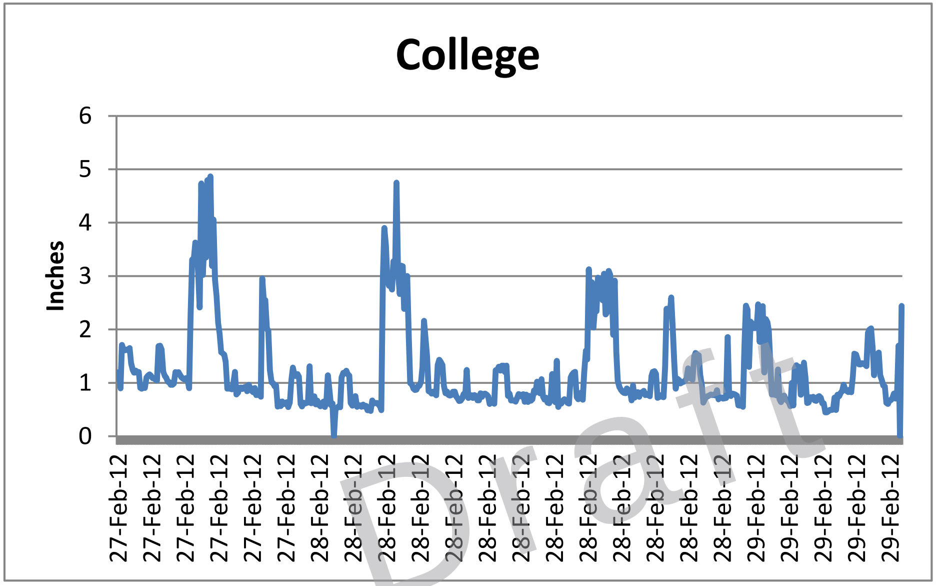
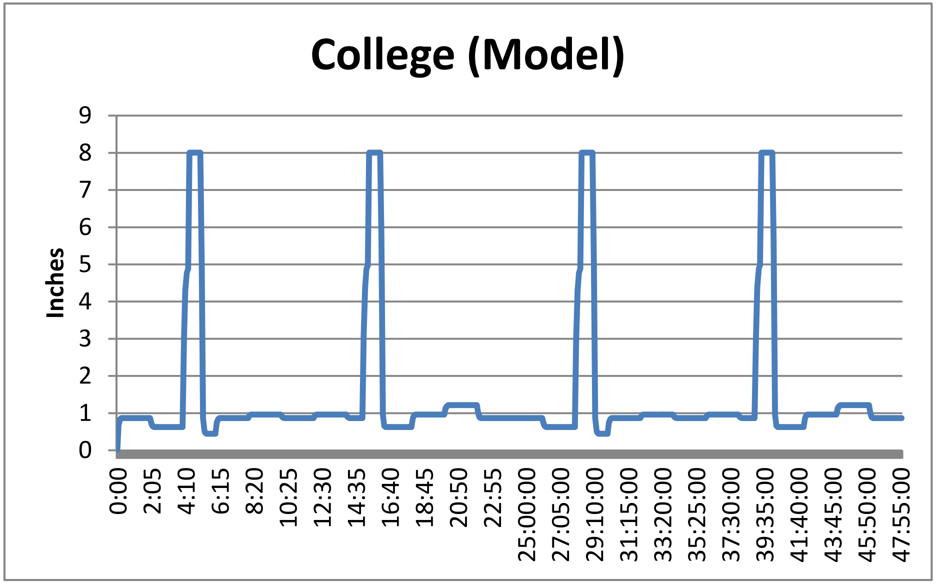


Figure 2.2.6-19. **Northern Marianas College Model Results**



Lift Stations

Incorporation of lift station operations into the hydraulic model is critical to developing an accurately calibrated model. Typically, pump size and operation cycles are incorporated into hydraulic models; these data are usually provided by the Operations or Engineering staff. Lack of data on existing pumps and motors used at the CUC lift stations was considered a significant data gap and identified early in the model development process. Appendix C presents the information on the lift stations provided by CUC operations.

It is important to note that no information on pump flow or head was provided. Flow and head data is essential for accurately representing lift stations within the model (as well as for good operations and maintenance). The lift station data supplied by CUC operations include horsepower, pump type, and in most cases the pump model. In the absence of other information, the project team used this limited data to estimate pump sizes for use in the model. The methodology used to estimate pump sizes is presented below.

Using Flygt^{tm} Software to Estimate Existing Pump Sizes

As can be observed from the lift station data in Appendix C, the majority of the lift stations use Flygt^{tm} pumps. For the purposes of this exercise it was assumed that all lift stations use Flygt^{tm} pumps. Flygt^{tm} provides pump selection software called Flyps. To estimate the pump sizes used at CUC's lift stations, the following steps were taken:

1. A range of flows were loaded into the Flyps software.
2. A fixed static head was entered into the software.
3. Dynamic head was determined using the as-built information and entered into Flyps.
4. With these three data points, the Flyps software provided output in the form of a pump model and horsepower requirement.
5. Flows were adjusted until the horsepower and model numbers in the Flyps software output matched the CUC provided information (i.e., model number and horsepower) (Appendix B).

The flow and total dynamic head information that matched the CUC pump data were input into the wastewater model. It should be noted that where flow and head data were available, (i.e., A-13, A-14, A-15, and T-1), these data were used and the Flyps software tool was not required to estimate pump sizing. The exercise described above was performed only for lift stations that had no flow or head data provided.

The results obtained from this exercise yielded higher than anticipated flow rates and velocities in the collection system pipes. Further review of these results and additional pump size information provided by CUC triggered a second pump sizing exercise.

Using 2010 Population Data to Estimate Existing Pump Sizes

A second approach was used to estimate pump sizes, i.e., utilizing the population within the sewersheds and the per capita flow estimates presented earlier. This approach provides the average daily flow. A peaking factor of 3 was used to convert the daily average flow to peak instantaneous flow. This approach is a common engineering approach to size lift stations in new developments where flows have not yet been established.

The results from this approach were compared against the limited design data provided by CUC, the limited available data in the CUC as-builts, and the lift station sizes estimated using the Flygt™ software; the results are presented below.

Selected Pump Size

The selected pump sizes were used in the model and compared against the metered results to verify that the selected pump sizes fell within the metered data rage. Table 2.2.6-9 represents the final pump sizes used based on the three approaches described above. The flow data shown below was used for both wet and dry weather conditions. Scenarios run under wet weather conditions experienced an increase in pump cycle time. These data were considered the best available at the time this report was prepared. Due to the significance of this data gap, it has been recommended that CUC further evaluate the pumps in existence and future pump selections at each lift station. The data provided below may be used as the benchmark for future pump selection, but must be verified by a professional engineer.

Table 2.2.6-9. **Lift Station Sizing Estimations**

ID	Flow (gpm)	Velocity (ft/s)	TDH (ft)	Force main Diameter (in)	Force Main Length (ft)
Sadog Tasi Service Area					
SR1	195	2.04	25.98	6	5,185
T1	760	4.78	111.72	8	6,417
S1	900	5.09	9.39	6	343
SR11	125	1.02	1.50	6	1,077
S5	600	3.83	18	8	1,132
S2	800	5.11	24	8	558
S8	2,400	9.80	67	10	999
S4	500	5.67	11	6	44
S9	700	4.47	8	8	65
S11	300	1.91	16	8	1,167
S12	200	2.27	14	6	955
S10	700	2.86	38	10	2,651
S6	300	3.40	25	6	2,147
Agingan Service Area					
A13	500	2.04	28	10	1,543
A14	750	2.13	51	12	2,222
A15	1,500	4.26	82	12	2,409
W6	200	5.11	8	4	13
W5	350	8.94	9	4	21
W4	500	5.67	11	6	14
A7	600	15.32	19	4	25
A6	800	9.08	12	6	25
A9	400	10.21	15	4	56
A8	400	10.21	15	4	52
A2	450	5.11	27	6	29
A3	150	1.70	34	6	64
A4	500	5.67	41	6	26
A5	1,000	1.60	44	16	2,854

Hydraulic Model and Capacity Assessment Results

The following sections provide a detailed discussion on the model results. The section on bottlenecks presents current collection system restrictions and is followed by recommendations to alleviate current bottleneck conditions. A discussion on lift station findings is also included, which identifies those areas where high head-loss and/or large velocities exist.

Bottlenecks

A bottleneck is defined as a section of the collection system where flow is restricted by the size, slope, or material of the collection system. Such a restriction results in backwater effects, solids deposition, pressurized flow, and reduced capacity. This condition can ultimately result in a sanitary sewer overflow. A pipe section is considered bottlenecked when the pipe has reached its full flow capacity. Figures 2.2.6-20 through 2.2.6-23 present the sections of the existing collection system based on current wet weather loading where such bottlenecks occur: Sadog Tasi North, Sadog Tasi South (Garapan), Agingan West (San Jose), and Agingan West (Chalan Kanoa). No bottlenecks were found in the Agingan East collection system.

Bottleneck Recommendations

The Sadog Tasi North bottlenecks occur in the Lower Base area where Capitol Hill and Lift Station T-1 converge near Lift Station S-1. The short-term solution for this bottleneck is to reduce I/I in the Tanapag area. This area was found to have deteriorating manholes where inflow may be significant. Upgrades to these manholes are included in the list of CIP projects. The long-term solution is to complete the upgrade to the Lower Base collection system, also included in the CIP project list in Section 4.3.1, “Project Identification and Prioritization.”

The bottlenecks in Sadog Tasi South occur where Lift Station S-10 discharges to the Middle Road collection system. Poor slopes result in reduced carrying capacity. Installation of a VFD at Lift Station S-10 is underway and will provide a short-term solution to this bottleneck. The long-term solution for this bottleneck, if persistent surcharging occurs, is upgrade and replacement of the collector line along Middle Road to which S-10 discharges.

Bottlenecks have also been identified downstream of Lift Stations S-4 and S-9. These bottlenecks are a result of how the lift stations are operated and do not result in physical downstream bottlenecks in the pipelines. No immediate action is needed. A bottleneck identified upstream of Lift Station S-3 is due to the high-level pump control setting at the lift station. Adjustment of this setting will correct this bottleneck.

The bottlenecks identified in Agingan West area are primarily found in the San Antonio and San Jose areas. These areas have been identified as needing collection system repairs to reduce I/I flows into the system. The collection line along As Perdido also has a bottleneck issue that is largely due to the peak flows generated in the Dan Dan area. The peak flows appear to be the result of a private lift station and/or laundromat periodically discharging flow to the sewer. The As Perdido line is made up of AC pipe and is an asset that has failed in the past. This line is recommended for replacement as a CIP project, which will resolve the bottleneck issue.

A bottleneck has also been identified downstream of Lift Station A-8. This bottleneck is the result of how the lift station is operated and does not result in additional physical downstream bottlenecks. No immediate action is recommended.

Figure 2.2.6-20. **Sadog Tasi North (Lower Base) Bottlenecks**

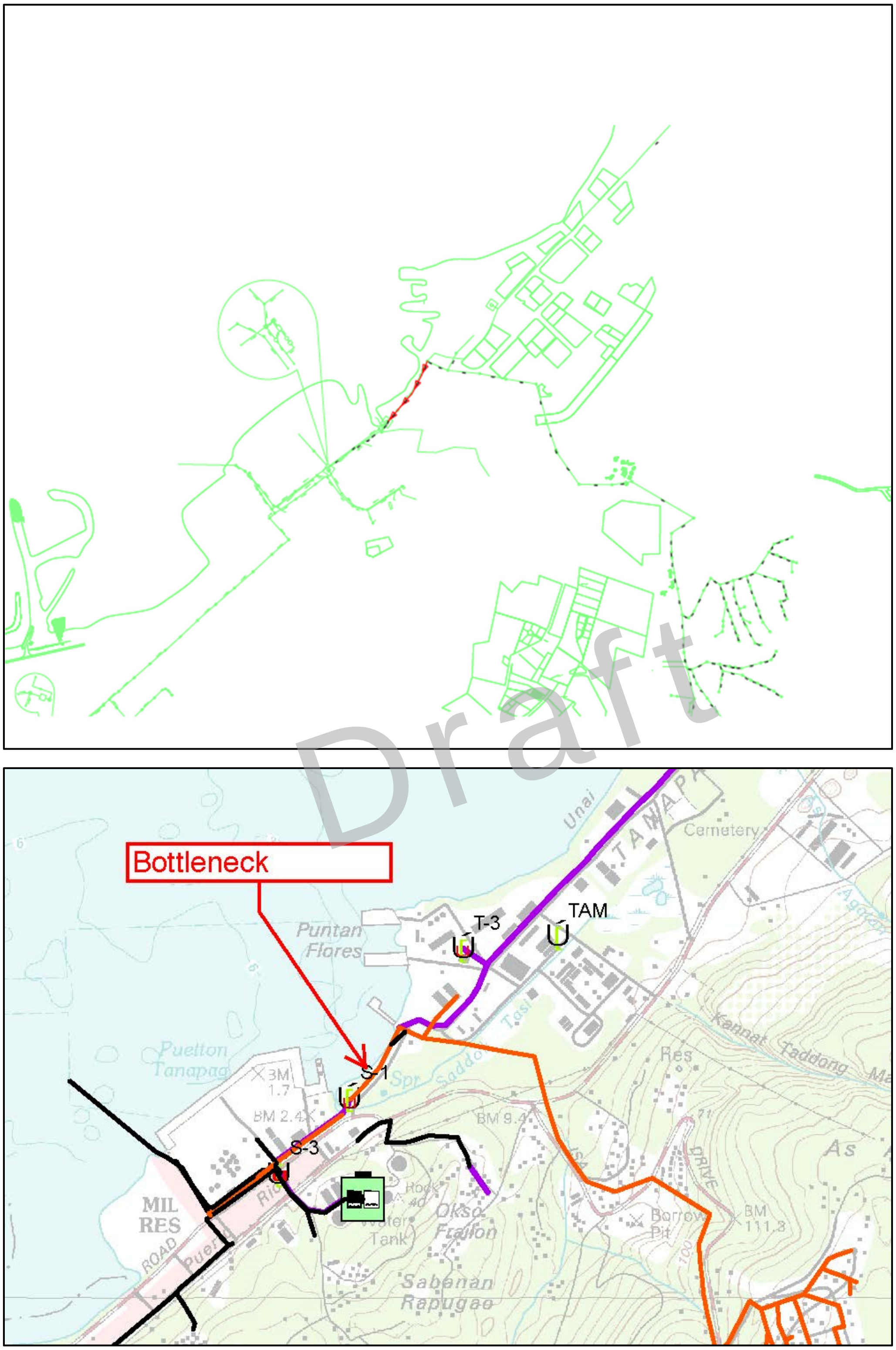


Figure 2.2.6-21. **Sadog Tasi South (Garapan) Bottlenecks**

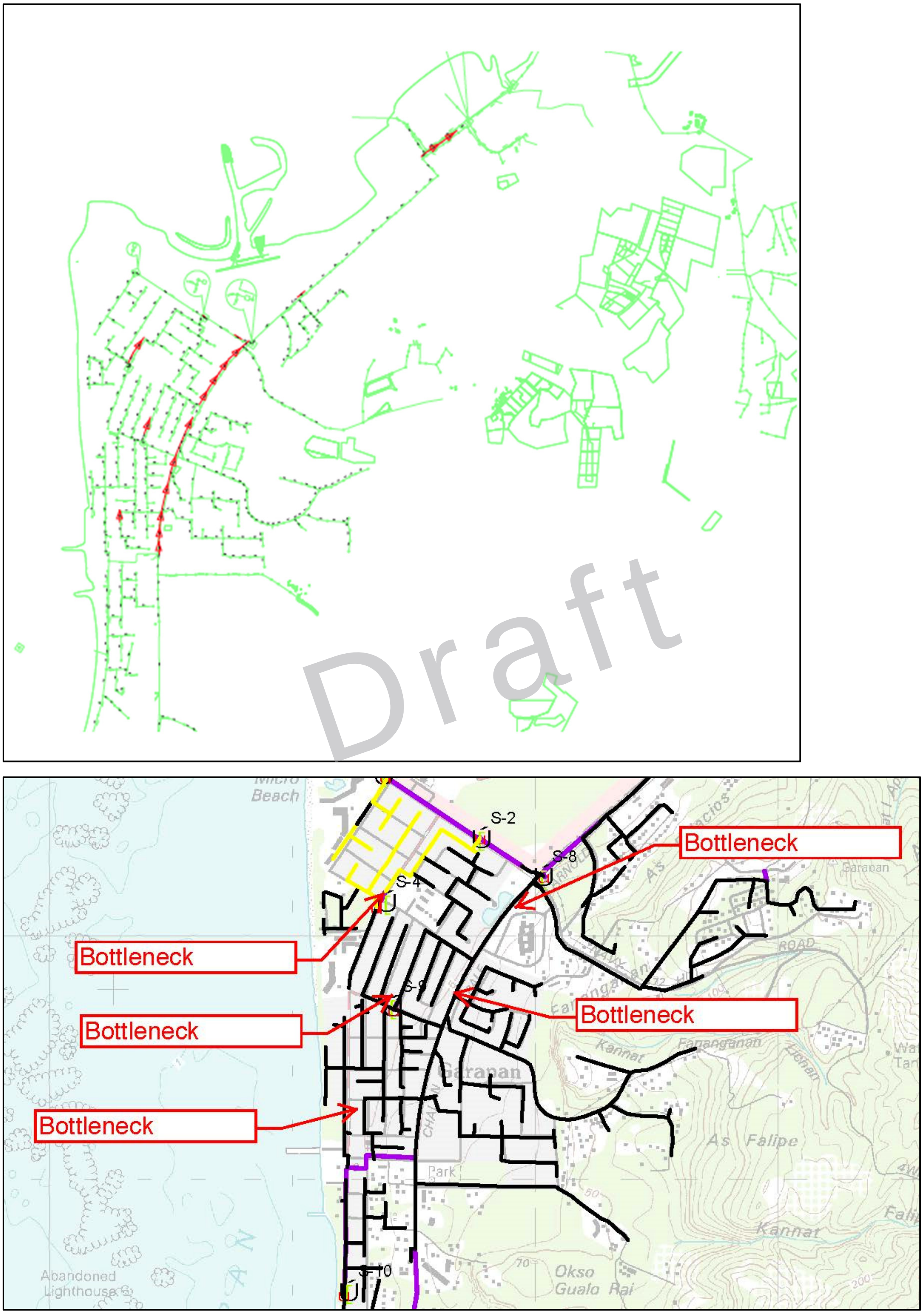


Figure 2.2.6-22. **Agingan West (San Jose) Bottlenecks**

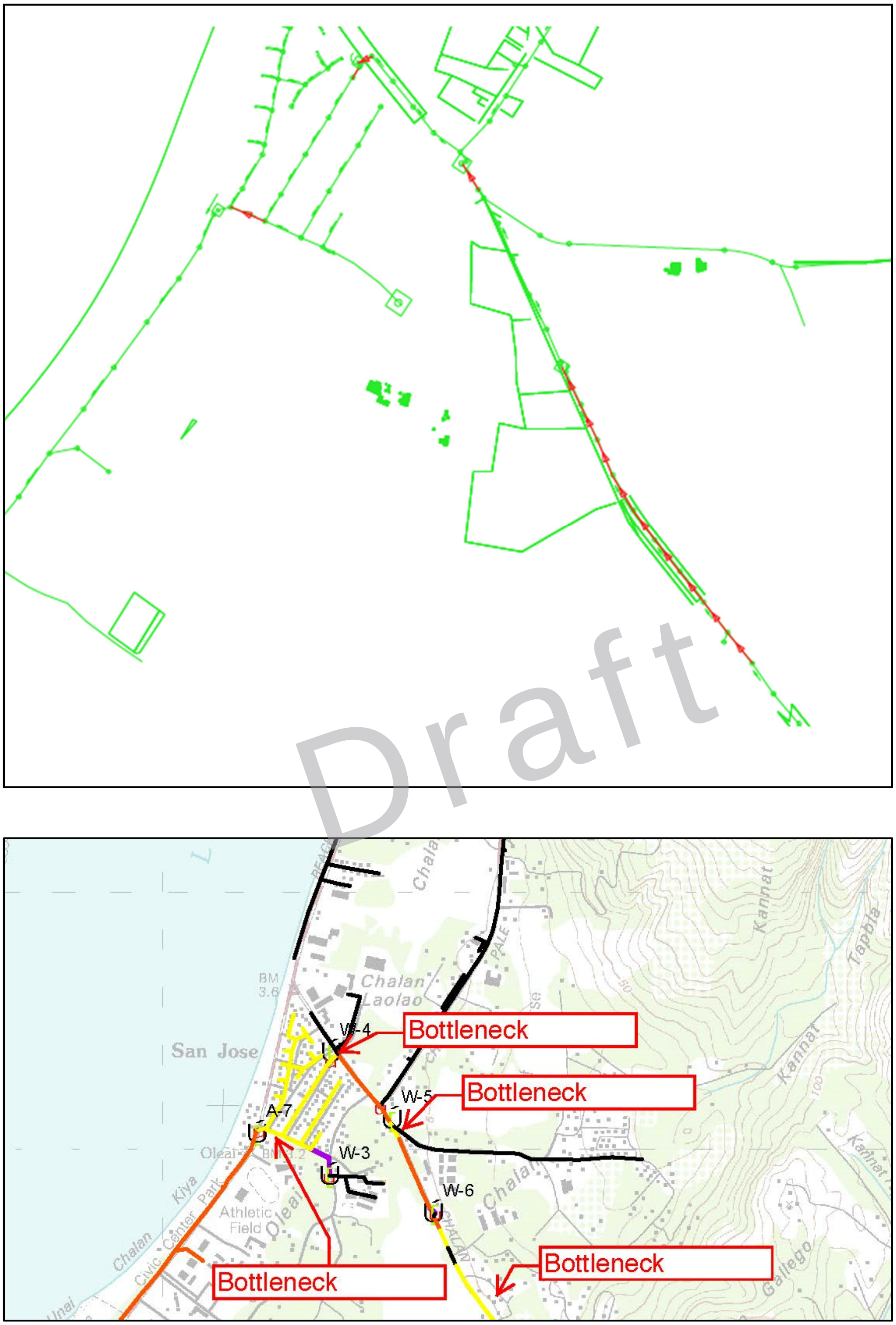
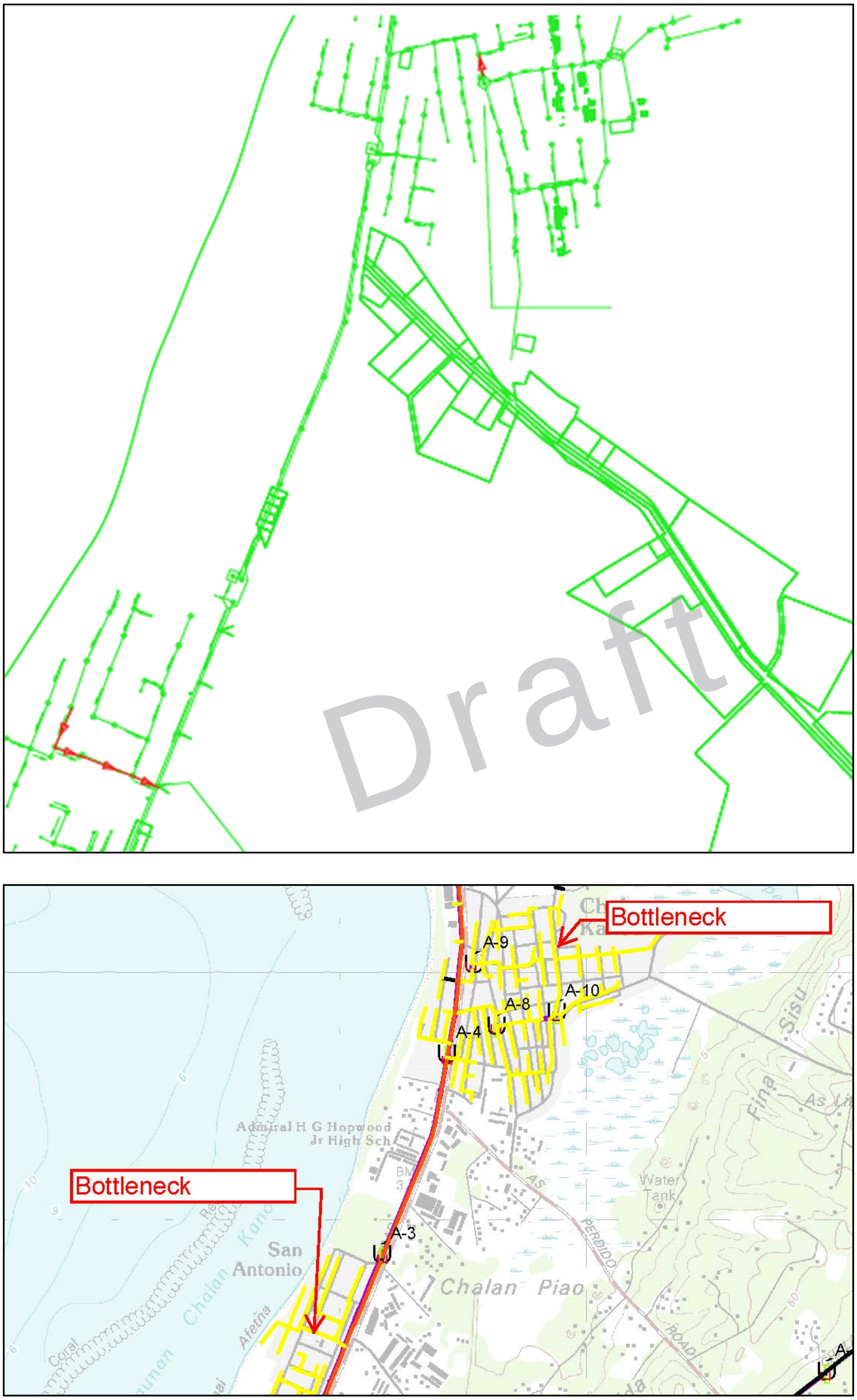


Figure 2.2.6-23. **Agingan West (Chalan Kanoa) Bottlenecks**



Lift Station Recommendations

The TDH at the T-1 pump station is high, which results in an excessively high electrical requirement (i.e., high power costs) and high pressure within the force main. Figure 2.2.6-24 presents the model output of the current operating condition of this force main. Increasing the force main size to 10 inches (Figure 2.2.6-25) from the existing 8 inches will reduce the TDH by half, resulting in power savings and a reduced operating pressure within the force main. The long-term recommendation is to upgrade this force main to 10 inches. The installation of a VFD to reduce the head is recommended as an interim upgrade.

The model predicts a flow velocity of 9.8 ft/s at Lift Station S-8, which is considered high. CUC has performed recent upgrades to this lift station that include new pumps and upgraded pump risers. The existing force main is in fair condition, and there have been no documented failures or operational problems with this force main. No immediate upgrade is needed, though it is recommended that CUC upgrade the control system to a VFD to save on power costs.

Lift Stations A-6 and A-7 and have modeled velocities above 9 feet/s, which is considered high. These lift stations have short force main runs (i.e., less than 30 feet) and are considered part of the Agingan service area. Rehabilitation of these lift stations is recommended as a CIP project and should include upgrades to increase the size of the force main.

Lift Stations A-8 and A-9 have modeled velocities above 10 feet/s, which is considered high. These lift stations have short force main runs of 55 ft. The existing force mains are in fair condition, and there have been no documented failures or operational problems with the force main. No immediate upgrades are needed, although it is recommended that CUC evaluate the pump sizes at these lift stations.

Figure 2.2.6-24. **T-1 Existing 8-inch Force main**

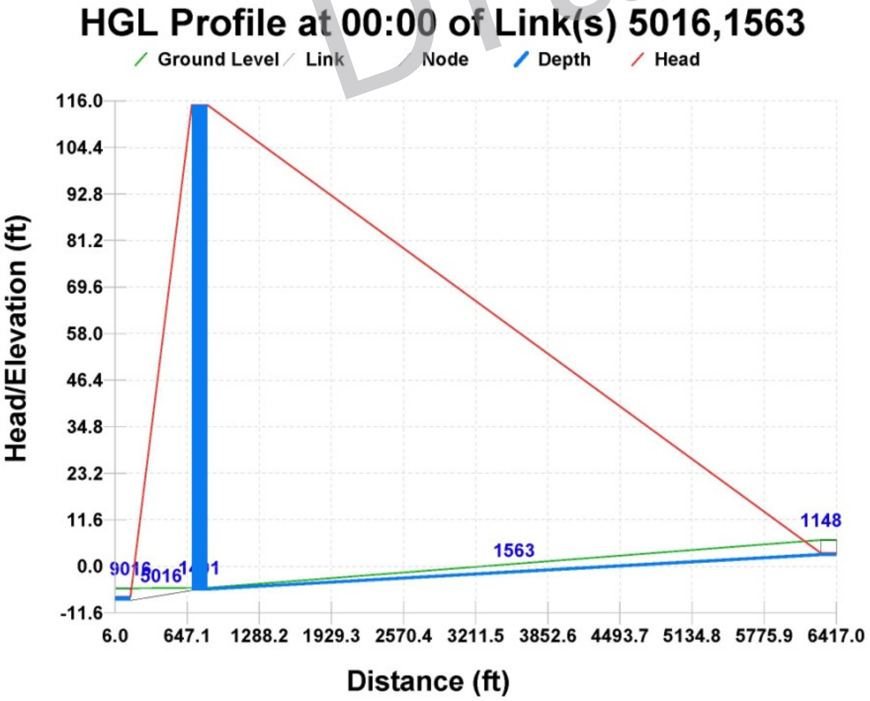
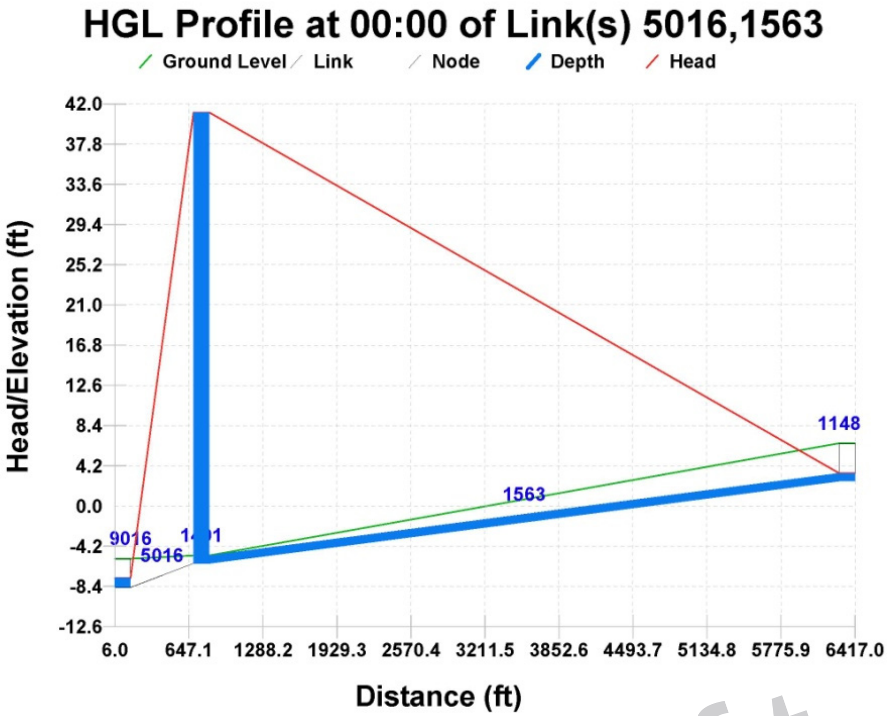


Figure 2.2.6-25. **T-1 Proposed new 10-inch Forcemain**



Lift Station W-5 is located in the middle of Chalan Monsignor Guerroro Road and is difficult to maintain. The hydraulic profile among Lift Stations W-6, W-5, and W-4 is shown as Figure 2.2.6-26. Based on this profile, Lift Stations W-6 and W-4 may be eliminated if Lift Station W-5 is deepened. This will allow gravity flow to a new W-5 lift station via a new, deeper gravity line. The new W-5 lift station will have a new force main that will terminate at the demolished W-4 lift station. This is a long-term recommended upgrade.

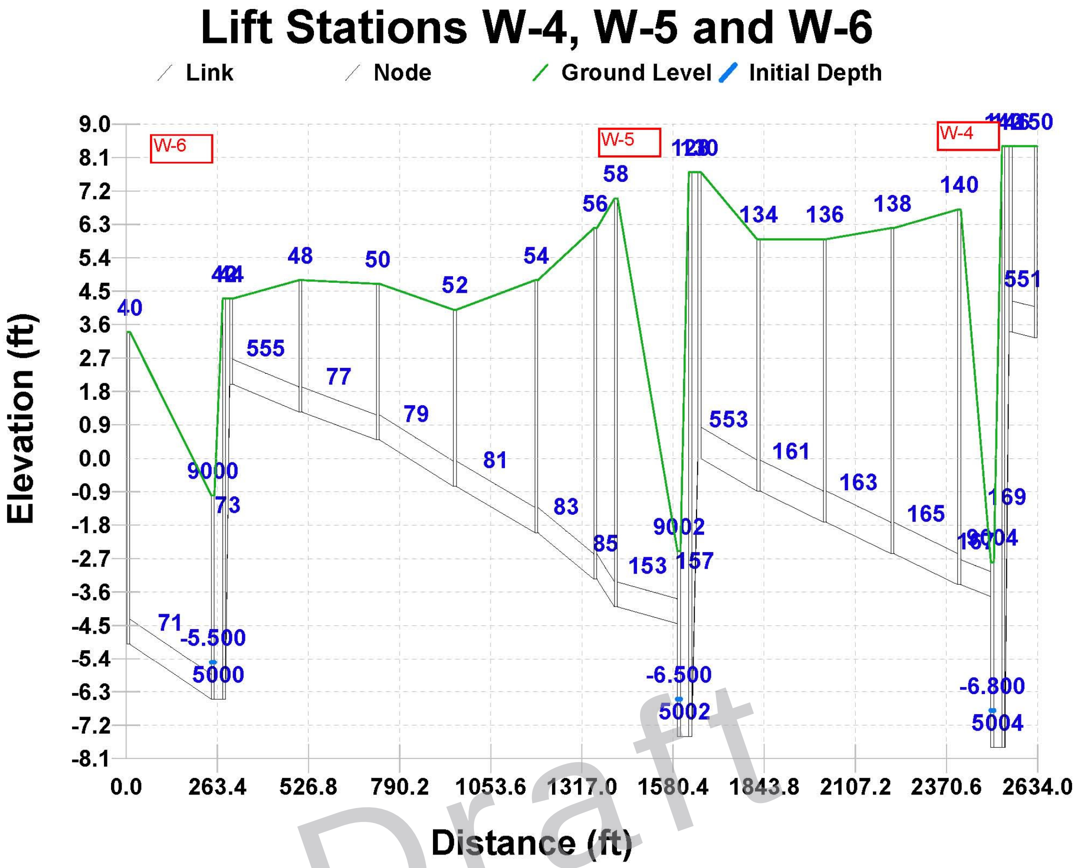
Future Loading

Each of the service area hydraulic models was adjusted to account for the anticipated flows in 2030. Appendix I provides a detailed discussion on the estimated future wastewater flows. The 2030 hydraulic models of the sewersheds identified the same bottlenecks as those discussed above. Additional bottlenecks were identified in the Sadog Tasi South collection system.

Appendix I presents results of the future flows hydraulic modeling exercise; segments of the collection system where the model predicted hydraulic issues are shown in a plan view in this appendix. Information on maximum (peak wet weather) flow, predicted full pipe flow, and predicted remaining capacities are presented for these trouble areas in the collection system:

- **Maximum Flow.** Represents the estimate peak flows modeled for each segment of sewer line. The results shown in Appendix I are for Peak 2030 flows.
- **Full Flow.** Represents the maximum carrying capacity of each pipe segment.
- **Reserve Capacity.** Represent the remaining capacity (if any) along the pipe segment. This value is the difference between Maximum Flow and Full Flow. If positive (Maximum Flow < Full Flow), then there is remaining capacity. If negative (Maximum Flow > Full Flow), then the pipe is at capacity for the modeled flow.

Figure 2.2.6-26. **Hydraulic Profile of Lift Station W-4, W-5, and W-6**



This information provides CUC with the locations of bottlenecks, which can be identified from the graphs in Appendix I by identifying where the remaining capacity in the pipe drops to zero.

It is recommended that CUC reevaluate these future wastewater flows in 5 years to determine whether these bottleneck conditions continue to exist. Recommended improvements on I/I and recommended upgrades to the lift station pumps and controls will improve existing conditions and prevent future bottlenecks.

2.2.7 Unsewered Areas Assessment

Section 58 of the Stipulated Order requires that the Master Plan include an assessment of and recommendations regarding unsewered areas. This requirement was addressed by evaluating groundwater quality data for nitrates and identifying the benefits of sewers and the potential impacts that septic systems may have on the beneficial uses (i.e., aquatic life and recreation) of groundwater and surface water in Saipan. The methodical approach taken to identify prioritized areas that should be considered for sewer service in Saipan follows.

Several areas on the island of Saipan are not currently sewered; the residences and businesses in these areas mostly rely upon individual wastewater disposal systems (IWDSs, also known as septic systems). Unsewered areas are defined as areas that do not have sewer lines or are not currently connected to a sewer collection system, including areas with septic systems that may be able to be connected to existing, expanded, or new wastewater collection systems, as well as areas that may not be able to be connected to a centralized wastewater system. See Figure 2.2.7-1 for a map of sewered and unsewered areas in Saipan.

Environmental Impacts of Unsewered Areas

Septic systems represent a potential risk to Saipan’s environment and population due to the impacts they may have on groundwater quality and associated drinking water wells, and beneficial uses of reefs, coastal shorelines, and surface waters. The potential exists for drinking water wells in areas without sewers to become contaminated, which can have public health impacts, particularly with regard to nitrates and nitrites found in the groundwater. Unsewered areas may also affect surface waters as a result of groundwater seepage and runoff. Due to these possible impacts it is necessary to evaluate the unsewered areas to ascertain the need for installation of sewers or wastewater treatment facilities. The emphasis of the evaluation has been placed on groundwater well nitrate analysis due to the large quantity of data available for nitrate concentrations observed in the drinking water wells.

It is important to note that there have been individual wells where the nitrate MCL was exceeded in the CUC source water system. The “Well Isolation Program” that has been implemented over the last 2 years has eliminated nearly all direct feed wells from the system. As such, the blended water being fed into the water distribution system has not had any MCL violations for nitrate. CUC is confident that this will continue to be the case, even if a few wells continue to exceed the MCL value of 10 mg/L. To ensure this is the case, CUC will prepare a nitrification action plan that will sequence the use of wells to make sure that the wells with the highest nitrate concentrations are the last to be turned on and first to be turned off. This strategy will provide the lowest possible nitrate concentration in the blended water from each well field.

Septic Systems

In the unsewered areas in Saipan, many homes rely on septic tanks with leach fields (also known as drain fields), dug latrines, or outhouses (DEQ, 2010). Septic systems (also known as onsite wastewater disposal systems) are used to treat and dispose of sanitary waste. A typical septic system includes three main components: a septic tank, a drain field, and soil. The wastewater from the residence flows into the septic tank, where it is held for a period of time to allow suspended solids to separate out. The heavier solids collect in the bottom of the tank and are partially decomposed by microbial activity under anaerobic conditions. Grease, oil, and fat float to the surface and form a scum layer. The partially clarified wastewater that remains between the layers of scum and sludge flows to the drain field, where it is further treated by the soil. As the wastewater effluent percolates down through the drainfield into the soil, chemical and biological processes further remove bacteria, viruses, organics, and nutrients before the effluent reaches the groundwater.

A septic tank will usually retain 60 to 70 percent of the solids, oil, and grease that passes through the system (USEPA, 1999a). Typical total nitrogen removal within septic tanks ranges from 10 to 30 percent, with the majority being removed as particulate matter through sedimentation or flotation (Oakley, 2004). Nitrate removal in soil is highly dependent on the soil type and percolation rate.

Potential Issues with Septic Systems

Septic systems are designed to operate indefinitely if properly maintained. For example, regular addition of an external bacteria source, such as yeast, is an effective method to maintain the health of a septic system. Unfortunately, most household systems are not well maintained, making the functional life of most septic systems 20 years or less (USEPA, 1999b). Most septic system failures are related to inappropriate design and poor maintenance; more specifically, most failures are a result of unpumped and sludge-filled septic tanks, which lead to hydraulic overloading of the septic system. To prevent septic system backups, septic tanks should be inspected regularly and sludge and scum removed through periodic pumping of the septic tank.

Septic system design-related failures may also be attributed to having an undersized drain field or undersized septic tank, which allows solids to clog the drain field and results in system failure. If a septic tank is not watertight, water can leak into the tank and cause hydraulic overloading of the system, resulting in inadequate treatment and the possibility that sewage may seep out to the ground surface. Because the wastewater seeping to the ground surface is not completely treated, it poses the risk that runoff to surrounding surface waters may harm aquatic life and recreational users of the water bodies.

Improper siting of septic systems may also lead to failures; inadequate site location, inappropriate site soils, excessive slopes, and high groundwater tables are all site-specific factors that can lead to hydraulic failure of septic systems and water resource contamination. Favorable sites for septic systems are where soils are relatively permeable and remain unsaturated to several feet below the septic system depth. Drain fields should be set well above water tables and bedrock. It is important to site septic systems at minimum horizontal setback distances from drinking water wells and minimum vertical setback distances from impermeable soil layers and the groundwater table. Areas with high groundwater tables and shallow impermeable layers should be avoided because there is insufficient unsaturated soil thickness to ensure sufficient treatment. Soil permeability must be adequate to ensure proper treatment of septage. If permeability is too low, the drain field may not be able to handle wastewater flows and surface ponding or plumbing backups may result. On the other extreme, if permeability is too high, the effluent may reach the groundwater table before it is adequately treated.

If the drainfield is not properly leveled during construction, wastewater can overload the system. To avoid failure of septic systems, vehicles and heavy machinery should be kept off the drain field during and after construction to prevent soil compaction, which reduces the wastewater infiltration rate into the soil.

Potential Impacts from Septic Systems

Septic systems present a risk to public health, drinking water resources, aquatic life, and other beneficial uses of water bodies due to the presence of bacteria, protozoa, viruses, nitrogen, phosphorus, and toxic chemicals found in the discharged septage from septic tanks. DEQ is responsible for enforcing the permitting, design, installation, and operations of septic systems to protect the environment on the island of Saipan. Septic systems that are properly designed, sited, installed, operated, and maintained can provide excellent wastewater treatment. However, improperly used or operated systems can be a source of groundwater and surface water contamination that can lead to waterborne diseases and other adverse health effects. Even properly functioning septic systems may not remove enough nitrogen to prevent contamination of surrounding water bodies. The most serious problems involve contamination of surface waters and groundwater with disease-causing pathogens and nitrates. Excessive nitrogen and phosphorus discharges to sensitive surface waters can also be problematic when eutrophication begins to occur in water bodies, which increases algal growth and lowers DO levels in water bodies.

Septic system failures may affect environmental and public health via three primary pathways:

1. Seepage of partially treated septage into the groundwater table where drinking water wells are located, leading to contaminated drinking water (nitrate, bacteria, and viruses are the primary contaminants of concern).
2. Seepage of partially treated septage into the groundwater table where surface water is directly impacted by the groundwater (nitrates, bacteria, and viruses are the primary contaminants of concern), resulting in impaired waters that are unable to meet the requirements for safe recreation or aquatic life.
3. Resurfacing of partially treated septage and the resulting runoff into surface waters (nitrate, bacteria, and viruses are the primary contaminants of concern), resulting in impaired waters that are unable to meet the requirements for safe recreation or aquatic life.

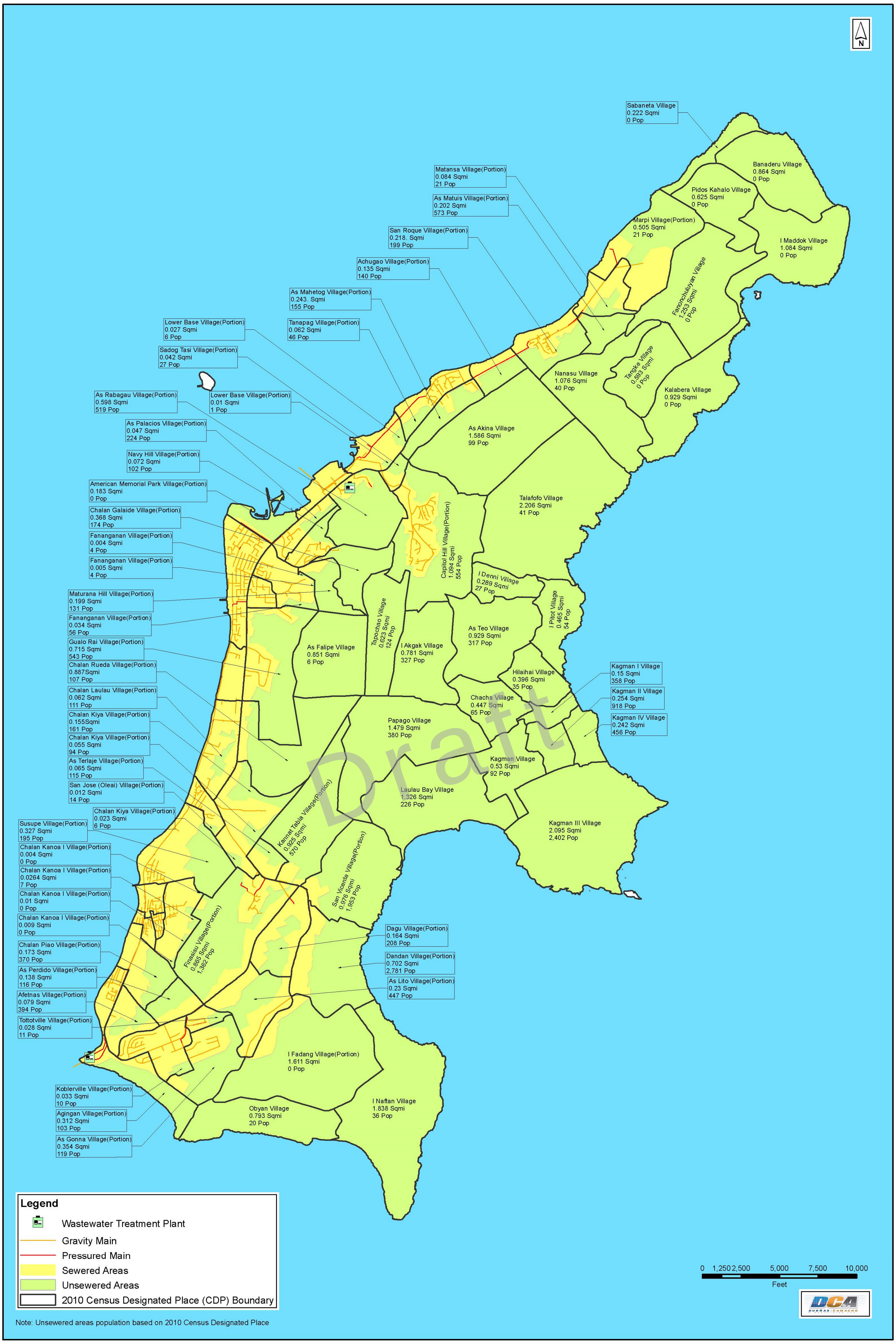
Development of Unsewered Areas Assessment Methodology

It is thought that the septic systems located in the unsewered areas on Saipan may be negatively affecting the island's groundwater and surface water resources, including drinking water wells. To determine whether these unsewered areas are impairing the drinking water in Saipan, a detailed nitrate analysis was performed and is presented in detail later in this section.

Other water resource impacts, in addition to contamination of drinking water wells, need to be considered when determining whether further analysis and potential infrastructure improvements are required in unsewered areas. Many areas in Saipan are currently not serviced by the CUC wastewater sewer infrastructure. Some of these unsewered areas may be more of a concern than other areas depending upon current conditions of water resources in the area and severity of potential impacts to water bodies within the area. To quantify potential impacts to water resources within the unsewered areas and to prioritize these areas for further analysis, a methodical approach was developed that considers the following factors:

- Location of groundwater protection zones in relation to where water is extracted for drinking water (i.e., the well fields)
- Suitability of soils for septic tanks
- Location of agricultural areas
- Location of unsewered areas and sewered areas
- Location of drinking water wells with nitrate MCL violations and the number of violations

Figure 2.2.7-1. **Saipan Sewered and Unsewered Areas**



Note: Unsewered areas population based on 2010 Census Designated Place

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- Suitability of soils for septic tanks
- Location of agricultural areas
- Location of unsewered areas and sewered areas
- Location of drinking water wells with nitrate MCL violations and the number of violations

Groundwater Protection Zones

According to the U.S. Geological Survey (USGS) publication, "Groundwater Resources of Saipan, Commonwealth of the Northern Mariana Islands," a total of 17 well fields are divided into geographical areas throughout the island of Saipan. For the purposes of the report, these 17 geographical areas were further grouped into population regions and sewered/unsewered areas. Table 2.2.7-1 lists the 17 USGS well fields, categorizes them as unsewered or sewered areas, and identifies the unsewered well field area (as defined for this report) in which they belong. Note that the upland spring and seeps well field located in the central uplands of the island are not being used as groundwater supplies by CUC.

Table 2.2.7-1. **USGS Well Fields**

USGS Designated Well Field	Unsewered/Sewered	Well Field Designation
Kagman	Unsewered	Kagman Well Field
Sablan Quarry	Unsewered	Central Well Field
Agag	Unsewered	Central Well Field
Capitol Hill	Sewered (Partial)	Central Well Field
Calhoun	Unsewered	Central Well Field
Maui IV	Unsewered	Central Well Field
Puerto Rico	Sewered (Partial)	Central Well Field
Gualo Rai	Sewered (Partial)	Central Well Field
Marpi Quarry	Unsewered	Northern well Fields
Isley	Sewered (Partial)	Isley Well Field

Table 2.2.7-1. **USGS Well Fields**

USGS Designated Well Field	Unsewered/Sewered	Well Field Designation
Obyan	Unsewered	Obyan well Field
Koblerville	Sewered (Partial)	Koblerville Well Field
Dan Dan	Unsewered	As Lito/Dan Dan North/San Vicente Well Fields
San Vicente	Unsewered	As Lito/Dan Dan North/San Vicente Well Fields
Chalan Kiya	Sewered (Partial)	As Lito/Dan Dan North/San Vicente Well Fields
Finasisu	Unsewered	There are no CUC production wells in this area.
Upland springs, seeps, and exploratory wells	Unsewered	There are no CUC production wells in this area.

Three groundwater protection zones have been established by DEQ for Saipan, which are defined by the quality of the groundwater within each zone. The relative water quality is based on the salinity of the groundwater in the specific zone. Figure 2.2.7-2 presents these zones. Zones that have relatively better water quality are given a rating of 3, moderate quality is rated as 2, and low quality is rated as 1. Unsewered areas that are located over an aquifer of "high quality" are given a score of 3, whereas unsewered areas located over an aquifer of "low quality" are given a score of 1. This scoring rationale places more weight on the aquifer that currently has the best water quality to protect the highest quality water sources on island from potential impacts by the unsewered areas.

Septic System Suitability of Soils

Ideally, septic tanks should only be utilized in areas where the soil is suitable for this type of sewage treatment. Not all soil types are equivalent when it comes to suitability of septic tanks. On Saipan there are limited options for wastewater treatment in unsewered areas, so in some cases septic tanks have been constructed in areas where the soil is not ideal or suitable for this type of treatment.

The unsewered areas analysis must consider the type and suitability of soils that exist in areas where septic systems are known to exist. The ranking system shown in Table 2.2.7-2 was used as part of the unsewered analysis methodology. None of the soil types in Saipan received the highest suitability rating of 1, so the design, construction, and maintenance of septic systems become more critical as the suitability of the soils decreases.

Table 2.2.7-2. **Septic System Suitability Scoring System**

Septic System Suitability Score
1 = Suitable
2 = Moderately suitable
3 = Moderately unsuitable
4 = Almost unsuitable
5 = Unsuitable

This section further discusses the various soil types found on Saipan and their relative suitability for septic systems.

Volcanic Soils

Volcanic soils occur in areas of volcanic geology. Depth to soft or hard weathered volcanic bedrock from ground elevation is usually shallow. Septic system leaching fields on Saipan are often built into bedrock, at least partially, because of the design depth requirements for leach fields. Volcanic soils occur in limited areas on Saipan. There is considerable experience with septic systems installed in this type of soil in areas such as Wireless, Finasisu, and portions of As Teo and Kagman.

Septic systems in these areas have a higher rate of failure than in other areas on Saipan. Septic system failure in this type of soil is usually in the form of hydraulic failure, resulting in surfacing of incompletely treated wastewater effluent. Hydraulic failure may occur directly within the leach field footprint or as down-slope seepage. Failures in these soil types often go unreported due to the seepage of effluent just off-site, and out of eyesight, of many installations. Groundwater resources do not typically exist in areas of volcanic geology, so impacts are primarily to surface waters, typically streams, or as a nuisance (e.g., odors, flies) and health hazard to residents and neighbors.

For the purposes of the unsewered analysis methodology, all volcanic soil types are ranked as "almost unsuitable" (score = 4) to "unsuitable" (score = 5) for septic systems on the basis of failure history. Rankings of "unsuitable" were assigned to volcanic soils where the slope is 30 to 60 percent. Refer to Figure 2.2.7-3 for a visual display of where the "almost unsuitable" and "unsuitable" areas are located.

Deep, Low Permeability Soils

Deep, low permeability soils are deep, clayey soils that occur in limited, but important, areas throughout Saipan, including portions of Kagman and Dan Dan. Percolation rates are usually very low in this type of soil and are often less than the limits set by DEQ as permissible for new septic system construction. In these cases, a holding tank system that requires pumping and disposal at the WWTP is usually required by DEQ in lieu of a septic system.

Septic systems in this soil type have a higher rate of failure than in other soil types. Septic system failure in this type of soil is usually in the form of hydraulic failure, resulting in surfacing of effluent that usually occurs directly within the leach field footprint. Some failures have been observed as a result of the leach field soils becoming saturated during the rainy season. Consequences of failure in these types of soils usually include nuisance (i.e., odors, flies) and health hazards to residents and neighbors and impacts to surface waters. Due to the low permeability of the soil, groundwater resources are not likely to be at risk from septic systems in these types of soils.

For the purposes of the unsewered analysis methodology, these most impermeable of soil types are ranked as "almost unsuitable" (score = 4) to "unsuitable" (score = 5) on the basis of previous DEQ permitting and enforcement experience. The "Kagman" series clays are ranked "moderately unsuitable" (score = 3) on the basis of better percolation characteristics and deep soil profiles, which likely minimizes impacts to groundwater. Refer to Figure 2.2.7-3 for a visual display of where the "moderately unsuitable," "almost unsuitable," and "unsuitable" areas are located.

Shallow Soils over Limestone

Shallow soils over limestone occur over most of the developable land areas of Saipan. Septic systems installed in these soils are almost always installed directly into limestone below the deepest soil horizon. In some areas, excavations may occur in mixtures of soils and limestone. Because of the lack of a soil matrix in which filtration of effluent can occur, septic systems installed into limestone do not function in the same way a traditional septic system does. The non-homogeneous nature of limestone also raises the possibility that effluent may be channeled downward from septic system leaching fields through fissures and channels in the limestone.

Septic systems installed in shallow soils over limestone typically do not fail in the traditional sense, which is to say that effluent does not surface. Though this has occurred in some cases, the cause of failure is almost always attributed to poor maintenance practices or overloading by the owner. Because of the nature of the “karst” limestone geology and the assumed lack of complete filtration in the leaching fields of the septic system, there is a greater potential for groundwater contamination resulting from the use of septic systems in areas with shallow soils over limestone. However, in most such areas, the depth to groundwater is considerable, from 100 to 300 feet in most areas of Saipan. Additional treatment through filtration and biological processes can take place as effluent seeps through the complex limestone and clay-limestone deposits that form most of the geology in the CNMI. The biological treatment in the soil improves over time as the bacteria populations mature and adapt to the type of sewage being treated.

For the purposes of the unsewered analysis methodology, these soils are mostly ranked as “moderately unsuitable” (score = 3) due to the potential for groundwater contamination, but it is important to note that impacts have not been observed in most areas in which these soil types exist. A few of these soils are ranked as “moderately suitable” (score of 2) due to deeper soil depths and more suitable textures. Refer to Figure 2.2.7-3 for a visual display of where the “moderately suitable” and “moderately unsuitable” areas are located.

Coastal (Shioya) Soils

Coastal soils in the CNMI consist primarily of areas of deep sandy soils or mixtures of permeable limestone and sand. Percolation rates can be very fast, exceeding permissible limits set by DEQ. As such, inadequate filtration is a problem with septic systems installed in these areas. Shallow depths to groundwater compound this problem. Septic systems installed in these areas are more likely to impact near-shore water quality. This may be mitigated in areas with intense wave action, but is likely to result in impacts to water quality and potential public health risks in quieter areas such as lagoons, where the sandy soils also attract beachgoers.

For the purposes of the unsewered analysis methodology, coastal soils are ranked as “almost unsuitable” (score = 4) for the Shioya soil type, due to proximity to public beaches and suspected/known water quality problems. Refer to Figure 2.2.7-3 for a visual display of where these “almost unsuitable” areas are located.

Low-Lying Wetland Soils

Soils in and near wetlands are unsuitable for septic system installation due to both the high water table conditions as well as setback distances to wetlands as required by DEQ. For the purposes of the unsewered analysis methodology, low-lying wetland soils are ranked as “unsuitable” (score = 5). Refer to Figure 2.2.7-3 for a visual display of where these “almost unsuitable” areas are located.

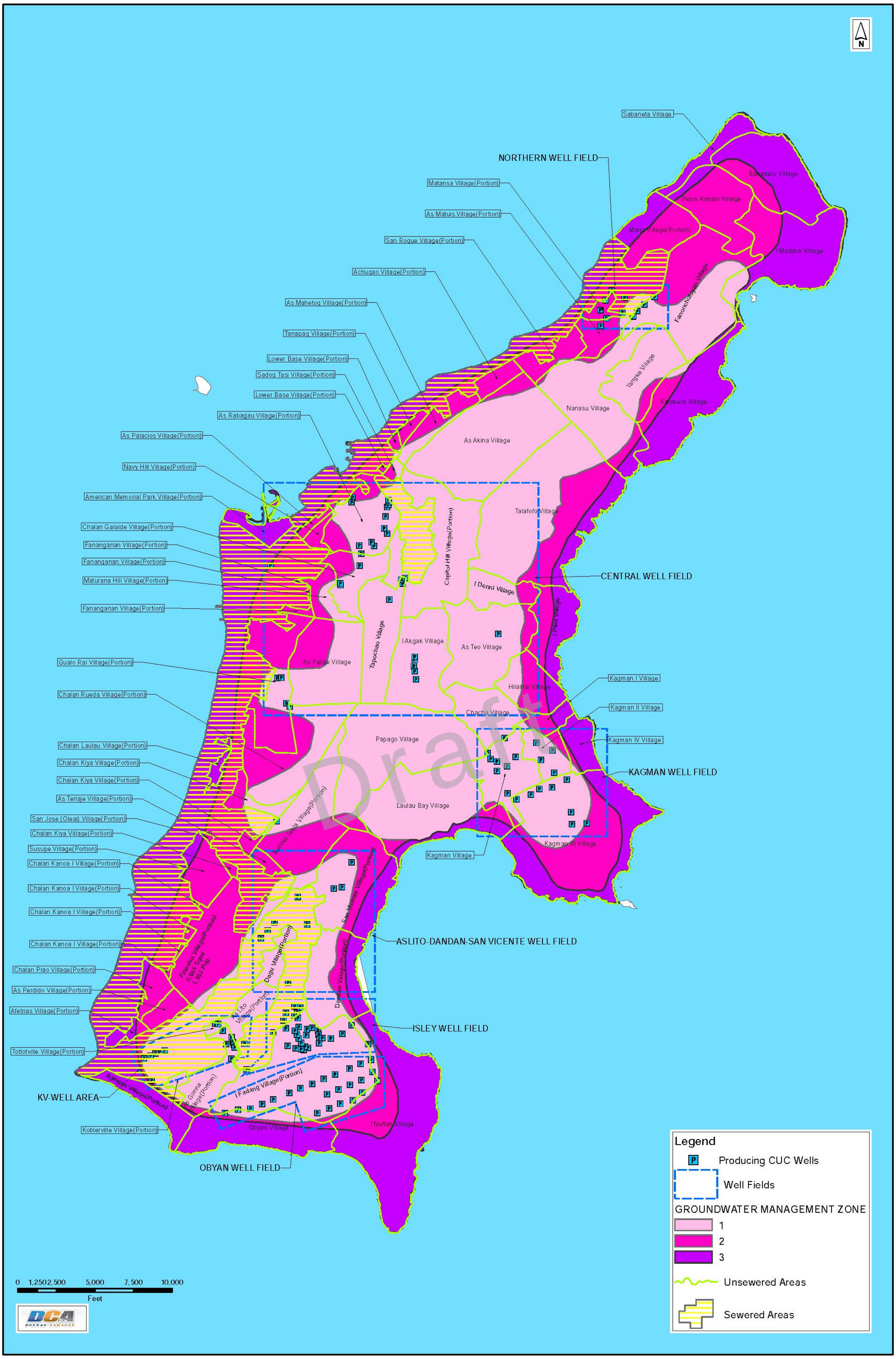
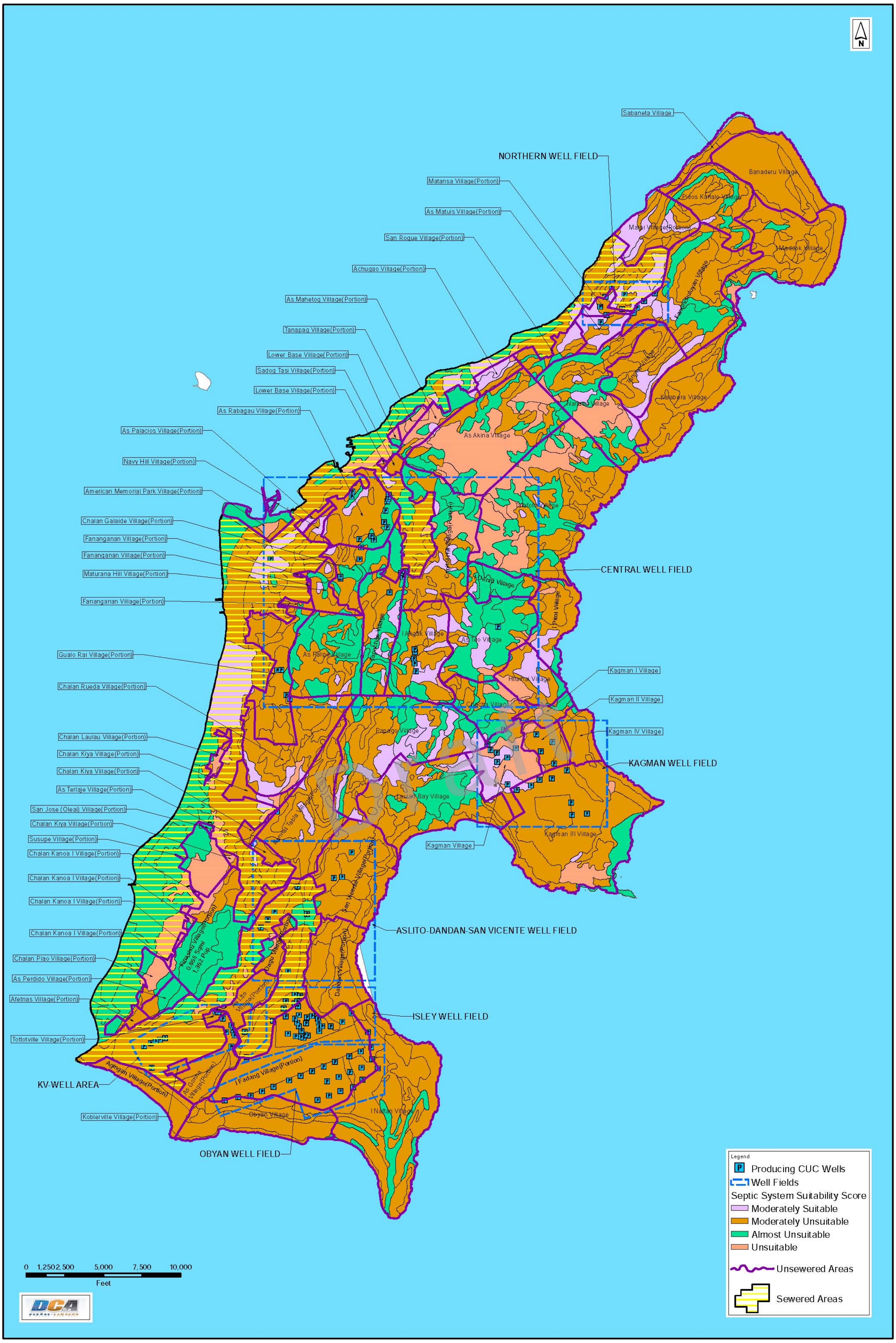

N
Sabaneta Village
NORTHERN WELL FIELD
Matansa Village(Portion)
As Matuis Village(Portion)
San Roque Village(Portion)
Achugao Village(Portion)
As Mahetog Village(Portion)
Tanapag Village(Portion)
Lower Base Village(Portion)
Sadog Tasi Village(Portion)
Lower Base Village(Portion)
As Rabagau Village(Portion)
As Palacios Village(Portion)
Navy Hill Village(Portion)
American Memorial Park Village(Portion)
Chalan Galaide Village(Portion)
Fananganan Village(Portion)
Fananganan Village(Portion)
Maturana Hill Village(Portion)
Fananganan Village(Portion)
Gualo Rai Village(Portion)
Chalan Rueda Village(Portion)
Chalan Laulau Village(Portion)
Chalan Kiya Village(Portion)
Chalan Kiya Village(Portion)
As Terlaje Village(Portion)
San Jose (Oleai) Village(Portion)
Chalan Kiya Village(Portion)
Susupe Village(Portion)
Chalan Kanoa I Village(Portion)
Chalan Kanoa I Village(Portion)
Chalan Kanoa I Village(Portion)
Chalan Kanoa I Village(Portion)
Chalan Piao Village(Portion)
As Perdido Village(Portion)
Afetnas Village(Portion)
Tottotville Village(Portion)
KV-WELL AREA
Koblerville Village(Portion)
OBYAN WELL FIELD
Banaderu Village
Pidos Kahalo Village
Marpi Village(Portion)
I Maddok Village
Fanonchuluyan Village
Tangke Village
Nanasu Village
Kalabera Village
As Akina Village
Talafofo Village
CENTRAL WELL FIELD
Capitol Hill Village(Portion)
I Denni Village
I Piti Village
Tapochao Village
I Akgak Village
As Teo Village
As Falipe Village
Hilaihai Village
Chacha Village
Kagman I Village
Kagman II Village
Kagman IV Village
KAGMAN WELL FIELD
Papago Village
Laulau Bay Village
Kagman III Village
Kagman Village
Namsai Tasi Village(Portion)
San Vicente Village(Portion)
ASLITO-DANDAN-SAN VICENTE WELL FIELD
Dagu Village(Portion)
Finasisu Village(Portion)
Dandan Village(Portion)
As Lito Village(Portion)
ISLEY WELL FIELD
As Gonno Village(Portion)
I Fadang Village(Portion)
Agingan Village(Portion)
Obyan Village
I Naftan Village
P
Legend
P Producing CUC Wells
Well Fields
GROUNDWATER MANAGEMENT ZONE
1
2
3
Unsewered Areas
Sewered Areas
0 1,250 2,500 5,000 7,500 10,000
Feet
DCA
Draft

Figure 2.2.7-3. **Septic Tank Suitability of Soils**



Agricultural Areas

Agricultural areas can be a significant source of nitrate in groundwater due to excessive or inappropriate use of nitrogen-containing nutrient sources, which include fertilizers and animal manure. Livestock and dairy practices that concentrate animals, such as feedlots, can also significantly contribute to nitrate contamination of groundwater if the animal wastes generated by the operation are not properly managed.

For the purposes of the unsewered analysis, an area where agriculture does exist was given a score of 2, while areas with no agriculture were assigned a score of 1. The higher score reflects the potential impact to the groundwater water quality.

Unsewered Areas Analysis

By considering all of the factors discussed in the previous sections for each of the unsewered areas in addition to analysis of the nitrate concentration data for wells, it is possible to determine the unsewered areas that should be prioritized for further analysis and to develop recommendations for improvements to existing (or non-existent) sewer infrastructure.

The methodology and scoring systems described above were applied to each of the unsewered areas; Table 2.2.7-3 lists the unsewered areas in Saipan. The scoring matrix shown in the table was developed based on the factors and scoring criteria previously identified. Quantitative scores were assigned to each unsewered area for each of the scoring criteria. A total score was determined by summing all of the individual scores. The highest-scoring unsewered areas become the highest priority areas that may require the most attention with regard to impacts to water resources.

Table 2.2.7-3**. Unsewered Areas Analysis Scoring System**

Village	**Septic Tank Suitability**	**Groundwater Protection Zone**	**Agriculture**	**Number of Times NO_3 > 10 mg/L**	**Number of Wells of Concern (average NO_3 > 5 mg/L)**	**Prioritization Score**
Kagman	5	3	2	1	10	**21**
San Vicente/ As Lito/ Dan Dan	5	3	2	0	2	**12**
Isley	5	3	1	84	23	**116**
Obyan	5	3	2	0	10	**20**
Koblerville	5	3	2	1	4	**15**
Central Well Fields	4	3	1	0	0	**8**
Northern Well Fields	3	2	1	0	0	**6**

Based on the total scores for the individual unsewered areas in Table 2.2.7-3, the unsewered areas that should be the subject of further analysis are, in order of priority, as follows:

1. Isley
2. Kagman
3. Obyan
4. Koblerville

5. San Vicente/As Lito/Dan Dan
6. Central Well Fields
7. Northern Well Fields

In order of priority, the unsewered areas should be evaluated in depth to determine the source of potential groundwater contamination. Depending on the findings, the recommendations to remediate the issues within the unsewered areas may vary widely from doing nothing to extending CUC wastewater infrastructure (sewers and/or wastewater treatment plants) into the area. This approach looks at all the impacts that septic systems may have on an area and provides a method for CUC to prioritize and focus its efforts on the most critical unsewered areas on the island.

Nitrate Contamination in Groundwater

The major source of drinking water for Saipan is groundwater pumped from the aquifer. The groundwater is susceptible to nitrate and nitrite contamination from the numerous on-site septic systems that exist in many villages on Saipan and possibly from the use of nitrate-based fertilizers on agricultural plots. Elevated nitrate and nitrite concentrations in groundwater may have negative public health and environmental impacts on the adjacent watershed.

EPA has determined that the maximum contaminant levels (MCLs) for nitrate and nitrite in drinking water are 10 mg/L and 1 mg/L, respectively. Ingestion of water containing high nitrate or nitrite concentrations can be fatal to infants (i.e., Blue Baby Syndrome). Nitrate and nitrite are rarely a problem for people older than six months. However, long-term exposure to nitrate and nitrite can lead to dieresis (that is, a division of bones or of soft parts that are normally continuous, as by a fracture, a laceration, or an incision), starchy deposits, and hemorrhaging of the spleen (DEQ, 2009). Due to the significant health threats related to nitrate and nitrite, public water systems are required to monitor drinking water for these constituents at regular intervals. Monitoring is required at least once per year, with increasing sampling frequencies required if concentrations increase to more than 50 percent of the MCL.

Potential Nitrate and Nitrite Sources in Saipan's Groundwater

The nitrogen cycle traces the movement of nitrogen through the ecosystem as organic and mineral components. The nitrogen cycle is closely linked to the hydrologic cycle as nitrogen is carried via precipitation, surface water, and groundwater. The nitrogen cycle does not normally produce detrimental levels of nitrogen and provides the primary source of nutrients for plant growth. Nitrogen and nitrogen compounds originating from dust fall can enter the subsurface and become part of an environment's nitrogen cycle. Additionally, atmospheric nitrogen can be fixed by plants and microorganisms contributing to the nitrogen content of surface and subsurface soils. Nitrogen compounds are also derived from decaying plant and animal matter that is incidentally deposited on the ground or deliberately deposited by humans as fertilizer.

Nitrogen exists in a number of natural and anthropogenic sources. Nitrate (NO_3) and nitrite (NO_2) are forms of inorganic nitrogen, in addition to nitrogen gas (N_2) and ammonia (NH_3). Organic nitrogen is found in humic acid compounds, protein sources, and amino acid and amine compounds. Animal feces are a significant source of nitrates, which can enter the groundwater at the source, while storm water runoff will deliver soluble and suspended nitrogen materials to sinkholes, ponding basins, and other low-lying areas. Because husbandry of chickens, pigs, goats, and cattle is common for many households and some commercial operations on Saipan, proper management of nitrogen-containing animal feces is warranted.

Domestic sewage typically contains a 60:40 ratio of ammonium (NH_4) to organic nitrogen (Metcalf & Eddy, 2003). Septic tanks can produce effluent with a concentration ranging upwards of 55 mg/L of ammonium and under 1 mg/L as nitrate (Quenga-Macdonald, 2002). Although no MCL exists for ammonium under the Safe Drinking Water Act regulations, it can be converted to nitrite and nitrate through the microbial metabolic process of nitrification. In the unsewered areas in Saipan, many homes rely on septic tanks with leach fields, dug latrines, or outhouses (DEQ, 2010). There are also large tracts of agricultural land that may also be contributing nitrogen sources to the groundwater through the use of natural or synthetic fertilizers.

Historical Presence of Nitrate in Saipan's Groundwater

CUC monitors for nitrate at more than 50 well sites throughout the distribution system. According to DEQ's "Project Synopsis Report" (DEQ, 2009), in June 2006 one water sample from the CUC southern water distribution system exceeded the nitrate MCL. While this was the first exceedance since monitoring began in 2001, one additional violation was noted in December 2006 and eight more in June 2007, with levels as high as 14 mg/L at well IF-20 (DEQ, 2009). At this time CUC was required to notify its customers of nitrate contamination and the risks from consuming the contaminated water.

Sampling of drinking water wells continued in the Lao Lao Bay, Kagman, San Vicente, Dan Dan, and Isley Field areas through 2011 for nitrate analysis. The San Vicente and Dan Dan wells did not have any nitrate concentrations exceed the MCL. One well in the Kagman area had a nitrate concentration of 11 mg/L, and several wells in the Isley Well Field exceeded the MCL. These data are presented in further detail in subsequent sections.

It is important to note that, since the earlier distribution system nitrate violations, CUC has implemented a well isolation program. The purpose of this program is to remove wells as direct feeds into the distribution system and blend all water from the wells into reservoirs and disinfect it prior to introducing the blended groundwater into the distribution system. The result of the program has been the elimination of all nitrate violations in the distribution system.

Saipan Wastewater Collection and Treatment

Several areas on Saipan have homes that are not connected to the sanitary sewers. The households in these areas utilize septic systems, seepage pits, pit latrines, or cesspits for their wastewater treatment and disposal. Cesspools have not been sanctioned since the early 1980s, although some homeowners are documented as still utilizing cesspools. Some households also utilize seepage pits. Though seepage pits are allowed under current DEQ regulations, they are discouraged due to concerns that they may result in greater contamination to groundwater and because at certain sizes they are classified as underground injection wells (USEPA, 2001a).

In some of the Saipan's villages where septic systems are commonly found, there is newly installed collection system infrastructure available for customers to connect to CUC's sewers. The new sewers in these formerly unsewered areas are currently underutilized. Residents are reluctant to connect to the CUC sewers because of the sewer fees associated with being connected to the sewer, as well as the high costs associated with the work to complete the connection. The average cost to connect a residence currently on a septic system to the CUC sewers is $2,500; this is a significant expense to the average CUC customer, especially in light of the current economic conditions on the island. Currently the homeowners are required to pay for connection to the sewers, though there is a possibility that these connections could be paid for through a State Revolving Fund (SRF) project. The ability to use grant funding to cover the capital costs does not resolve the concern of customers being able to pay the monthly sewer usage fees.

The CNMI regulations, as set forth by DEQ, provide guidance for design and construction of IWDSs and onsite wastewater treatment systems (OWTSs). The regulations provide minimum set-back distances for placement of septic tanks with respect to water sources, such as wells. This regulation has not always been enforced historically, and there are several wells throughout Saipan, notably in Kagman, where wells are installed closer to septic systems than the regulations allow. Both CUC and DEQ require households to tie into a sewer if the point of connection is within 200 feet of the sewer (Northern Mariana Islands Administrative Code, 2004), although this has not been strictly enforced for the reasons already stated. For previously unsewered areas with new sewer lines, households that are currently on septic systems must be connected to the sewer system within 3 years of a sewer being available. Though it is within CUC's authority to require connection to the sewers, CUC has not actively begun to mandate this regulation yet. Regulating such a policy would require significant manpower from CUC's wastewater department. In the future, as capital improvement projects are identified for previously unsewered areas CUC may consider including funding the cost of connecting to the sewers as part of relevant projects. This should only be considered if the projects are grant funded so the existing CUC sewer customers are not paying for new customers to be connected.

Previous Studies Related to Unsewered Areas and Nitrates

Several studies and reports have been completed since 2005 related to the unsewered areas and their potential effects on area groundwater. The information from these studies is referenced throughout this section and is used to support future recommendations. A brief summary of each of these previous studies is provided below.

Value Engineering Study for Kagman Wastewater Treatment and Collection System

A Value Engineering (VE) Study was conducted by EarthTech (2005) to compare the recommended wastewater collection and treatment system for Kagman (as recommended by U.S. Army Corps of Engineers and SSFM International) and two other alternatives (as identified by EarthTech), with the goal of finding an effective and affordable solution to the perceived wastewater treatment and disposal concerns in the Kagman Subdivision. Cost estimates for construction and operations and maintenance (O&M) were developed for each of the alternatives. Based on the present value costs, the following is the final recommendation from the VE Study:

- Conventional gravity wastewater collection system
- Pond/wetland system, if land requirements can be met
- Reuse by irrigation of the nearby Lao Lao Golf Course and disposal of excess effluent (during the rainy season) via ocean outfall

Summary of Onsite Sewage Disposal System Survey for Kagman and Dan Dan

In 2010, DEQ performed a survey of the Kagman and Dan Dan homesteads to document the number of developed lots and the type of wastewater disposal being used on those lots. A total of 2,486 lots were surveyed: 649 lots in Dan Dan and 1,837 lots in Kagman. The majority of developed lots in both homesteads use an IWDS for wastewater disposal, with a small number of lots using pit latrines, cesspits, or holding tanks. Thirty-six lots were identified as having no wastewater disposal and 6 lots with an unknown type of disposal. The results from this study are presented in Appendix J.

Spatial and Temporal Nitrate Variations in Groundwater from Southern Saipan Project Synopsis Report

The goal of the "Spatial and Temporal Nitrate Variations in Groundwater from Southern Saipan Project Synopsis Report" conducted by DEQ and CUC (2009) was to provide regulatory guidance to CUC on monitoring frequency for nitrate concentration in southern Saipan's aquifers. Prior to this study, it was observed that the nitrate concentrations in the groundwater at the southern end of Saipan fluctuate rapidly and appear to be dependent upon rainfall. This report summarized the findings of the research performed jointly by DEQ and CUC to investigate the potential relationship between rainfall and nitrate concentration in southern Saipan's groundwater.

The methodologies included collection and analysis of weekly samples from 20 wells in southern Saipan over a 1-year period (April 2008 to April 2009). Four rain gauges were installed in southern Saipan to support the analysis. The results of the 1-year sampling program showed that the nitrate concentrations in the groundwater varied drastically across southern Saipan, from less than 1 mg/L to greater than 10 mg/L. The groundwater with the highest concentration of nitrates was found in the village of Dan Dan, a community that uses septic systems for onsite disposal of wastewater. In general, the nitrate concentrations at individual wells did not vary much over time, with one exception being Well IF-20. At the time of the Synopsis Report submission, a detailed analysis of the relationship between rainfall and nitrate concentration had not been performed, although a trial analysis was performed using the Well IF-16 nitrate data. A very strong negative correlation between nitrate concentration and the previous 30-day total rainfall was observed (i.e., as the rainfall increased the nitrate concentration decreased). The report recommended no increase in the monitoring frequency for nitrates at wells due to the highly stable nature of the nitrate concentrations.

Kagman and Dan Dan Wells Nitrate/Nitrite Data Analysis

Prior monitoring for nitrates in drinking water wells in the Kagman Homestead, Laulau Bay, San Vicente, Dan Dan, and Isley Field areas has been performed by CUC and DEQ between 2001 and 2011. These existing historical water quality data were compiled, reviewed, and presented by Allied Pacific Environmental Consulting (APEC) in the report "Kagman and Dan Dan Wells Nitrate/Nitrite Data Analysis" (APEC, 2011). DEQ commissioned this study for the purpose of ascertaining the potential need for installation of sewers to alleviate potential impacts on public health from current human activities such as farming and the use of septic systems for homes and businesses in the aforementioned areas. The APEC report is intended to aid DEQ in determining whether the septic systems are impacting the groundwater and near-shore areas.

The APEC report tabulates the nitrate data collected at various drinking water wells, illustrates the locations of the wells, and presents several recommendations for identifying the sources of potential nitrate/nitrite contamination in the study areas. The final report recommendations are summarized here:

- Regular sampling of wells, especially for wells where there has been a lack of monitoring
- Focused sampling at areas within a certain radius of wells considered "hot," i.e., with nitrate values above the current MCL.
- Study of septic discharge of homestead areas
- Groundwater Under Direct Influence (GWUDI) study
- Study of projected future impacts of increased homesteading with and without the benefit of a sewer system
- Identification of effluent sources by utilizing chloroform deoxyribonucleic acid (DNA) polymerase chain reaction (PCR) chromatography methodology and specific genetic markers for human, bovine, avian, or other DNA
- Comprehensive study of the potential impacts of septic systems on drinking water quality and stormwater discharge and impacts on the reef and other near-shore marine life

Saipan's Unsewered Areas

The majority of the sewer infrastructure in Saipan lies along the western side of the island, with very little infrastructure in the interior and on the east side. The location of CUC sewers mostly coincides with the heavily populated areas on the island, with the major exception being the Kagman area on the east side of the island. Figure 2.2.7-4 illustrates the sewered and unsewered areas on Saipan and identifies the boundaries, population, and size of villages on the island. This section discusses these unsewered areas with regard to water quality issues and the potential need for wastewater infrastructure in these areas in the future.

Kagman

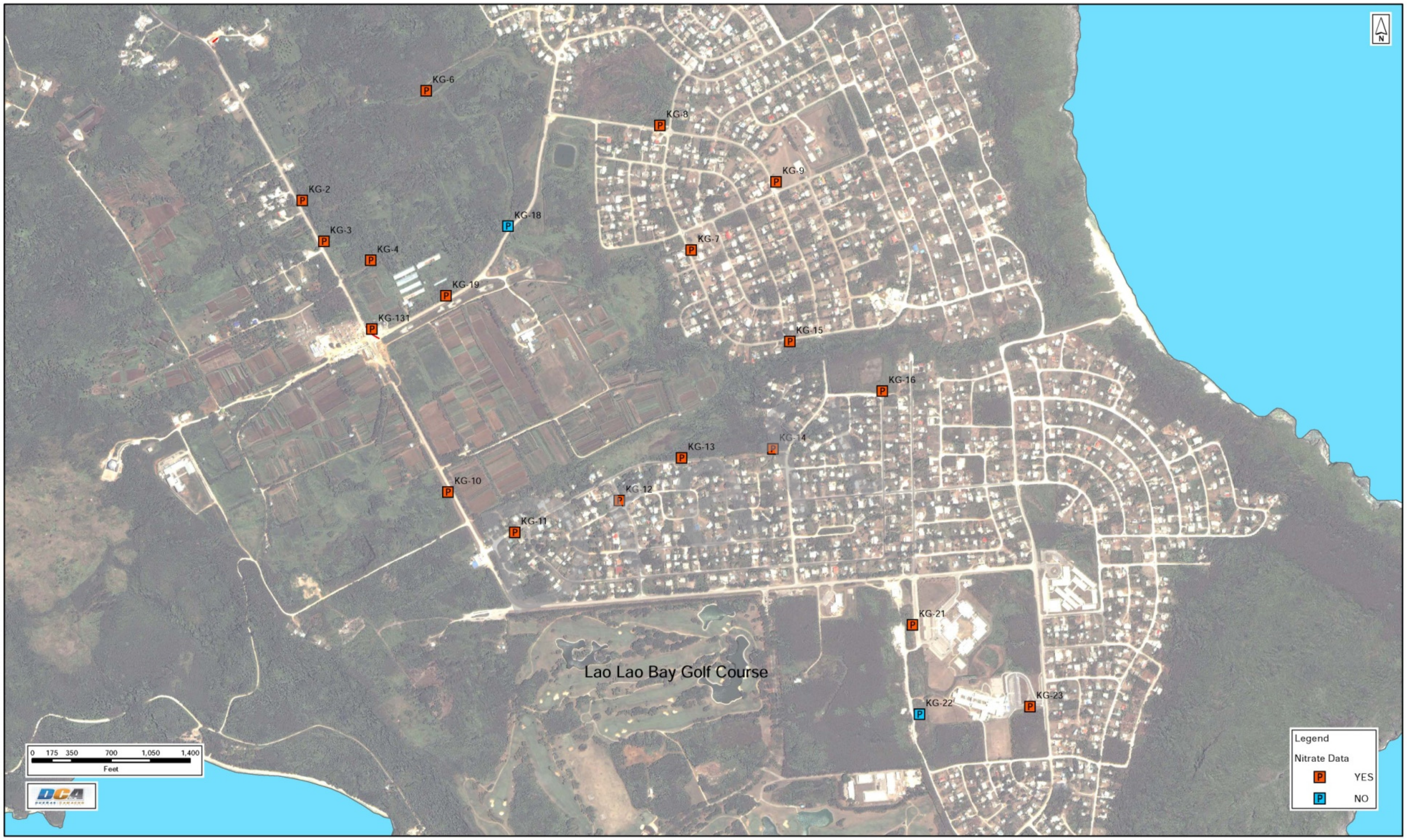
The Kagman Area is the main residential area in eastern Saipan and is the highest populated unsewered area on Saipan. The current population is estimated at approximately 4,200 people. In 2010, 1,837 lots were surveyed by DEQ as part of the onsite sewage disposal system (OSDS) survey; of these lots, 83 percent were fully or partially developed. Those lots that were partially developed are considered to be uninhabitable. Kagman has in recent years been the fastest growing area on the island, but it has come close to reaching maximum build-out with a limited number of unoccupied and habitable lots remaining.

The Kagman area overlies the Kagman aquifer, an aquifer of very good water quality. It has been estimated that the aquifer has a sustainable capacity to provide 2 mgd of potable water (EarthTech, 2005). Eighteen CUC-owned groundwater wells are in operation in the Kagman area; one well (KG-20) that is currently on loan to the National Resource Conservation Service (NRCS) is not included in this analysis. Figure 2.2.7-5 shows the locations of wells in the Kagman area. With the predominant use of septic tanks and onsite disposal at Kagman residences, there is potential for the groundwater to become contaminated in the form of elevated nitrate concentrations. Because of the large population in the unsewered Kagman area, it has been important for CUC to observe the groundwater nitrate concentrations to ensure that public health is protected.

Kagman is home to the Lao Lao Golf Course on the southern edge of Kagman, which operates private groundwater wells for irrigation purposes and may contribute to nitrate contamination associated with routine use of fertilizers for maintaining the golf course. Agricultural land use in the Kagman area also may be contributing to nitrate concentrations in the groundwater.

Figure 2.2.7-4. **Groundwater Wells in Unsewered and Sewered Areas**

Figure 2.2.7-5. **Kagman Well Field**



Water Quality Evaluation

All 18 of the drinking water wells in the Kagman well field have been sampled for nitrate at least one time. The Kagman wells are listed in Table 2.2.7-4, which also summarizes the sampling results including the number of samples analyzed and the minimum, maximum, and average nitrate concentrations. Wells KG-4, KG-21, and KG-23 have limited nitrate data for analysis; each was sampled less than five times. KG-21 and KG-23 only have one sample event because these are new wells that were placed online in 2012. Samples were collected at all of the Kagman wells during both the dry and wet seasons with the exception of wells KG-21 and KG-23. For the purpose of this analysis, the dry season is considered January through May, June is a transition month, July through November is the wet season, and December is a transition month.

Only one well in the Kagman area has had a documented nitrate concentration above the MCL; Well KG-19 exceeded the MCL with a nitrate concentration of 11 mg/L in September 2011. Ten other wells in Kagman are considered “wells of concern” because their average nitrate concentration is greater than or equal to 50 percent of the MCL (5 mg/L). Wells of concern require increased frequency of monitoring due to the increased average nitrate concentration. The maximum nitrate concentration at Wells KG-14 and KG-16, although not exceeding the MCL of 10 mg/L, are disconcerting due to the concentrations hovering just below the MCL. Of the wells of concern, four wells—KG-12, KG-13, KG-14 and KG-19—have exhibited an increase in nitrates from 2001 to 2011. All other wells have no indication that nitrate concentrations are increasing over time.
Figures 2.2.7-6 and 2.2.7-7 demonstrate the nitrate concentrations in Kagman wells over time.

Table 2.2.7-4. **Kagman Area Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
KG-2	12	1.72	2.41	2.8	No
KG-3	11	1.55	2.09	2.5	No
KG-4	4	1.4	1.78	2.2	No
KG-6	12	0.902	1.29	1.5	No
KG-7	9	5.27	5.91	6.5	No
KG-8	12	2.1	2.8	5.6	No
KG-9	11	4.8	5.28	5.6	No
KG-10	13	3.1	4.11	5.3	No
KG-11	16	4.4	5.79	7.7	No
KG-12	11	4.31	6.43	8.1	No
KG-13	14	4.17	6.61	8.6	No
KG-14	15	5.58	8.19	9.2	No
KG-15	13	4.6	5.2	6.3	No
KG-16	12	7.7	8.78	9.9	No
KG-19	11	3.67	7.88	11	Yes
KG-21	1	3.4	3.4	3.4	No
KG-23	1	8.2	8.2	8.2	No
KG-131	15	2.4	3.44	4	No

Figure 2.2.7-6. **Nitrate Concentrations in Kagman Wells of Concern**

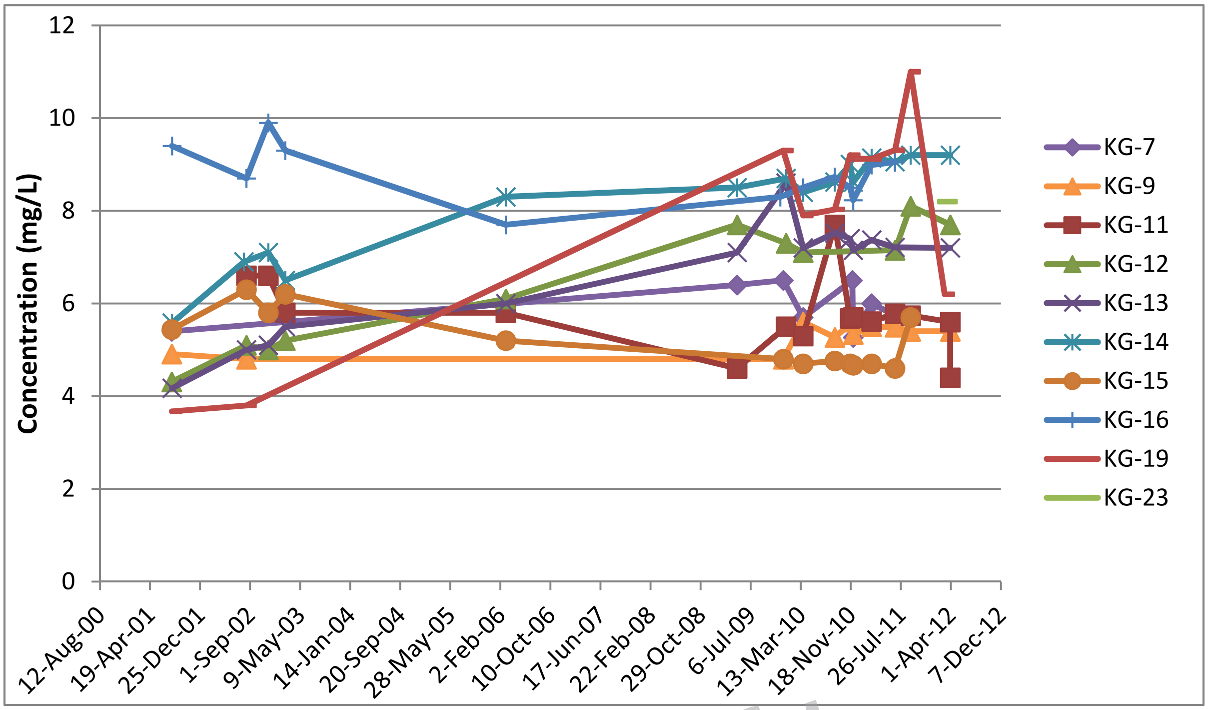
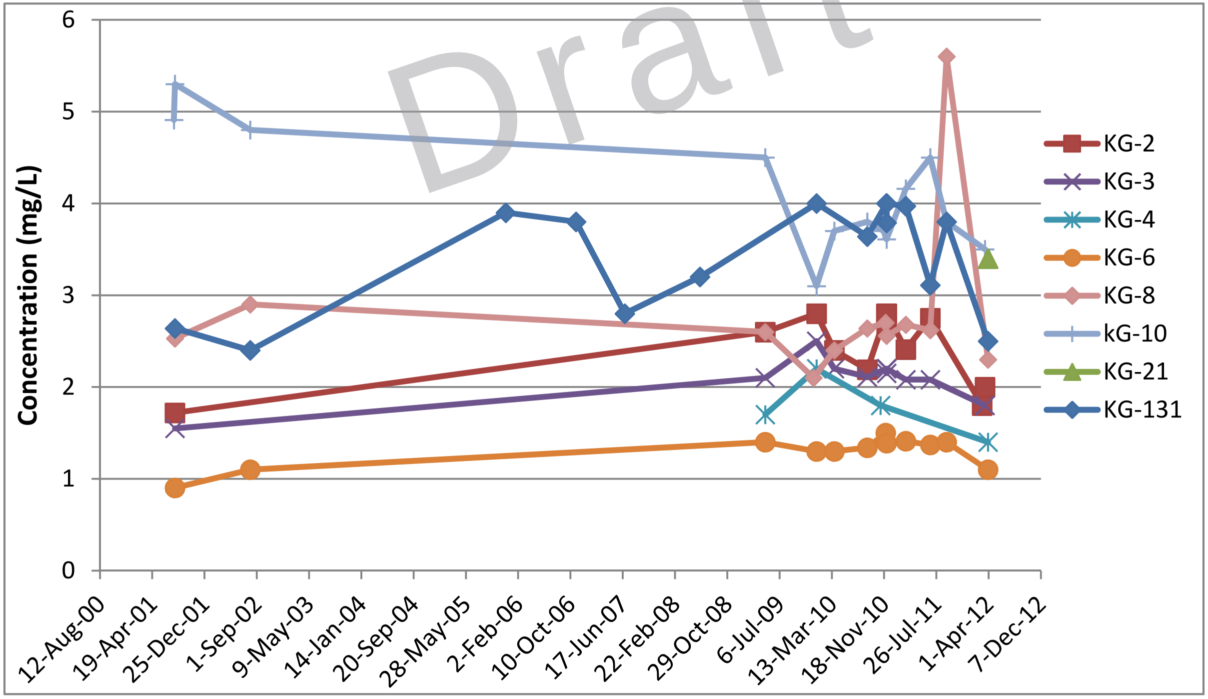


Figure 2.2.7-7. **Nitrate Concentrations in Other Kagman Wells (Not Wells of Concern)**



Recommendations for Addressing Nitrate in Kagman Groundwater

In the 10 years of well sampling, only one violation of the MCL has occurred in the Kagman area, which occurred before the well isolation program had been completed. All available data show that the blended Kagman well flow are not in continuous, or even intermittent, violation of EPA drinking water regulations. In addition, the Kagman well field is designed so that none of the wells directly feed into the distribution system, so the consumers are always provided with a blended source of water that has never had an MCL violation for nitrate.

In the future, if nitrate concentrations are observed to continuously increase near the MCL for the blended water entering the distribution system, it may become necessary to consider abandoning specific high-nitrate wells or replacing the predominant use of septic tanks with new wastewater infrastructure. Two of the three alternatives provided below for addressing nitrate in Kagman groundwater wells consider these options.

Alternative 1: No Treatment. Based on the analysis of available data, there is not enough evidence to seriously consider the cost associated with a new wastewater collection, transmission, or treatment system in Kagman. With only one documented nitrate MCL violation since sampling began in 2001, the Kagman area is currently providing drinking water that meets EPA standards. Although no additional treatment or new wastewater conveyance infrastructure is recommended in this alternative, the sampling of Kagman wells should continue at a regular frequency to monitor the nitrate levels. Sampling should occur more frequently in the Kagman wells of concern or any wells that become of concern due to an average nitrate concentration greater than or equal to 5 mg/L, in addition to the blended water entering the distribution system. A sampling plan should include a frequency of one sample per quarter for wells of concern and the blended water supply, and one sample seasonally for all other wells. If nitrate concentrations are observed to be continuously increasing at any of the Kagman wells, resulting in MCL violations, then other means may be necessary to address the water quality concerns, such as Alternative 2 or Alternative 3 discussed below. Another approach would be to shut down the wells that are exhibiting the highest nitrate concentrations to maintain a blended water quality below the nitrate MCL.

Alternative 2: New Conveyance System and Kagman WWTP. Currently there is no central wastewater treatment on the east side of the island, which is why residents in Kagman utilize septic tanks and other onsite wastewater treatment methods. The two WWTPs on island, Sadog Tasi WWTP and Agingan WWTP, are not located ideally to allow for Kagman to send its wastewater there. The jungle and hilly geography of the island makes it difficult and expensive to construct force mains between Kagman and either of the WWTPs. If treatment of sewage is eventually required in Kagman, one solution will be to build a regional WWTP in the Kagman area.

This alternative would require design and construction of a new collection system and a new WWTP, in addition to connecting individual homes and businesses to the new collection system. The placement of a new WWTP in Kagman poses several challenges; a significant concern that would need to be overcome before permitting a new Kagman WWTP is the way in which the WWTP effluent would be discharged. Most of the Kagman reef and shoreline areas are protected, and wastewater effluent could have serious impacts to the environment that would make the permitting process a challenge. The CNMI water quality standards, at present, do not allow for the granting of new zones of mixing in Class AA waters, which makes a new outfall almost impossible to permit in the Kagman area unless water quality criteria can be met end-of-pipe.

Another concern is associated with the cost and feasibility of CUC operating a third, relatively small WWTP. This would create a number of inefficiencies and staffing challenges as the pool of qualified wastewater treatment operations staff is very limited on the island.

Alternative 3: New Kagman Collection System and Transmission System to Agingan Wastewater Treatment Plant. Several hurdles are involved with the implementation of Alternative 2, including the significant cost of building a new plant and the environmental impacts associated with discharge of WWTP effluent to the protected reef area in Kagman. If treatment of sewage is eventually required, an alternative to building a new plant in Kagman would be to send Kagman's sewage to the Agingan WWTP in Southern Saipan. Agingan is one of two existing WWTPs on island. Kagman is approximately equidistant to the two existing plants, but, due to the island's topography, transmitting wastewater to the Agingan WWTP is most feasible. Designing a transmission system to deliver sewage from Kagman to Agingan WWTP is not ideal and will be challenging to design and construct due to the landscape on this part of the island.

This alternative would require designing and constructing a new collection system within the Kagman area, connecting homes and businesses to the new collection system, and designing and constructing a new pump station and force main to deliver the collected wastewater from Kagman to the upper area of San Vicente. This new force main would likely traverse the existing railroad grade between Kagman and San Vicente. An additional pump station and collection system will be needed in San Vicente. The point of discharge will be the 16-inch collection system coming from the airport though Koblerville.

San Vicente, Dan Dan, As Lito

San Vicente and Dan Dan Villages are on the east side of the Saipan, located by Laulau Bay. Portions of these villages are unsewered. As Lito, although a sewered area, has monitoring wells that have provided nitrate data and are in proximity to San Vicente Village. For comparison, the As Lito wells are included in this analysis. The population of San Vicente and Dan Dan Villages is 1,953 and 2,781, respectively.

There are three CUC wells in each of the villages; see Figure 2.2.7-8 for a map and Table 2.2.7-5 for a list of these wells. The San Vicente wells are located in unsewered areas, creating potential for contamination from nearby septic tanks used by homeowners. Similar to the Kagman area, with the exception of the Dan Dan well, none of the other wells directly feed into the distribution system. In these cases a blended supply of water is distributed to the customers.

Water Quality Evaluation

None of the wells in these areas have reported a nitrate MCL violation since sampling began in 2001, although two of the wells, DD-8 and SV-7, have an average nitrate concentration greater than 5 mg/L, so they have been identified as wells of concern. Table 2.2.7-5 provides a summary of the nitrate data available from these wells, while Figure 2.2.7-9 shows the nitrate concentrations over time at the wells. The As Lito wells (i.e., AS-1, AS-2, and AS-5) do not have a lot of data points because sampling in this area did not begin until 2009. Several wells in these areas do not have an accurate representation of nitrate data from both the dry and wet seasons; for a complete analysis, it is ideal to have a number of data points from both seasons. Wells DD-7, SV-1, and SV-2 do not have any nitrate data for the dry season, while wells DD-3, AS-2, and AS-5 have no data for the wet season.

Addressing Nitrate in San Vicente, Dan Dan, and As Lito Groundwater

Historically, no nitrate MCL violations have been reported in these areas, so no action is needed at the present time. Continued sampling is recommended as it was for the Kagman well field; the wells of concern and blended water supply should be sampled quarterly while all other wells are sampled on a seasonal basis to ensure a good dataset including seasonal data is collected. As samples are collected and analyzed, one particular trend to look for is a steady increase in nitrate concentrations at any well.

Figure 2.2.7-8. **As Lito-Dan Dan-San Vicente Well Fields**

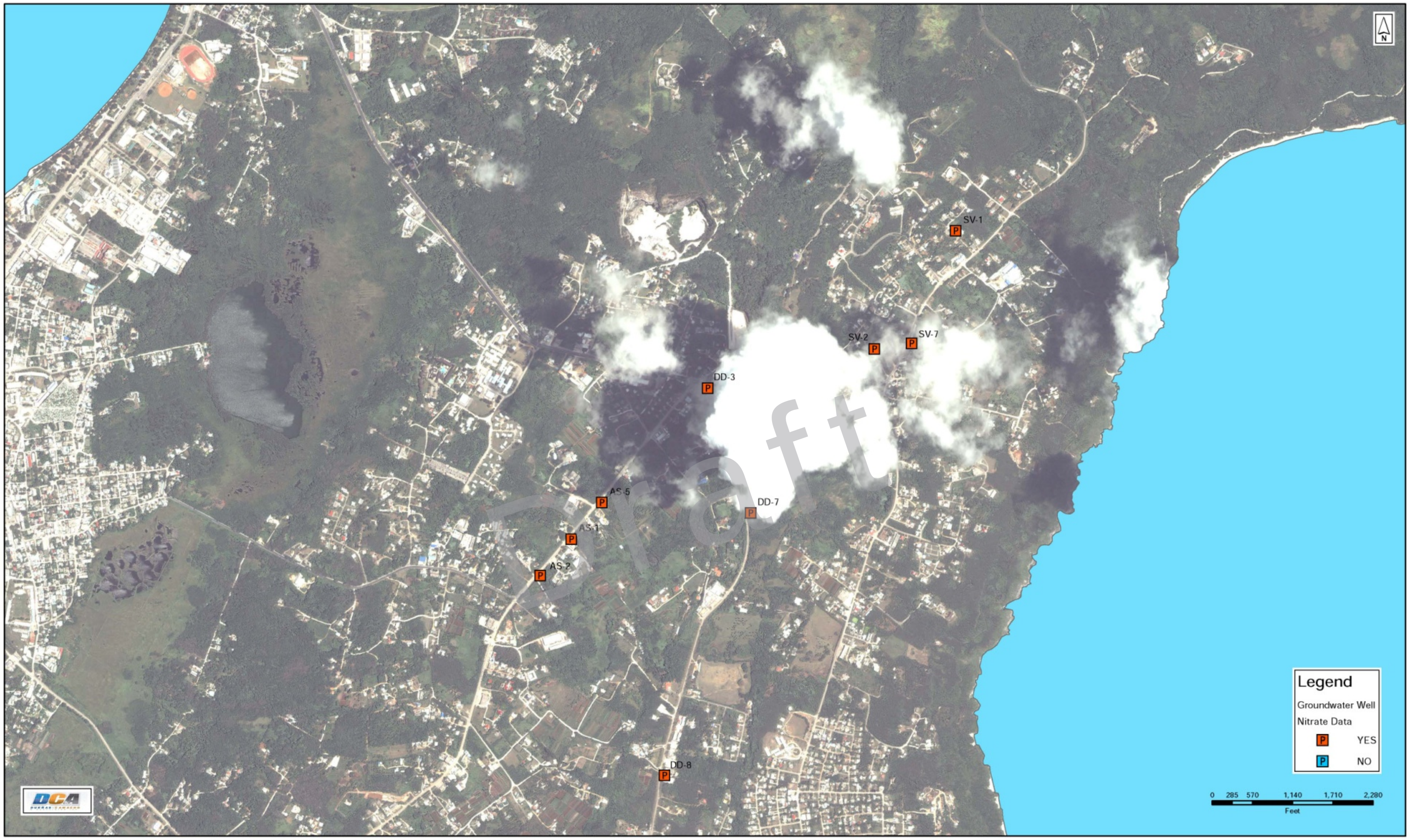
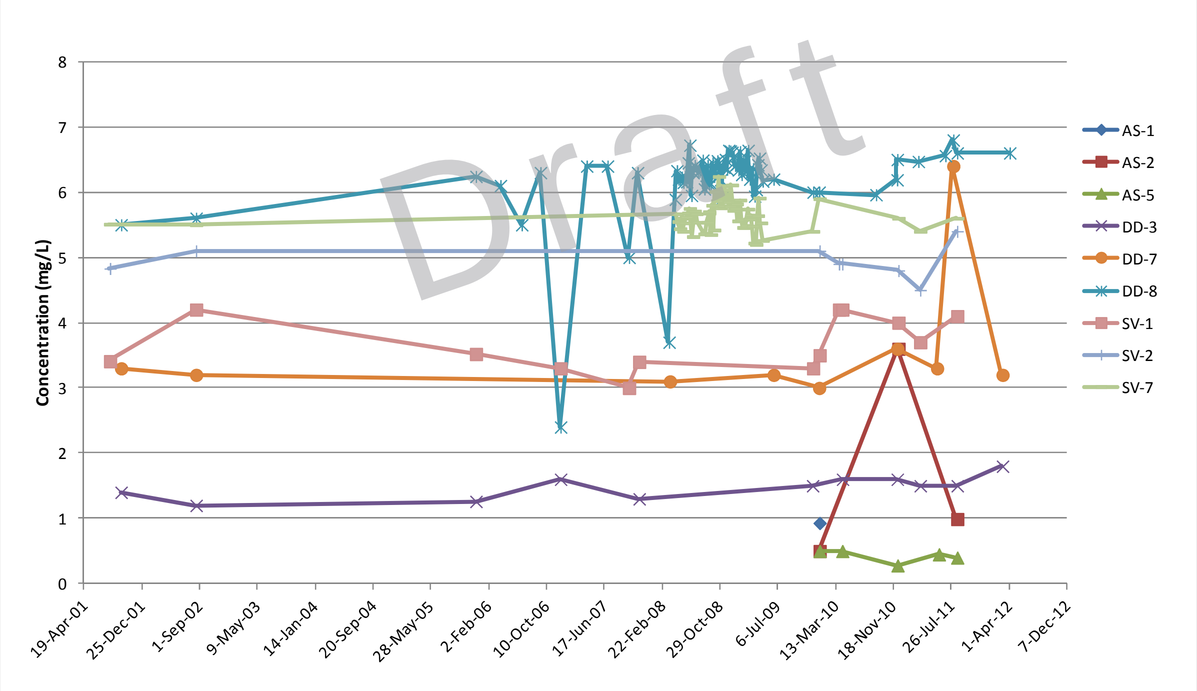


Table 2.2.7-5. **San Vicente and Dan Dan Area Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
DD-3	11	1.2	1.48	1.8	No
DD-7	9	3	3.59	6.4	No
DD-8	78	2.4	6.19	6.8	No
SV-1	13	3	3.68	4.2	No
SV-2	8	4.5	4.94	5.4	No
SV-7	57	5.2	5.63	6.24	No
AS-1	4	0.93	2.83	3.6	No
AS-2	3	0.5	1.7	3.6	No
AS-5	5	0.28	0.43	0.5	No

Figure 2.2.7-9. **Nitrate Concentrations in San Vicente, Dan Dan, and As Lito Wells**



Isley

The Isley well field is one of Saipan's larger well fields, with 32 wells located in the area. Isley is in the southern part of the island, is not sewered, and does not have a populated homestead in the area. Similar to the other well fields, the wells do not directly feed into the distribution system and are blended prior to distribution to the customers. Although there are no residents in the Isley area, the Dan Dan Village and As Lito Village border the Isley well field; these villages are populated and Dan Dan Village is not sewered. Figure 2.2.7-10 shows the locations of the groundwater wells in Isley and how close the populated village of Dan Dan (to the north) is to some of the wells. Isley Well IF-208 is on airport property and has been abandoned, thus it is not included in this analysis.

Water Quality Evaluation
Table 2.2.7-6 summarizes the nitrate data analysis for the Isley wells. Of the 32 drinking water wells in the Isley well field, 23 have a maximum nitrate concentration greater than or equal to 5 mg/L and have been identified as wells of concern. Five wells have had one or more MCL violations in the past, as identified in Table 2.2.7-6. Additionally, five wells had at least one nitrate data point that came very close to the MCL of 10 mg/L (IF-6, IF-7, IF-105, IF-202, and IF-203).

The following wells had limited nitrate data available (i.e., less than 5 samples) for analysis: IF-203, IF-204, IF-22, IF-25, and IF-26. These same wells had incomplete seasonal data available for the analysis (i.e., no nitrate data were available for either season).

As seen in Figure 2.2.7-11, most of the wells of concern have exhibited a slow increase in nitrate concentrations over time. In Figure 2.2.7-12, which shows the nitrate concentrations over time for all other wells (not of concern), the nitrate concentrations are observed to slowly decrease over time in all of the wells except for IF-21.

Recommendations for Addressing Nitrate in Isley Well Field Groundwater
This area has had many wells where the MCL has been exceeded and is also showing an increasing trend in nitrate concentrations over time. Septic tanks are not located in this well field as there are no homesteads, so the source of nitrate contamination cannot be attributed to the fact that Isley is an unsewered area. Additional research is needed to understand the cause of this increase.

Based on the USGS groundwater map (Appendix K) and a review the sample results from the Isley well field, there appear to be impacts from the surrounding Dan Dan Homestead and Dagu area. The groundwater flow lines presented on the USGS map indicate that groundwater from the Dagu area flows toward the Isley well field. The wells along the northern rim of the Isley well field (IF-211, IF-105, IF-4, IF-7, IF-106, IF-6, IF-205, and IF-5) and in the path of the Dagu flow stream all see high nitrate concentrations. The wells along the eastern rim of the Isley well field also see elevated levels of nitrate. This eastern rim abuts the densely populated Dan Dan homestead. It should be noted that the wells along the southern area of the Isley well field are generally below 5 mg/L. Also noteworthy is the cone of depression within the Isley well field.

Recommendations to address the nitrate concentrations in the Isley wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the frequency for wells of concern (see sampling plan recommendations for the Kagman area).
- Conduct a detailed groundwater study of the Isley Well Field.
- Based on the results of the groundwater study, consider elevating the priority for installation of a gravity collection system within the Dan Dan Homestead.
- Connect homes and businesses along Tun Herman Pan Road (Dagu area) that are not presently connected to the sewer system.
- Once feasible, reduce production within the Isley well field, particularly from the northern and eastern rim wells that have the highest levels of nitrate.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.

If the blended water supply starts to reach the MCL level for nitrate, CUC will need to consider additional treatment to continue use of the well field.

Figure 2.2.7-10. **Isley Well Field**

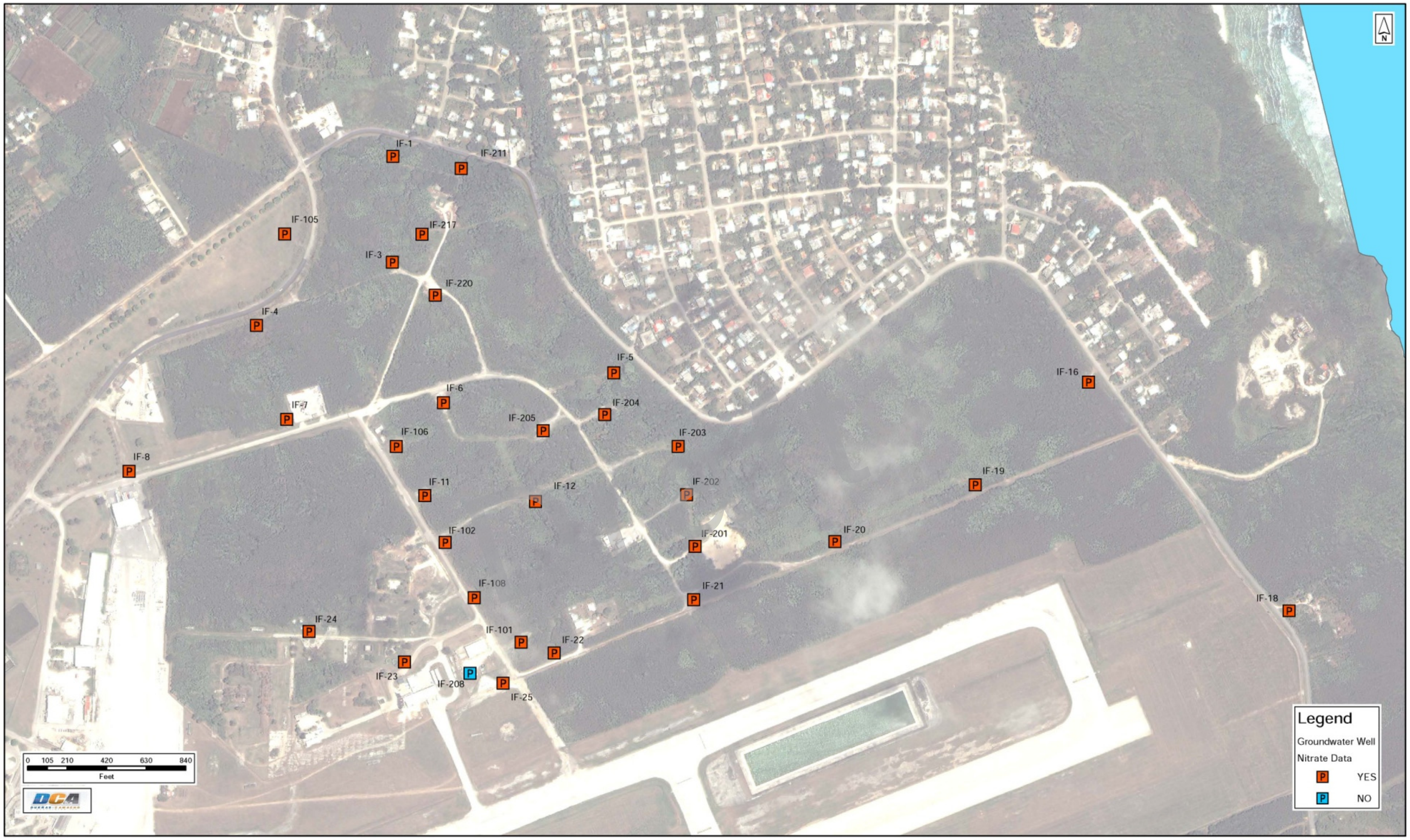


Table 2.2.7-6. **Isley Field Area Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
IF-1	54	6.6	7.23	7.64	No
IF-101	6	2.5	4.76	5.54	No
IF-102	7	4.3	5.78	6.17	No
IF-105	65	6.9	8.9	9.87	No
IF-106	65	4.9	8.55	10.1	Yes
IF-108	9	4.2	4.83	5.3	No
IF-11	9	3.3	5.06	6	No
IF-12	8	4.9	6.88	7.44	No
IF-16	64	4.5	6.06	6.9	No
IF-18	59	0.549	0.79	5.1	No
IF-19	8	4.5	6.63	7.2	No
IF-20	48	5.9	9.88	14	Yes (23 violations)
IF-201	7	3.1	6.83	8.7	No
IF-202	9	3.3	7.72	9.02	No
IF-203	2	9.62	9.65	9.68	No
IF-204	2	4.6	5.66	6.71	No
IF-205	55	4.2	6.62	10.7	Yes
IF-21	8	2.9	4.78	6.8	No
IF-211	63	5.8	7.8	8.55	No
IF-217	11	5.8	6.57	6.92	No
IF-22	1	3.2	3.2	3.2	No
IF-220	11	5.4	6.93	7.6	No
IF-23	7	3.8	4.35	5.4	No
IF-24	9	3.78	4.13	4.4	No
IF-25	4	1.5	2.28	3.3	No
IF-28	6	2.5	2.85	3.2	No
IF-3	10	5.6	6.36	6.8	No
IF-4	55	6.9	9.12	11	Yes (2 violations)
IF-5	60	9.79	10.59	11.7	Yes (58 violations)
IF-6	11	4.81	7.66	9.1	No
IF-7	8	4.7	8.67	9.7	No
IF-8	10	2.1	3.14	4.47	No

Figure 2.2.7-11. **Nitrate Concentrations in Isley Field Wells of Concern**

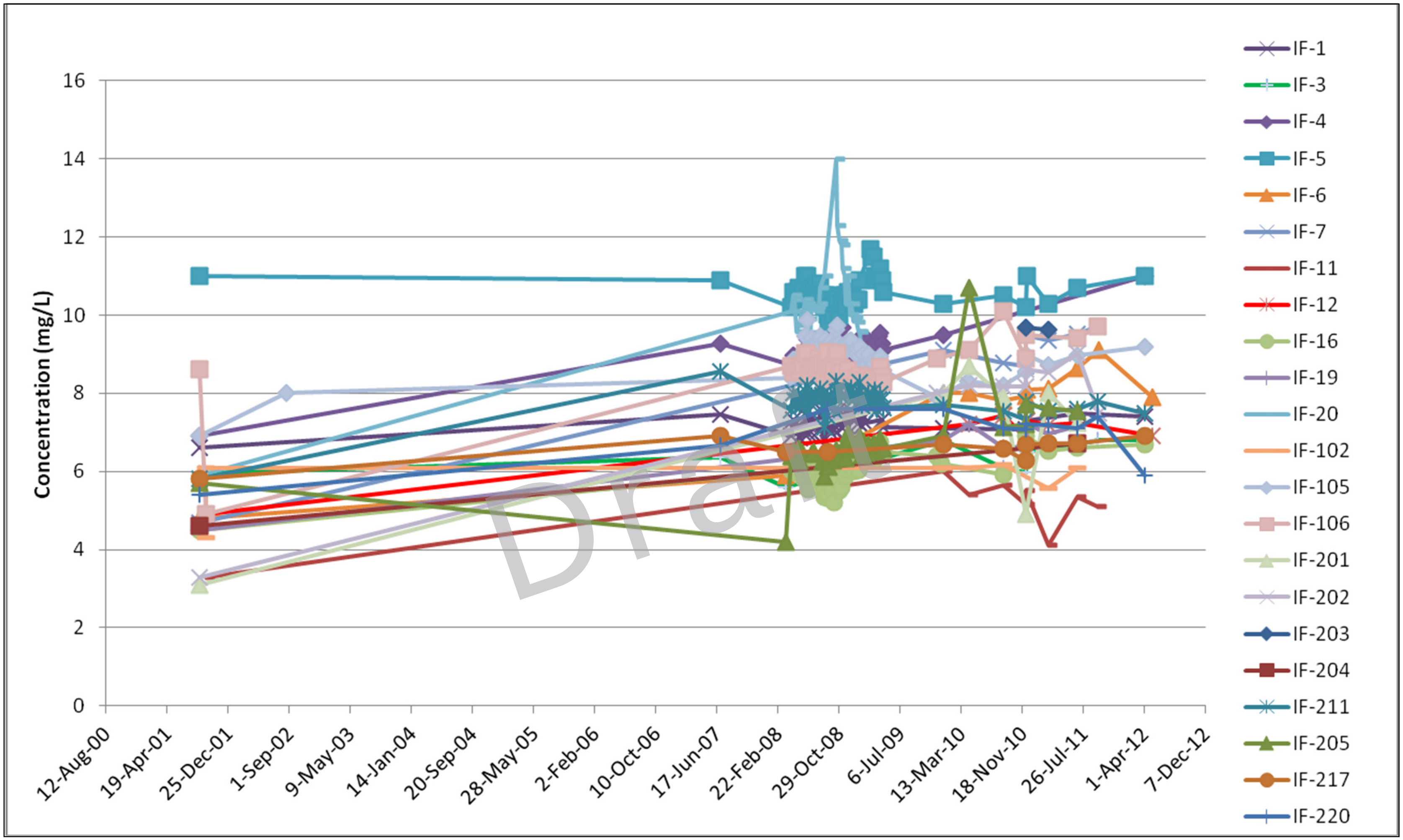
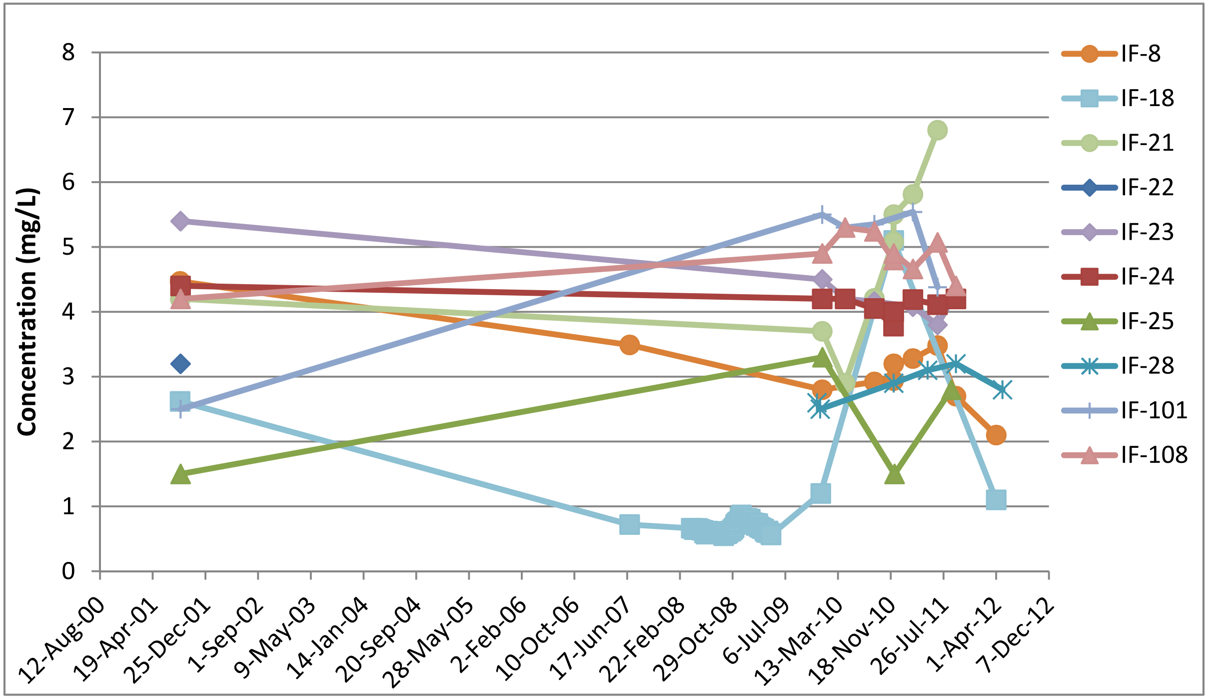


Figure 2.2.7-12. **Nitrate Concentrations in Isley Field Other Wells (Not of Concern)**



Obyan Well Field

The Obyan well field is located in an unsewered area in the southern part of Saipan, just south of the Isley well field and in proximity of the airport. No homestead is within the boundaries of the well field. The Obyan Village, an unsewered area with a very small population of approximately twenty people, is the closest residential area to the well field where septic tanks may be in use. Twenty-four groundwater wells in the Obyan well field owned and operated by CUC to provide drinking water. Similar to the other well fields, the wells do not directly feed into the distribution system and are blended prior to distribution to the customers. Figure 2.2.7-13 illustrates the location of these wells within the well field; the airport can be seen to the north of the wells.

Water Quality Evaluation

The Obyan wells have had no recorded sampling events where the nitrate MCL has been exceeded since the beginning of sampling in 2001. The well nitrate analysis summary provided in Table 2.2.7-7 indicates that, although there have been no MCL violations, several of the wells do have an average concentration equal to or greater than 5 mg/L. These wells of concern are OB-4, OB-14, OB-15, OB-18, OB-19, OB-20, OB-21, OB-22, OB-23, and OB-24. Though none of the wells violated the MCL, Wells OB-22 and OB-23 do have a maximum nitrate concentration very close to 10 mg/L.

The following wells had a limited nitrate data set (i.e., less than five samples): OB-20, OB-21, OB-10, OB-11, OB-18, OB-19, OB-4, and OB-8. Wells OB-18 and OB-19 had incomplete seasonal data available for the analysis (i.e., nitrate data were available only during the transition months).

As seen in Figures 2.2.7-14 and 2.2.7-15, some Obyan wells have experienced a steady increase in nitrate concentrations over time; these wells include OB-16 and OB-7 (not wells of concern) and all of the wells of concern excluding Wells OB-20, OB-4 and OB-14.

Figure 2.2.7-13. **Obyan Well Field**

Table 2.2.7-7**. Obyan Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
OB-20	4	5.8	6.3	6.5	No
OB-21	4	5.2	5.58	6.1	No
OB-1	6	0	2.38	3.04	No
OB-10	4	0.7	0.81	0.991	No
OB-11	4	2.7	3.49	5.56	No
OB-12	5	3	3.77	4.67	No
OB-13	5	3.29	3.72	4.7	No
OB-14	61	3.4	7.03	8.3	No
OB-15	8	4	6.88	8.1	No
OB-16	6	1.5	4.23	7	No
OB-17	5	4.1	4.28	4.5	No
OB-18	4	2.1	5.08	6.2	No
OB-19	4	3.7	6.25	8	No
OB-2	7	1.1	1.62	2.64	No
OB-22	5	0.4	6.44	9.3	No
OB-23	5	4	7.44	9.4	No
OB-24	5	4	5.66	6.4	No
OB-3	62	1.33	3.46	3.87	No
OB-4	4	4	5.75	7.1	No
OB-5	5	1.7	2.23	3.86	No
OB-6	5	1.1	1.35	2.17	No
OB-7	5	0.6	1.7	5.5	No
OB-8	4	0.8	2.1	5	No
OB-9	51	1.2	1.32	1.9	No

Figure 2.2.7-14. **Nitrate Concentrations in Obyan Wells of Concern**

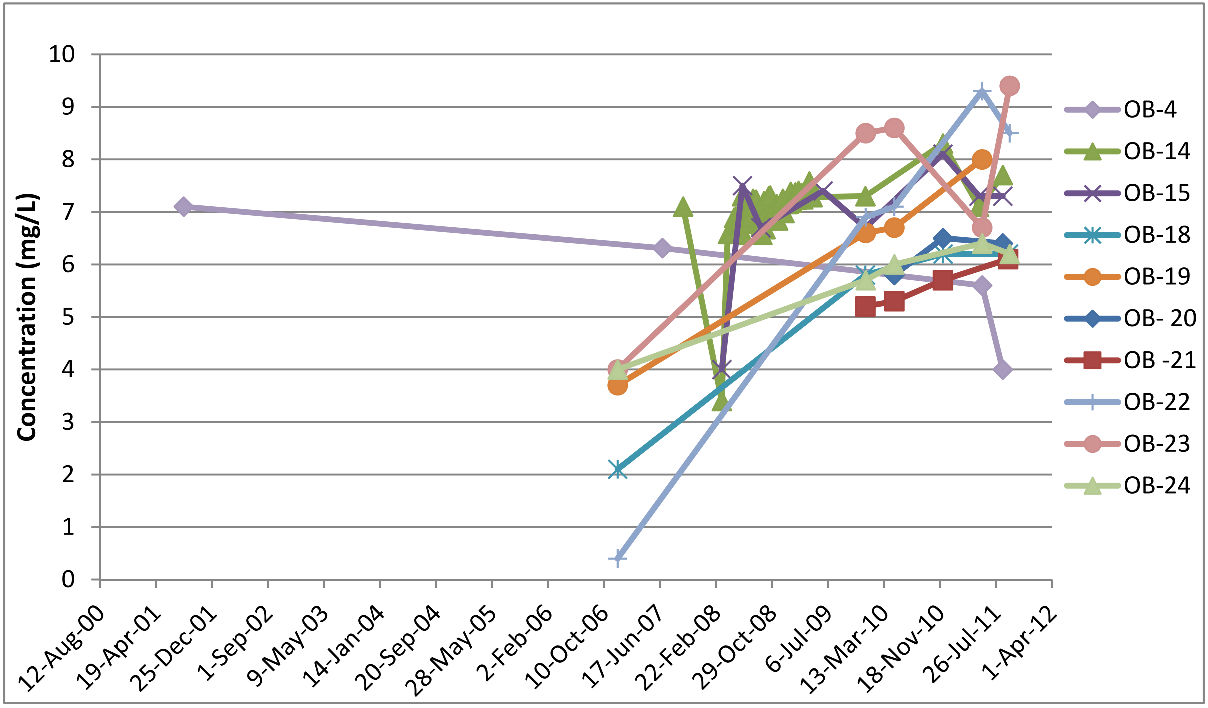
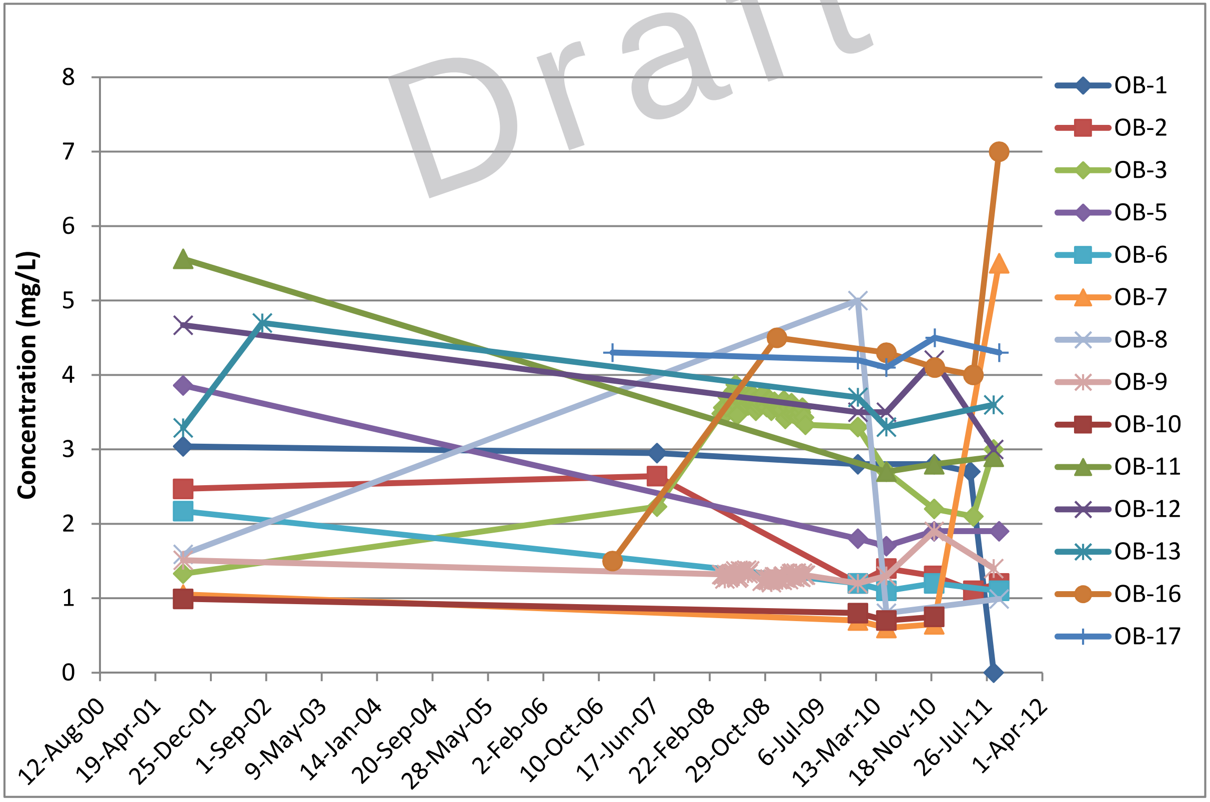


Figure 2.2.7-15. **Nitrate Concentrations in Obyan Other Wells (Not of Concern)**



Recommendations for Addressing Nitrate in Obyan Well Field Groundwater

This area has had no wells with MCL violations, but many wells are of concern due to their elevated average nitrate concentration. Some wells are also showing an increasing trend in nitrate concentrations over time. Similar to Isley well field, septic tanks are not located in this well field because there are no homesteads, so the source of nitrate contamination cannot be attributed to Obyan being an unsewered area. Additional research is needed to understand the cause of this increase in nitrates over time.

Recommendations to address the nitrate concentrations in the Obyan wells are the same as those for the Isley well field:

- Continue sampling at all wells, increasing frequency for wells of concern and blended water.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.

Koblerville Well Field

Koblerville is a small, partially sewered homestead village with a population of 1,510. Tottotville is a fully sewered subdivision. The area just north of Tottotville village is an unsewered area (population 32) located within close proximity to the Koblerville wells and is considered to be part of the "Koblerville Unsewered Area" for purposes of this study. The Koblerville wells lie to the west of the Isley well field and northwest of the Obyan well field. The area in Koblerville Village where CUC has groundwater wells is unsewered. Ten wells in this area, the locations of which are displayed in Figure 2.2.7-16. Similar to the other well fields, the wells do not directly feed into the distribution system and are blended prior to distribution to the customers.

Water Quality Evaluation

Koblerville well nitrate data are summarized in Table 2.2.7-8. One well, KV-9, did exceed the nitrate MCL in 2001, the only MCL exceedance recorded in the Koblerville well area. One other well, KV-16, has a maximum nitrate concentration of 9.7, which is very close to the MCL for nitrate. Four of the wells in this area—KV-15, KV-16, KV-17, KV-111, and Maui I—are classified as wells of concern as a result of their average nitrate concentration. The wells in Koblerville had a lot of historical data available to use as part of the analysis, only well KV-11 had fewer than five samples taken. All wells had seasonal data adequately represented in the data set.

The change in nitrate concentrations over the sampling period, from 2001 to 2012, is shown in Figures 2.2.7-17 and 2.2.7-18 for the wells of concern and all other wells, respectively. As seen in these figures, the nitrate concentrations are not exhibiting an increasing trend over time; in some cases, the concentrations have decreased over the sampling period.

Figure 2.2.7-16**. Koblerville Wll eField**

Table 2.2.7-8. **Koblerville Area Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
KV-11	3	3.72	4.87	6.2	No
KV-111	6	6.2	7.1	8.1	No
KV-116	61	2.3	3.9	5.1	No
KV-12	6	2.7	2.82	2.9	No
KV-13	55	3.2	3.67	4.1	No
KV-15	5	5.44	6.55	7.5	No
KV-16	5	4.5	6.8	9.7	No
KV-17	6	3.8	5.15	7.9	No
KV-9	53	3.1	4.48	12	Yes
MAUI 1	6	4.7	5.63	6.4	No

Figure 2.2.7-17. **Nitrate Concentrations in Koblerville Area Wells of Concern**

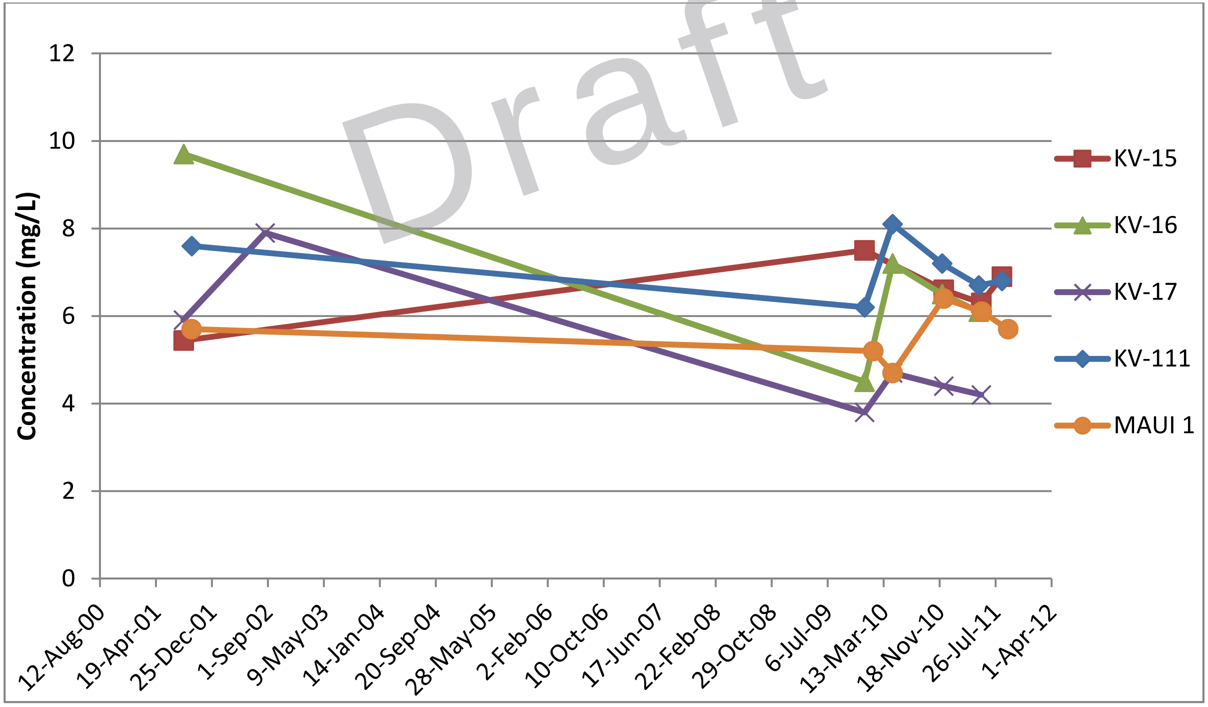
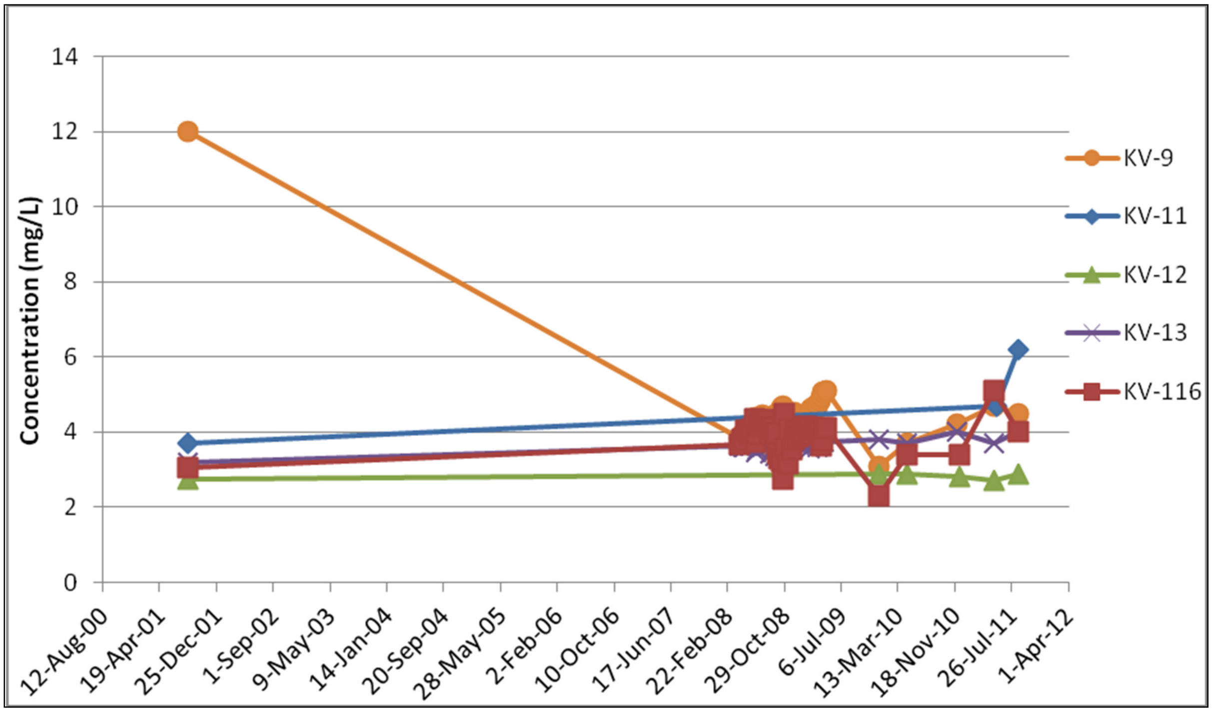


Figure 2.2.7-18. **Nitrate Concentrations in Koblerville Area Other Wells (Not of Concern)**



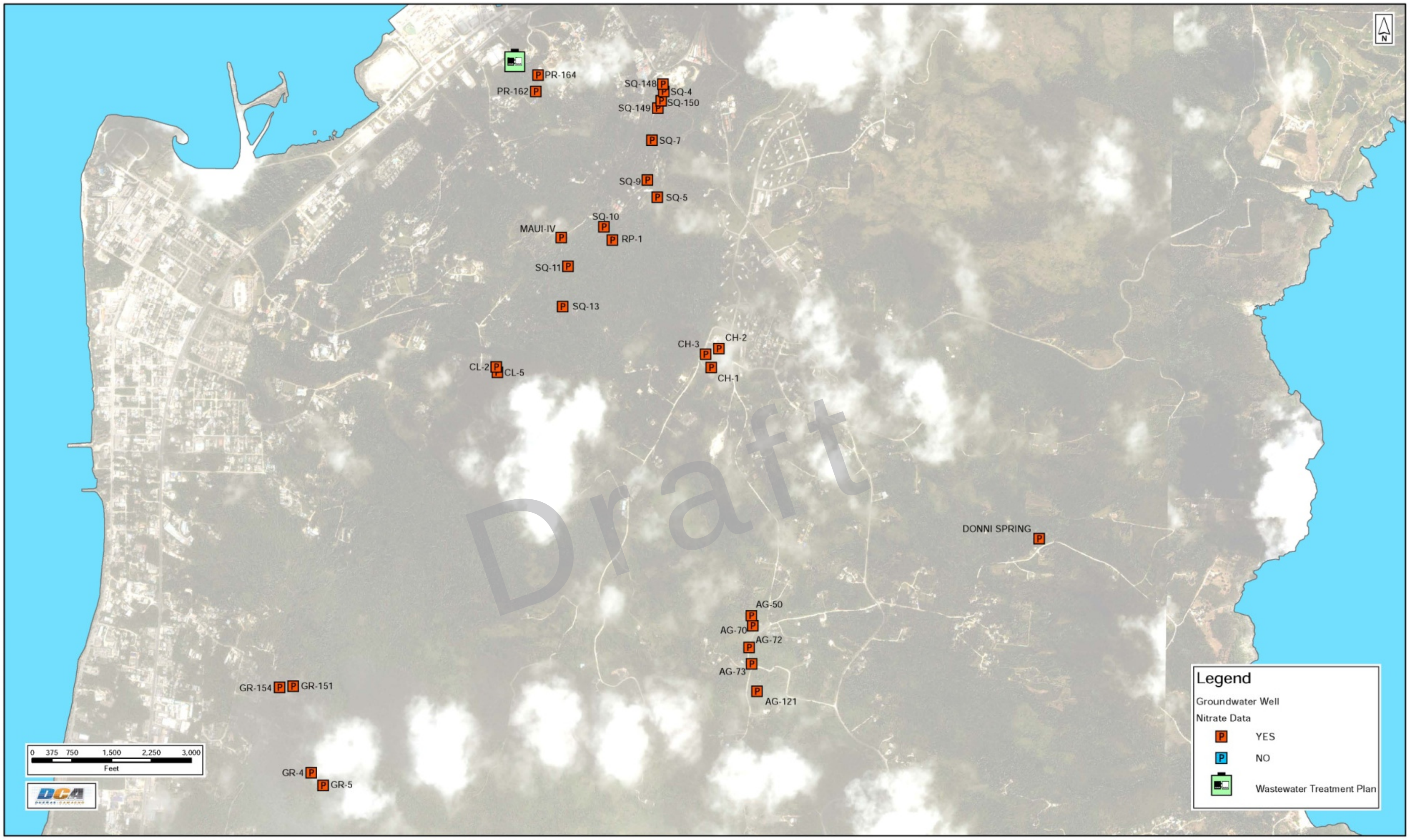
Recommendations for Addressing Nitrate in Koblerville Wells Groundwater

This area had only one sampling event where the MCL was exceeded in 2001, but several wells are of concern due to their elevated average nitrate concentration. Some wells are also showing an increasing trend in nitrate concentrations over time. Nitrate concentrations in the groundwater at Koblerville wells, based on the available data, is not a current concern. For this reason, the only further action recommended for Koblerville is to continue sampling at all wells, and sampling at an increased frequency for wells of concern and the blended supply as outlined in the Kagman recommendations. As the samples are analyzed, trends in nitrate concentrations at each well should be reviewed to determine whether nitrate concentrations are increasing over time.

Central Well Fields

Several smaller, isolated well fields are located in the central part of Saipan. Most of the wells in this area are in areas where there are currently no sewers. The villages of Agag, As Teo, Tapochau, Capitol Hill, Chalan Galaide, As Rabagau, and Gualo Rai all have wells located within their unsewered areas. A total of 30 CUC-owned groundwater wells are located in the central well fields. Although these villages are populated, the drinking water wells are generally not located close to the highly populated residential areas, as seen in Figure 2.2.7-19. Similar to the other well fields, the wells do not directly feed into the distribution system and are blended prior to distribution to customers.

Figure 2.2.7-19. **Central Well Fields**



Water Quality Evaluation

The nitrate data analysis for these 30 wells is summarized in Table 2.2.7-9. These well fields have not exceeded the nitrate MCL, and no wells have an average nitrate concentration greater than 5 mg/L. Comparatively, the wells in the central well field had fewer data available for the analysis than other well fields; in Table 2.2.7-9, there are 10 wells that had less than five samples taken at the well. Additionally, six of these wells had incomplete seasonal data available for the analysis (i.e., nitrate data were available only during the transition months): AG-72, AG-121, CL-5, RP-1A, SQ-9, and SQ-11. The nitrate concentrations at the central well field wells are shown over time in Figures 2.2.7-20 and 2.2.7-21.

Recommendations for Addressing Nitrate in Central Well Fields Groundwater

Because there have been no events where the MCL has been exceeded and there are no wells of concern in this area, nitrate in the groundwater is not a current concern in the central well fields. For this reason, the only further action that is recommended for this area is to continue sampling the wells annually per the EPA requirements.

Table 2.2.7-9. **Central Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
AG-121	3	0.432	1.94	2.8	No
AG-50	5	1.78	2.14	2.3	No
AG-70	6	1.2	2.11	2.4	No
AG-72	1	2.35	2.35	2.35	No
AG-73	7	2.57	2.7	2.8	No
CH-1	6	3.7	4.06	4.37	No
CH-2	6	3.69	4.19	4.4	No
CH-3	6	4	4.29	4.5	No
CL-2	5	1.8	2.02	2.3	No
CL-5	2	1.8	1.8	1.8	No
DONNI	7	2.3	3.04	4.31	No
GR-151	8	1	1.33	1.6	No
GR-154	7	0	1.39	1.9	No
GR-4	5	1.6	1.69	1.8	No
GR-5	4	1.4	1.5	1.7	No
PR-162	5	2.5	2.7	2.8	No
PR-164	4	2.5	2.6	2.7	No
RP-1 B	3	2.4	2.6	3	No
RP-1A	1	2.5	2.5	2.5	No
SQ-10	5	2.8	3.54	3.9	No

Table 2.2.7-9. **Central Wells – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
SQ-11	1	2.14	2.14	2.14	No
SQ-13	2	2.3	2.45	2.6	No
SQ-148	6	2.4	2.67	3.09	No
SQ-149	5	0.21	2.63	3.35	No
SQ-150	5	2.3	2.68	2.9	No
SQ-4	5	2.99	3.27	3.54	No
SQ-5	6	3.41	3.99	4.4	No
SQ-7	5	3.1	3.65	4	No
SQ-9	4	1.98	3.65	4.7	No
MAUI IV	8	1.57	1.96	2.8	No

Figure 2.2.7-20. **Nitrate Concentrations in Central Well Fields – Part 1**

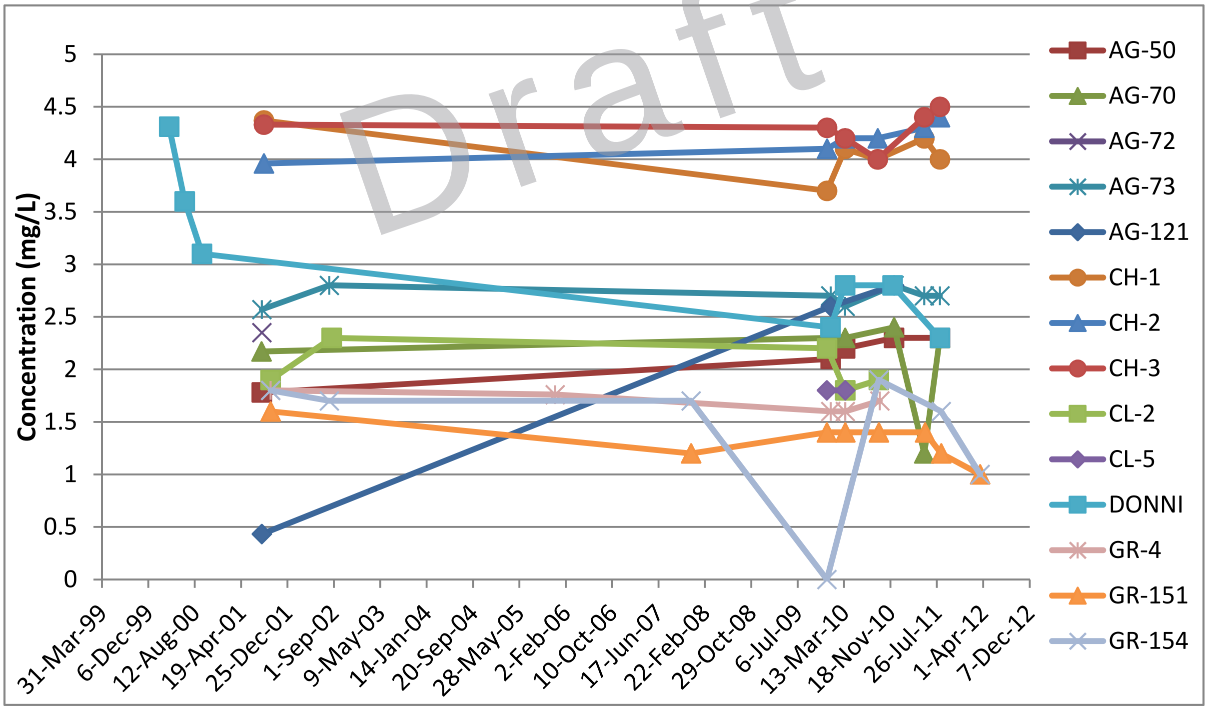
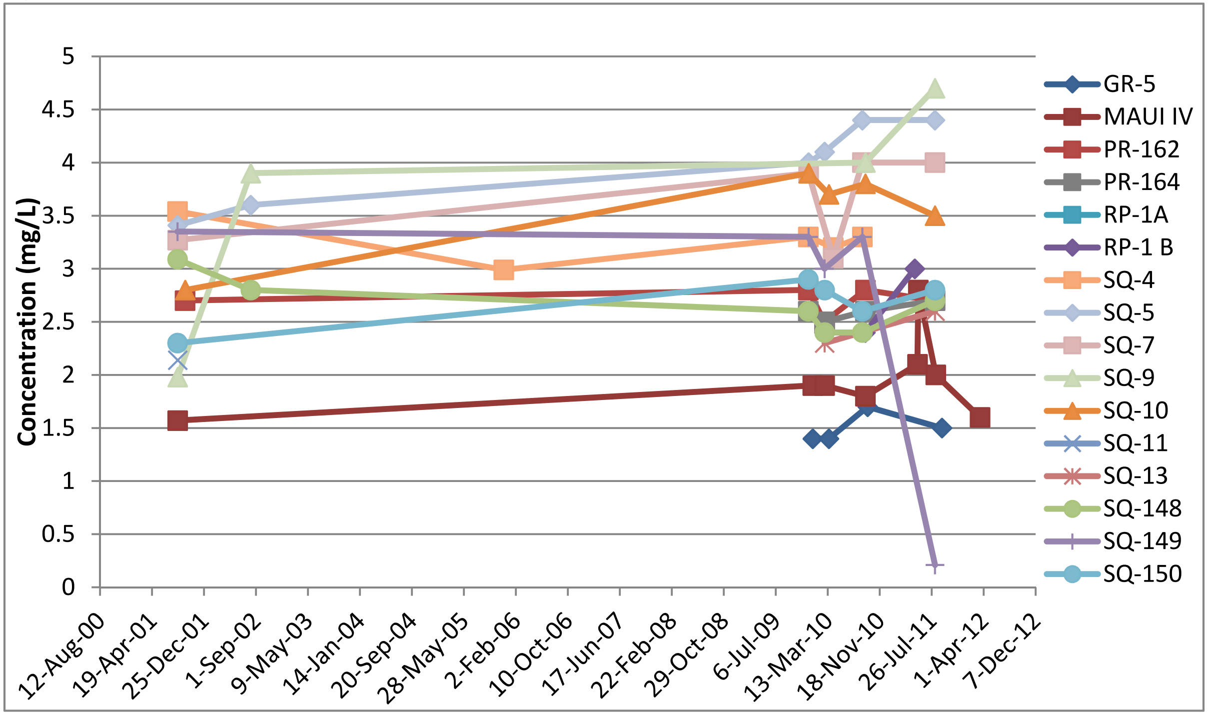


Figure 2.2.7-21. **Nitrate Concentrations in Central Well Fields – Part 2**



Northern Well Fields

Ten CUC-owned groundwater wells are located in a well field in the northern part of Saipan near Marpi Village. Although the village is populated and the drinking water wells are located in an unsewered area, the wells are generally not located close to the populated residential areas as seen in Figure 2.2.7-22. Similar to the other well fields, the wells do not directly feed into the distribution system and are blended prior to distribution to customers.

Water Quality Evaluation

The nitrate data analysis for these 10 wells is summarized in Table 2.2.7-10. These well fields have had no events where the nitrate MCL has been exceeded, and no wells have an average nitrate concentration greater than 5 mg/L. The wells in the northern well field had fewer data available for the analysis than other well fields; all but one well had fewer than 5 samples collected for nitrate analysis. Additionally, three of these wells had incomplete seasonal data available for the analysis (i.e., nitrate data were available for the transition months): MQ-1, MQ-10, and MQ-16. Figure 2.2.7-23 demonstrates the nitrate concentration in the northern wells over time.

Recommendations for Addressing Nitrate in Northern Wellfields Groundwater

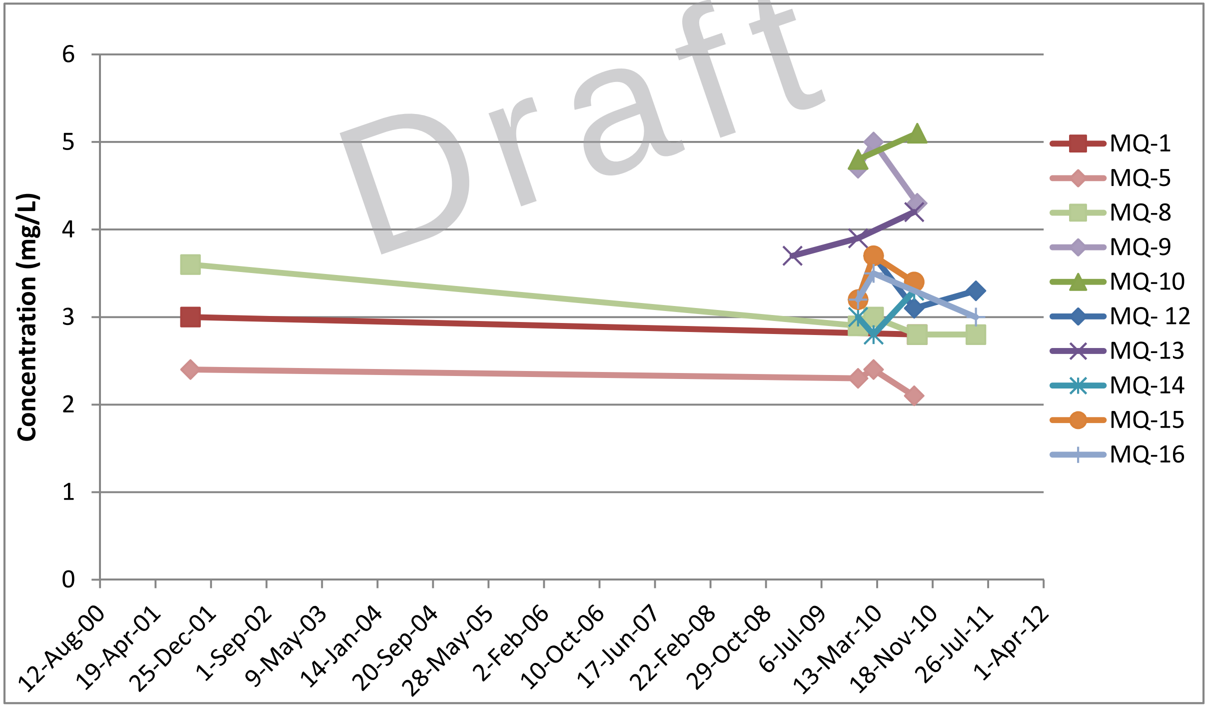
Because there have been no events where the MCL has been exceeded and there are no wells of concern in this area, nitrate in the groundwater is not a current concern in the Northern Wellfields. For this reason, the only further action recommended for this area is to continue sampling the wells annually per EPA requirements.

Figure 2.2.7-22. **Northern Well Fields**

Table 2.2.7-10. **Northern Well Fields – Nitrate Data Summary**

Well ID	Number of Samples	Minimum Nitrate Concentration (mg/L)	Average Nitrate Concentration (mg/L)	Maximum Nitrate Concentration (mg/L)	MCL Exceeded
MQ-12	4	3.1	3.33	3.7	No
MQ-1	2	2.8	2.9	3	No
MQ-10	2	4.8	4.95	5.1	No
MQ-13	3	3.7	3.93	4.2	No
MQ-14	3	2.8	3.03	3.3	No
MQ-15	3	3.2	3.43	3.7	No
MQ-16	3	3	3.23	3.5	No
MQ-5	4	2.1	2.3	2.4	No
MQ-8	5	2.8	3.02	3.6	No
MQ-9	3	4.3	4.67	5	No

Figure 2.2.7-23**. Nitrate Concentrations in Northern Well Field**



Summary of Recommendations

Recommendations resulting from the unsewered areas analysis include prioritization of unsewered areas, a well blending program, specific recommendations for Kagman and the Isley well field, and general recommendations applicable to all unsewered areas on Saipan.

Prioritization of Unsewered Areas

Based on the results of the unsewered areas analysis (Table 2.2.7-3), the unsewered areas should be evaluated in order of priority to determine the source of water contamination. Depending on the findings, the recommendations to remediate the issues within the unsewered areas may vary widely: from doing nothing to extending CUC's wastewater infrastructure (sewers and/or wastewater treatment plants) into the areas. The analysis approach taken considers all of the impacts that septic systems may have on an area and provides a method for CUC to prioritize and focus its efforts on the most critical unsewered areas on the island.

Based on the scores for the individual unsewered areas in Table 2.2.7-3, the priorities are as follows:

1. Isley
2. Kagman
3. Obyan
4. Koblerville
5. San Vicente/As Lito/Dan Dan
6. Central Well Fields
7. Northern Well Fields

Well Blending Program

CUC should prepare a well blending program for each of the well fields that identify the sequence in which wells are turned and off to ensure that the wells with the highest concentration of nitrate are brought online last and are the first to be shut down. This approach will ensure that the blended water supply entering the distribution system has the lowest nitrate concentration possible. The approach has been successfully used by Irvine Ranch Water District, California (EPA Region 9) since the 1990s and has been a California Department of Public Health-approved program to mitigate elevated nitrate levels in parts of the District's well field.

Kagman

For the Kagman area where nitrate concentrations are a concern due to the large population in the Kagman Villages, it is recommended to proceed with Alternative 1: No Treatment and continue to carefully monitor the nitrate concentrations in the Kagman wells and blended supply. If an increasing trend in nitrate concentrations is observed or if MCL violations in the blended supply begin to occur on a regular basis, consideration of other alternatives is warranted. As GWUDI water quality data are collected from the Kagman well under investigation (KG-7), the data should continue to be evaluated for any abnormalities that may be related to the proximity of the well to septic tanks. This study will begin in August 2012 and be completed in January 2013. A continued sampling program has previously been discussed in more detail in the Kagman section of this Master Plan and will be discussed in the following "General Recommendations for All Unsewered Areas" section.

In the future if nitrate levels increase to an unacceptable level, CUC may want to consider biological nitrate treatment for the high nitrate wells. This would be a significantly less costly approach than constructing a large sewer system and expanding treatment capacity on the island. The American

Water Works Association (AWWA) has had an active committee focusing on drinking water biological treatment for the past 3 years. Biological treatment has been practiced in Europe for decades and is gaining traction in the United States because of the cost effectiveness of the treatment process.

Isley Well Field

The Isley Well Field causes the most concern with regard to nitrates present in the drinking water due the significant number of times the MCL has been exceeded in individual wells and wells of concern, in addition to the general increasing trend of nitrates in the wells. Further sampling and research is needed in this area to completely understand the source of the nitrate contamination in the groundwater. A continued sampling program is discussed in more detail in the following "General Recommendations for All Unsewered Areas" section. Additionally, a separate study should be initiated to determine why nitrate concentrations are so high in this well field. The water quality impacts could potentially be associated with the septic systems from the Dan Dan homestead area due to the groundwater flow direction from Dan Dan to Isley, or impacts may be due to past agricultural land use activities. Additional investigations are recommended to understand the major contributing influences on the Isley Well Field water quality.

General Recommendations for All Unsewered Areas

The APEC report (2011) made recommendations for the Kagman, San Vicente, Dan Dan, and Isley Field well areas based on APEC's nitrate data analysis. These recommendations can be applied to all of the unsewered areas on Saipan where drinking water wells are in proximity to residences where septic tanks are in use. As noted in the APEC report, several potential sources for nitrate contamination in groundwater include, but are not necessarily limited to, household septic systems, agriculture and livestock, golf courses, and other human activities. Due to a lack of more in-depth data needed to pinpoint the exact causality and full extent of the elevated nitrate levels, APEC made several recommendations to consider before determining that the nitrate concentrations are directly related to septic systems in unsewered parts of the island.

Continued sampling was only one of the recommendations from the APEC report (APEC, 2011). Some of the recommendations presented in the APEC report that have not already been undertaken should also be considered for implementation. These modified recommendations should be considered for unsewered areas with drinking water wells:

- A 12-month spatial sampling program of agricultural and drinking water wells should be conducted, especially in wells where there is a lack of data. This will require the development of a detailed Quality Assurance Project Plan (QAPP) and accompanying Sampling and Analysis Plan (SAP) that will identify the wells to be sampled and will ensure a higher frequency of well sampling to provide a more robust data set for evaluation of nitrate concentrations in the drinking water supply. This program should be funded and conducted by DEQ as the cause of the elevated nitrate levels has not been determined.
- Until the 12-month sampling plan is developed and implemented, it is recommended that CUC continue to sample quarterly at wells of concern and seasonally for all other wells in the same area where there are wells of concern. In the central and northern well fields no additional nitrate sampling is necessary.
- An additional 12-month focused sampling in areas within a certain radius of wells considered hot based on the 12-month spatial sampling program should be performed. This sampling should be funded and conducted by DEQ as the cause of the elevated nitrate levels has not been determined.

- A study of septic discharge of homestead areas island-wide, with a focus on areas with minimal past agriculture influence, should be funded and conducted by DEQ.
- A comprehensive study of the potential impacts of septic systems on groundwater quality and stormwater discharge impacts on the reef and other near-shore marine life should be undertaken. DEQ has selected a contractor to develop a QAPP and SAP for six high-priority impaired water segments on the island of Saipan (RFP 12 – DEQ – 045), one of which is the Kagman watershed segment. The investigation is proposed to begin at the start of the 2013 rainy season. This study should be funded and conducted by DEQ as the cause of the elevated nitrate levels has not been determined.

It is also recommended that DEQ consider developing and adopting a comprehensive onsite wastewater disposal management approach that oversees the full range of issues related to wide-spread use of septic systems—planning, siting, design, installation, operations, monitoring, and maintenance. Improving the management of septic systems is essential when any form of contamination has been identified as a known or potential issue in a community.

Alternatives for Unsewered Areas

As discussed previously, several areas on the island of Saipan are not currently sewered; the residences and businesses in these areas rely primarily upon septic systems (see Figure 2.2.7-4 for locations of unsewered areas in Saipan). This section of the Master Plan addresses the Stipulated Order requirement to consider alternatives to the use of septic systems in these areas. The alternatives considered as part of this evaluation include connecting to existing sewer infrastructure, clustered decentralized wastewater treatment, and water reuse. These alternatives are discussed in more detail below.

Connecting to Existing Infrastructure

In some of the Saipan's villages where septic systems are commonly found, existing collection system infrastructure is readily available, but residents are reluctant to connect to the CUC sewers because of the monthly sewer fees associated with being connected to the sewer and the high costs associated with the work to complete the connection. As part of the development of the CIP, the "Island-Wide New Sewer Service Connections" project was identified for inclusion in the Saipan wastewater 20-year CIP. This project is intended to complete 50 connections to the sewer per year for the next 20 years in all areas that can be connected through existing infrastructure with minimal upgrades (i.e., new manhole and lateral crossing). In addition, new sewer projects, such as the Upper Dan Dan Homestead, will bring sewer infrastructure into some unsewered areas that are near large existing trunk lines that have excess capacity available. The following list of projects from Section 4.3.1, "Project Identification and Prioritization," would add sewer to currently unsewered areas on Saipan:

- Afetna Sewer Collection System Upgrades and Expansion
- As Lito and Koblerville Sewer Collection System Expansion
- As Matuis Collection System
- As Perdido Road Sewer Collection System
- Chalan Kiya Sewer Collection System Replacement
- Collector Lines - Chalan Kanoa Beach Club Area
- Dan Dan Phase I: Dan Dan Homestead Gravity Sewer Collection
- Dan Dan Phase II: Dan Dan Homestead Pressurized Sewer Collection
- Fina Sisu Collection System
- Kannat Tabla/Upper Dan Dan Sewer Collection System

- Lower Base Phase IIa: As Mahetog Sewer Collection System
- Lower Base Phase IIb: Southern Tanapag and Chalan Pale Arnold Sewer Collection System
- Lower Sadog Tasi Sewer Collection System
- Sadog Tasi Gravity Sewer Collection System
- San Vicente Phase I: Gravity Sewer Collection System Extension
- San Vicente Phase II: Pressurized Sewer Collection System Extension
- Texas Road Collection System Expansion
- Wireless Road Phase I: Gravity Sewer System Expansion
- Wireless Road Phase II: Pressurized Sewer Collection System Expansion

More detailed information on these projects can be found in the complete project list in Appendix S. For the prioritized sewer extension projects that are included in the CIP, the capital costs are presented in Section 4.3.2, “Cost Estimation of Wastewater System Capital Improvement Projects.” Connecting buildings to existing sewer infrastructure is the preferred alternative to using septic systems when the connections are cost effective.

Decentralized Treatment Systems

For those villages where connecting to existing CUC sewers is not an option because of either distance to connect or limited capacity, there are alternatives that these areas may consider for treatment of wastewater flows. Use of septic systems for onsite wastewater treatment is considered the conventional decentralized treatment method. Nonconventional decentralized options include:

- Cluster systems: A wastewater collection and treatment system that collects wastewater from two or more dwellings or buildings and conveys it to a treatment and dispersal system located on a suitable site near the dwellings or buildings
- Alternative onsite wastewater technologies
  - Constructed wetlands
  - Aerobic treatment units (small package plants)
  - Alternative subsurface infiltration designs (e.g., mound systems, pressure and drip distribution)

Implementation of any of these nonconventional decentralized treatment systems is not currently being recommended for the unsewered areas in Saipan due to economic and operational constraints. To ensure proper operation and maintenance of these systems, CUC would need to hire additional skilled staff or place additional burdens on existing operational staff. Management of biosolids produced with some of these treatment system alternatives is also a drawback as this would result in additional operational costs for the labor, transportation, and disposal of biosolids. The other limiting factor for installing decentralized treatment is disposal during wet seasons when local land disposal systems are overwhelmed and not available. Typically, decentralized systems are located upstream of regional plants for this type of emergency discharge. Emergency backup capabilities are especially important in Saipan where it is very difficult to build new ocean outfalls and discharge of partially treated wastewater into the groundwater basins would not be acceptable.

As discussed previously, additional studies and review of water quality data must be performed before treatment alternatives are recommended in any of the unsewered areas. Cost estimates for decentralized alternatives are not presented in this Master Plan because they are not recommended for Saipan.

Water Reuse

Current DEQ regulations prohibit the use of treated reuse wastewater for irrigation of food crops and landscape irrigation (NMIAC §§ 65-120-1610 and 65-120-1615). Historically, DEQ has allowed the application of reuse water for golf course irrigation numerous times, although the regulations can be interpreted such that golf course irrigation with reuse water is also prohibited. The DEQ water reuse regulations currently require secondary treatment proceeded by an equivalent of 30 days storage in a ponding basin and disinfection. The DEQ regulations would need to be amended to allow the use of reuse water for agricultural purposes, and the regulations should be clarified to explicitly allow the use of reuse water for golf course irrigation. The following discussion on the feasibility of implementing water reuse on Saipan assumes that the DEQ wastewater reuse regulations would be revised to require tertiary treatment and disinfection of reuse water, similar to the Title 22 regulations used to enforce water reuse applications in the State of California. Adoption of similar regulations would ensure the reuse water be of acceptable quality (i.e., virus and pathogen free) for landscape and agricultural irrigation. The water reuse applications of golf course and agricultural irrigation have been safely practiced across the United States since the early 1920s.No illness associated with the use of recycled water for any reuse project has been reported.

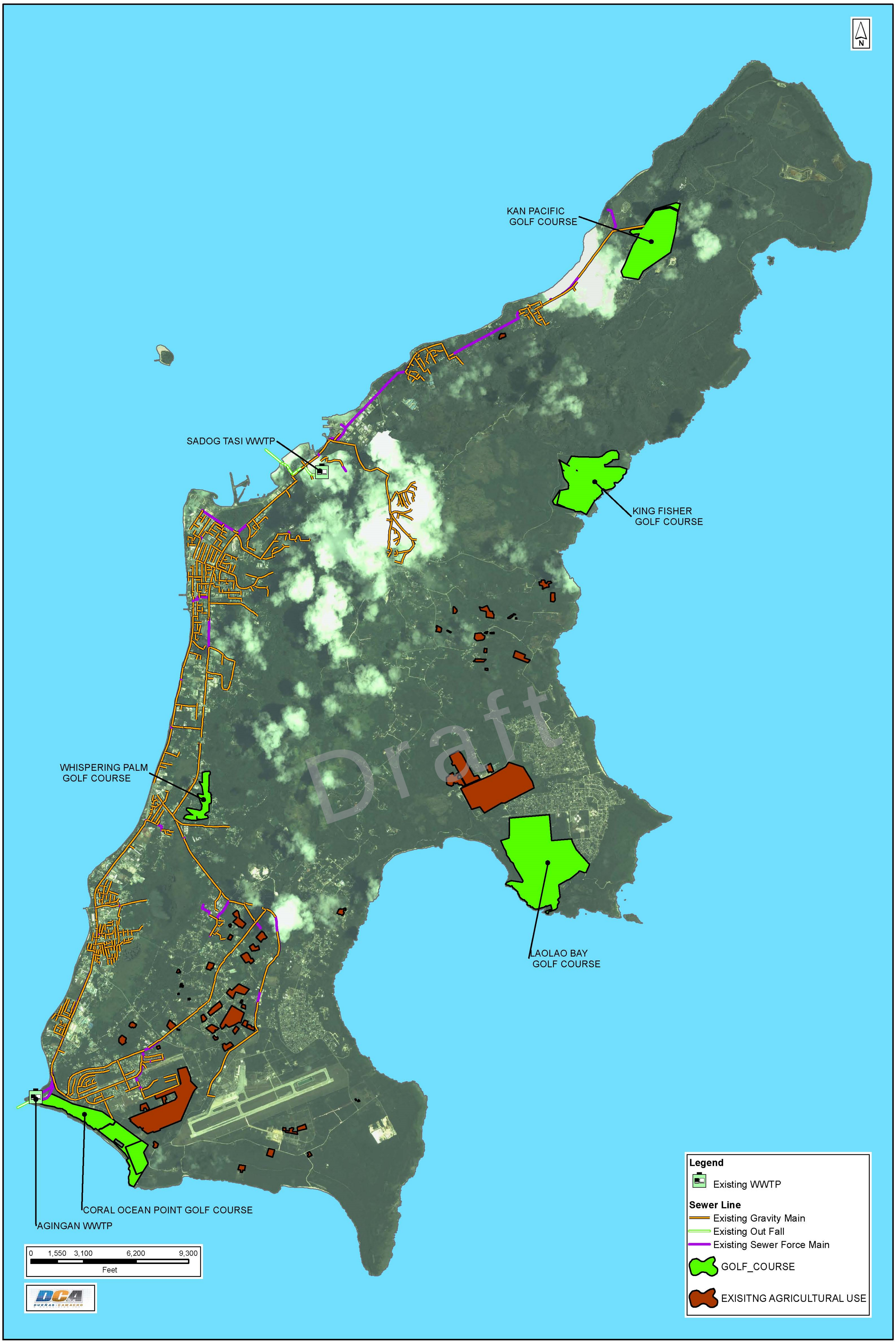
Significant water demand is created by agriculture and golf courses on the island of Saipan, both traditional and well founded applications for the use of recycled water. The potential exists to decrease the demand on the drinking water wells if these uses were switched from potable water to recycled, or reclaimed, water. To supply reclaimed water to agricultural or golf course customers, the existing WWTP(s) that provide the water would require upgrades to include tertiary treatment and disinfection so that the water is of acceptable quality for this type of use. Additionally, one of the largest costs for a recycled water system is the distribution system required to convey the water to the customers. This cost, based on experience with recycled water systems across the continental United States, can be greater than 50 percent of the cost of the entire water reuse program.

Both the Sadog Tasi and Agingan WWTPs were evaluated to determine whether treatment and delivery of reclaimed water to appropriate customers is feasible. It was determined that the Sadog Tasi WWTP is not an ideal candidate for this application because too few large irrigation users are in close proximity to the Sadog Tasi WWTP. Treatment and delivery of tertiary-treated wastewater from the Agingan WWTP to some large irrigation areas is considered to be a stronger possibility due to the shorter distance from the distribution system to a large agricultural area and golf course. It may be possible to run a tertiary-treated water line from Agingan WWTP to the adjacent golf course and up to the As Lito Village to serve the farmers there. Figure 2.2.7-24 shows the location of the agricultural and golf course areas with respect to the WWTPs.

The cost of installing the additional treatment and constructing the distribution system would need to be weighed against the quantitative benefits of reducing well pumping and distribution. One additional factor would be the qualitative benefits of being able to shut off poor quality wells to improve the overall quality of drinking water provided to customers.

Another factor that must be considered as part of the decision making process would be to ensure that the end users are agreeable to accepting recycled water in lieu of drinking water. Numerous projects in the continental United States have been delayed or underutilized after significant capital expenditures by the utility as a result of inadequate attention to this area.

Figure 2.2.7-24. **Location of the Agricultural and Golf Course Areas with Respect to the WWTPs**



Decentralized wastewater treatment is often tied directly to recycled water systems to reduce the cost of distributing the recycled water. Numerous utilities throughout EPA Region 9 have incorporated decentralized treatment into their systems to increase the use of recycled water in their service areas. In most cases, these utilities have downstream capacity at large regional wastewater treatment plants for disposal of the excess recycled water during low-demand periods.

2.2.8 Geographic Information System Application and Development

The Stipulated Order calls for the Master Plan to "include a plan with a detailed schedule for the development of a Geographic Information System (GIS) of CUC drinking water and wastewater systems to facilitate better management of CUC's systems." The GIS shall include the functionalities to locate, map and develop GIS layers for all of the following: treatment facilities, wells, waterlines, storage tanks, collection systems, pump stations, sewer laterals and CUC's and DEQ's water quality monitoring stations. *The scope of the Master Plan preparation provides for the development of a GIS of CUC drinking water and wastewater systems.*

The GIS program developed under this Master Plan for the CUC wastewater system on Saipan and completed in December 2012 provides the following products:

- Existing wastewater system facilities information in GIS format for Saipan featuring the location, layout, and inventory with photos of wastewater collection, transmission, treatment, and disposal facilities and major appurtenances based on available documentation and data obtained from field investigation.
- Fully functional GIS work station using ArcGIS containing the information listed above with appropriate GIS layers as described below.

The completed GIS program yields the following byproducts:

- The capability to identify, catalog, and track geo-referenced components of the wastewater system(s) graphically and/or by tabulation according to location, function, type, material composition, size, and capacity.
- The capability to update the GIS database with additional and new data on components of the CUC Saipan wastewater infrastructure system.
- Provide data and support in the preparation, updating and operation of the selected computerized wastewater system infrastructure model.
- Provide a valuable tool in support of the preparation of population projections by categorizing and geo-referencing census data by census districts with correlations to wastewater services districts.

The GIS is intended to be managed, operated, maintained, and updated by designated and trained CUC personnel organized as a separate section under the office of the Chief Engineer. Organizational recommendations are discussed under Section 3.4, "Assessment of Current CUC Management Policies, Procedures, and Operating Rules and Regulations."

GIS Input and Mapping Methodology

Per the Stipulated Order the development of a plan to implement a GIS is a required component of the Master Plan. Implementation of GIS will facilitate CUC's management of its wastewater system. The GIS must locate, map, and contain GIS layers for the following:

- Wastewater treatment facilities
- Collection systems and laterals
- Lift stations

This section of the Master Plan discusses how the GIS for the wastewater system was developed.

Available Data

Wastewater facilities data made available by CUC in the form of as-built drawings and system maps or, in the absence of such, engineering design drawings were compiled by the project team and input into ArcGIS to create an editable geodatabase as follows:

- Digitized or plotted if in hard copy/document format
- Imported into the GIS platform if in a compatible electronic drawing format
- Converted into compatible electronic drawing format and then imported into the GIS platform

DCA had developed preliminary GIS databases in tabular and graphic format of a large portion of existing CUC Saipan wastewater infrastructure assets prior to undertaking this project. CUC asset data not already in GIS format were added to complete the preliminary creation of the geodatabase.

The computer-aided design (CAD) drawings of the Saipan sewer system provided data that had to be modified (shifted and rotated) to coincide with the 1966 Mariana Islands Coordinate System. Archived images (dated 8/17/11) containing scanned drawing of the sewer system were also geo-referenced and used to update the wastewater system geodatabase at Master Plan project initiation.

The geodatabase created from the desktop effort was validated and corrected to the extent possible by actual field surveys. A detailed description of the creation of the geodatabase is contained in Appendix L.

Field Verification of the Saipan Wastewater Infrastructure Appurtenances

The location of major wastewater infrastructure appurtenances that are visible must be geographically referenced to ensure accurate representation. The scope of work required that visible major wastewater system components on Saipan be field-located and verified, and that results be represented in GIS format. As part of the asset inventory and condition assessment survey, a team consisting of a GIS Specialist and survey aides performed field verification surveys of the following:

- Wastewater manholes
- Wastewater pump/lift stations
- Major wastewater system appurtenances

The surveys included taking photographs of aboveground wastewater system features.

Field Survey Equipment

Field surveys were conducted using the Ashtech MobileMapper 100, a handheld global positioning system (GPS) survey and mapping device designed for GIS data collection and mapping. This GPS device has real-time submeter (decimeter/centimeter) accuracy when operated in conjunction with companion data collection and post-processing software and within 200 kilometers of National Geodetic Survey Continuously Operating Reference Stations (CORS), of which there are two on Saipan and three on Guam. The GPS survey equipment included a camera that enabled the operator to capture a photo of the asset along with a geo-referenced reading of its location. See Appendix M for a description of the GPS equipment used in the field surveys.

Field Surveys

GPS surveys of the CUC Saipan wastewater system were conducted from August 19 through September 16, 2011.

Concurrent Asset Inventory

The GPS field surveys were integrated with the asset inventory data-gathering task of the master planning effort, which included gathering information on asset description, size, capacity and condition.

GIS Mapping Process

Wastewater system assets were mapped using the most recent available rectified aerial maps for the base background. Base map source descriptions are described in Appendix N. Wastewater system asset data imported from documents and contained in the geodatabase have either been validated by or revised to coincide with GPS field survey results.

GIS Geodatabase Construct

The GIS geodatabase is categorized by asset *feature class*, each of which is supported by data fields providing information about the asset. Table 2.2.8-1 describes the specific features of the CUC wastewater system components contained in the geodatabase. Appendix O contains the Asset Feature Class descriptions and data fields for wastewater system assets.

Table 2.2.8-1. **Saipan Wastewater System Components in Geodatabase**

CUC Wastewater System Features	Used
Sewer Casings (sewer line encasements)	
Sewer Clean Outs	✓
Sewer (Network) Control Valves	✓
Sewer Detention Areas	
Sewer Discharge Points	✓
Sewer System Fittings	✓
Sewer Gravity Mains	✓
Sewer Inlets	✓
Sewer Lateral Lines	✓
Sewer Manholes	✓
Sewer Network Structures (WWTPs, Pump Stations)	✓
Sewer (Storm) Open Drains	
Sewer Pressurized (Force) Mains	✓
Sewer Service Connections	
Sewer System Valves	✓
Sewer Taps	
Sewer Test Stations	
Sewer Virtual Drain lines	

Saipan Wastewater System Infrastructure

The GIS geodatabase development and mapping of the CUC wastewater system assets for Saipan have been completed. The following figures are sample plots of GIS-based wastewater system map. Figures 2.2.8-1 through 2.2.8-3 are GIS-based maps of the Saipan Wastewater System and Figure 2.2.8-4 is a sample tabular database of selected wastewater system components.

Figure 2.2.8-1. **GIS-based Maps of the Sadog Tasi and Agingan Wastewater Systems**

Figure 2.2.8-2. **GIS-based Maps of the Saipan Agingan Wastewater System**

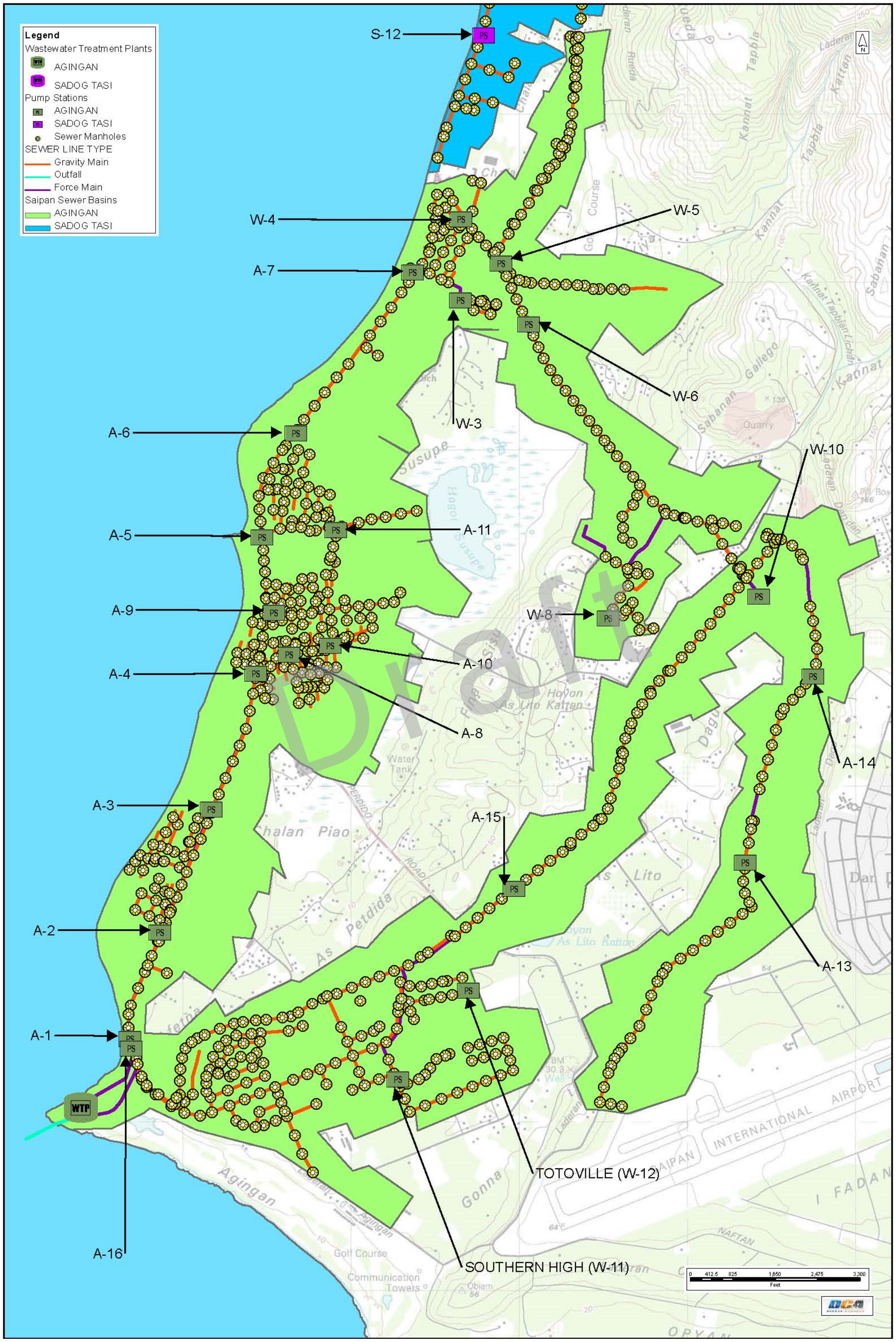


Figure 2.2.8-3. **GIS-based Maps of the Sadog Tasi Wastewater System**

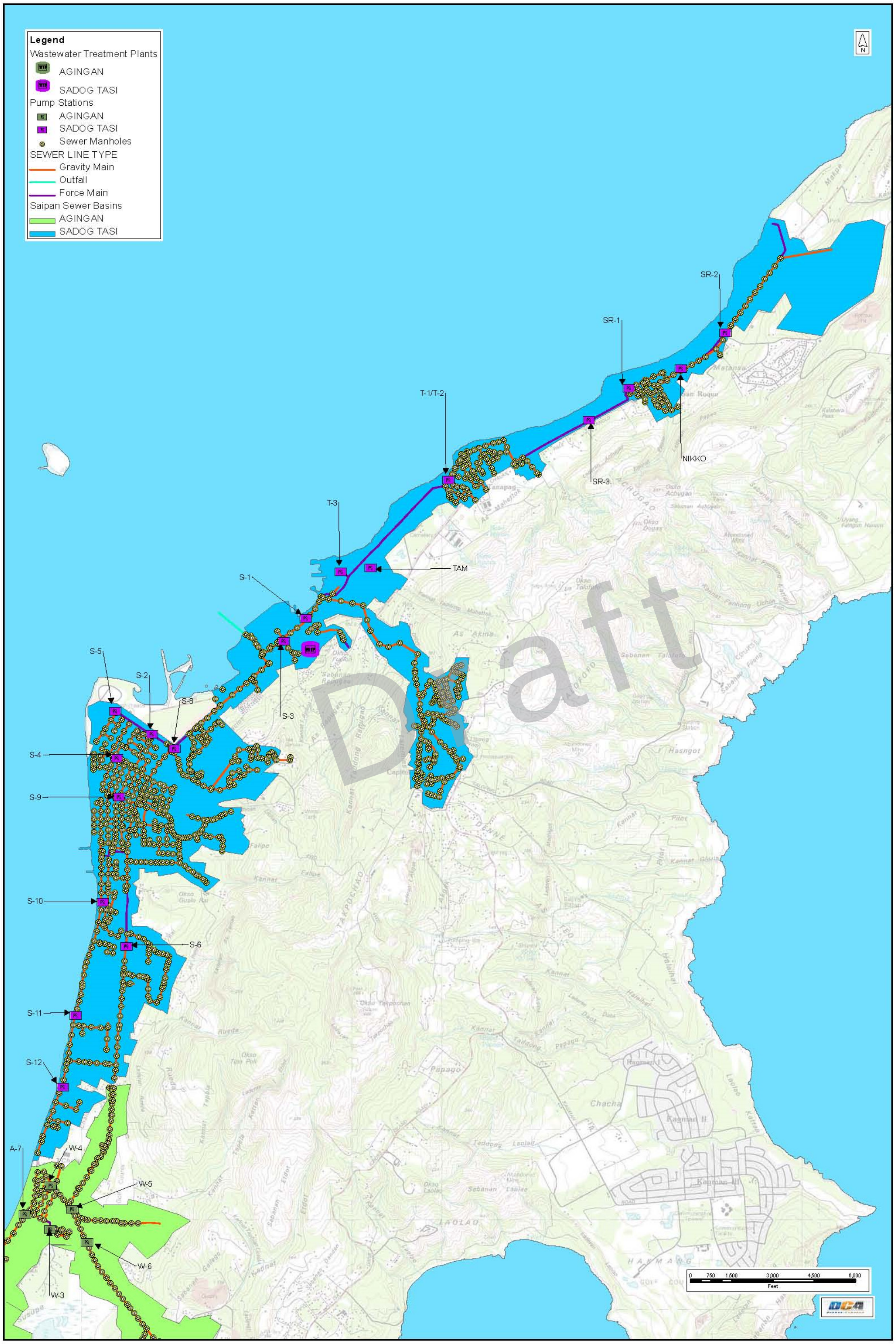
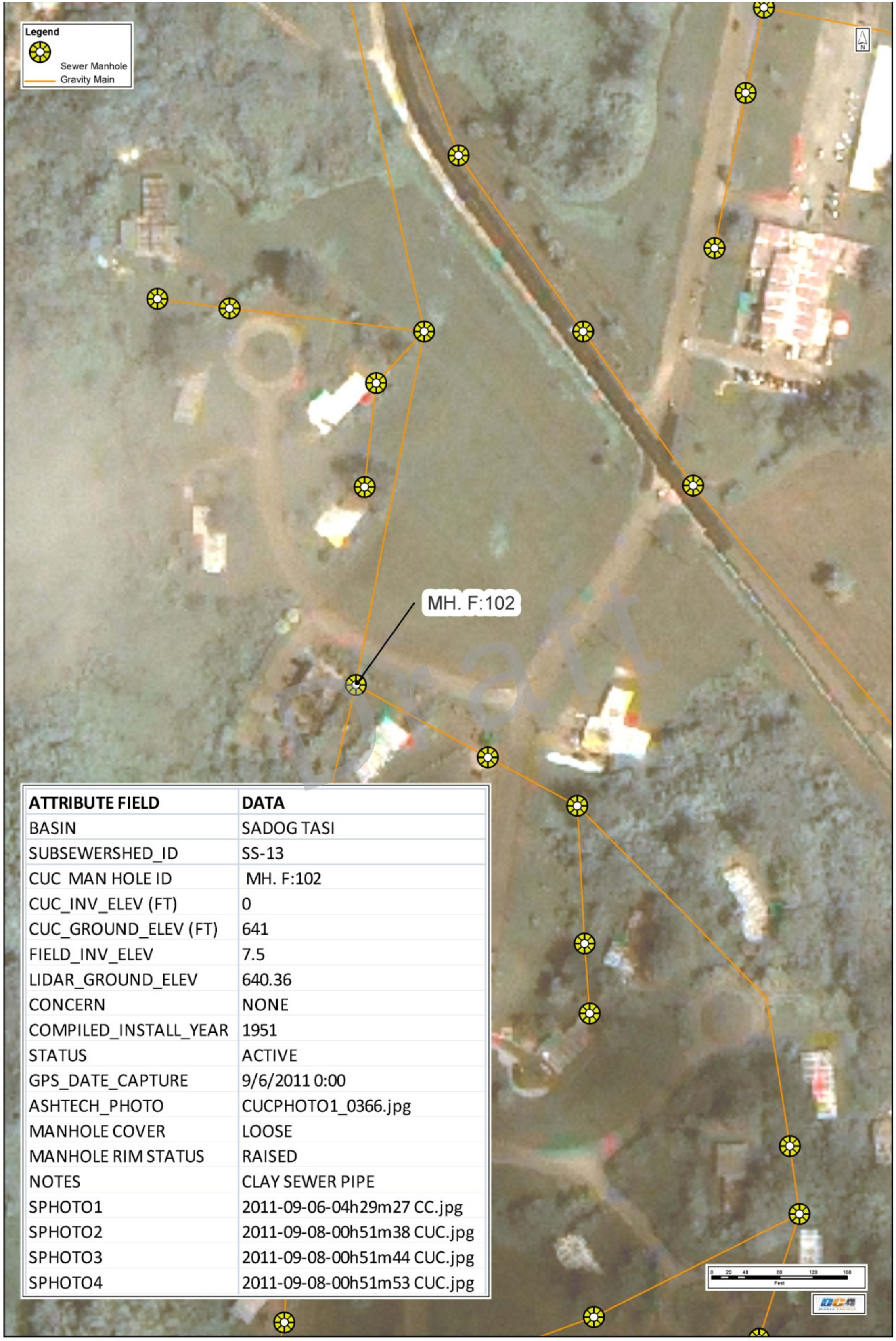


Figure 2.2.8-4. **Sample of the Tabular Database of Selected Wastewater System Component**



ATTRIBUTE FIELD	DATA
BASIN	SADOG TASI
SUBSEWERSHED_ID	SS-13
CUC MAN HOLE ID	MH. F:102
CUC_INV_ELEV (FT)	0
CUC_GROUND_ELEV (FT)	641
FIELD_INV_ELEV	7.5
LIDAR_GROUND_ELEV	640.36
CONCERN	NONE
COMPILED_INSTALL_YEAR	1951
STATUS	ACTIVE
GPS_DATE_CAPTURE	9/6/2011 0:00
ASHTECH_PHOTO	CUCPHOTO1_0366.jpg
MANHOLE COVER	LOOSE
MANHOLE RIM STATUS	RAISED
NOTES	CLAY SEWER PIPE
SPHOTO1	2011-09-06-04h29m27 CC.jpg
SPHOTO2	2011-09-08-00h51m38 CUC.jpg
SPHOTO3	2011-09-08-00h51m44 CUC.jpg
SPHOTO4	2011-09-08-00h51m53 CUC.jpg

GIS Program Capabilities and System Turnover

The GIS program and database for the CUC Saipan wastewater system are complete and were used extensively in support of other master planning tasks. The GIS is now functional as follows:

- The GIS will identify, catalog, and track geo-referenced components of the existing wastewater system for Saipan graphically and/or by tabulation according to location, function, type, material composition, size, and capacity.
- The GIS database is ready to accept with additional and new data on components of the CUC water and wastewater infrastructure systems. Asset feature classes have been created for future use as noted in Table 2.2.8-1.
- The GIS will provide supporting data for the setup and continuing operation of the computerized wastewater system infrastructure model.

The complete GIS workstation consisting of the most recent licensed version of ArcGIS Desktop (Version 10.1), computer hardware, and wastewater system geodatabase was turned over to CUC in December 2012.

GIS Training

Training of CUC personnel in the use, operation and maintenance of the system was provided to CUC. Manuals in two volumes providing guidance and instructions on the use and operation of the GIS program were turned over to CUC in December 2012.

GIS Use and Operation

The recommended primary uses of the CUC wastewater system GIS program are as follows:

- **Update Wastewater Systems Assets/Facilities Database.** The GIS program will be used to update the CUC wastewater system database when major or significant system components are replaced or added.
- **Retrieve Systems Asset Data/Information.** The program can be queried to provide information on component/equipment type, make, capacity, and/or condition. GIS-based information should be used to schedule systems maintenance and component replacement as routine tasks.
- **Create Wastewater System Layouts.** The program can provide a graphic layout (and concurrent tabular database) of the local, service district, or island-wide wastewater system for informational or analytical purposes in conjunction with systems modeling software provided under the Master Plan.
- **Analyses of Proposed Wastewater System Improvements.** The program, when interacting with computer modeling software, can provide real-time analysis of the viability and potential efficacy of proposed wastewater system improvements.

A structure and protocol for instituting the recommended uses and operation of the GIS program must be developed as an integral part of the reorganization of the CUC Engineering.

Real Estate Requirements

Section 8194 of the Commonwealth Code (Title to Property: Easement Rights) (NMICC 2009) provides for the conveyance of real property to CUC and grants CUC the right of perpetual access to and use of all easements on Public Lands within which CUC assets/facilities are located except for lands owned by the Commonwealth Port Authority. The law further provides that the Department of Public Lands shall grant, as a ministerial act without further consideration, such titles to CUC within 28 days of a demand by the Corporation. Such a grant may be made subject to survey, the cost of which shall be borne by the Department of Public Lands (DPL).

The project team recommends that easements, right-of-way corridors, and real estate (land parcels) on public lands containing CUC wastewater system assets be surveyed, mapped, and CUC ownership documented by title or written declaration. The GIS program developed for CUC under this Master Plan contains all the information in geo-referenced layers necessary to determine the real estate requirements for each CUC wastewater system asset. The project team also recommends that CUC undertake the following process for documenting its real property interests utilizing the GIS program where appropriate:

1. Meet with DPL to discuss CUC's real estate ownership goals, intention to seek titles to real properties containing CUC water and wastewater systems assets, and the process to achieve these requirements.
2. Establish a prioritized list of CUC wastewater system assets on Saipan that need real estate ownership documentation and communicate this list to DPL.
3. Determine the general real estate requirements for each prioritized asset, such as parcel size and easement/right-of-way width.
4. Using the GIS program/database, generate a conceptual layout of the real estate requirements of each wastewater system asset (in order of priority for documentation).
5. Submit partial requests (demands) to DPL for survey, mapping, and grant of title to the real property or declaration of easement/right of way containing each CUC wastewater system asset. CUC requests should be made in manageable increments in consultation with DPL and in the predetermined order of priority for real property ownership documentation.
6. Provide for the orderly filing of real property information at CUC and for the input and maintenance of the real estate information in the GIS program database.

The process of establishing real property ownership by CUC can then be followed by valuation of CUC's real property assets with this information subsequently reflected in future CUC financial statements.

2.2.9 Asset Risk Assessment for the Commonwealth Utilities Corporation Wastewater System

This section presents the results of the asset risk assessment performed by the project team and CUC on the Saipan wastewater system. The analysis of risk assessment results helped to form the basis of the recommendations for the CIP. This risk assessment activity was performed in a workshop setting with CUC staff. Risk assessment for water and wastewater assets for all three islands (Saipan, Rota, and Tinian) were performed during these workshops; as such, reference to both water and wastewater risk assessment process are discussed in this section of the report. The detailed results from the Saipan water system, Rota water system, and Tinian water system can be found in their respective Master Plans that have been developed by the project team.

Asset risk assessment is part of a greater asset management approach. Asset management concepts are presented below to provide context for the activities of the project team.

Asset Management

Asset management is defined as “an integrated set of processes to minimize the life-cycle costs of infrastructure assets, at an acceptable level of risk, while continuously delivering established levels of service”(Association of Metropolitan Water Agencies [AMWA], 2007). It comprises four key elements:

- **Integrating Processes.** The integration of processes is a continuous business practice that includes investigation, assessment, evaluation, prioritization, and decision-making about utility infrastructure maintenance, operation, and development to meet the stated levels of service of the utility in an economically responsible manner.
- **Minimizing Life-Cycle Costs.** Life-cycle costs consist of planning, design, capital, O&M, and salvage costs. Asset management focuses on identifying risk so that costs can be minimized while maintaining desired levels of service.
- **Establishing Levels of Service.** Levels of service provide a utility with established metrics for judging performance and progress. Levels of service categories encompass measures for regulatory compliance, system reliability, fiscal impacts, and workplace and environmental safety.
- **Identifying an Acceptable Level of Risk.** Acceptable risk levels must be defined based on the condition of existing infrastructure, the likelihood of infrastructure failure, and the consequence associated with infrastructure failure. Risk is managed by understanding the risks that exist for a utility, how risk affects levels of service, and the cost to mitigate risk.

Asset management is a rigorous and defensible decision-making process that results in better managed risk, improved public confidence, improved internal utility coordination and communication, effective information and knowledge transfer and retention, and improved regulatory compliance (AMWA, 2007). Table 2.2.9-1 provides key concepts for effective asset management.

Table 2.2.9-1. **Key Concepts of Asset Management (Adapted from AMWA, 2007)**

Knowledge of:	Mission of the utility and its levels of service
	Assets and their characteristics
	Physical condition of assets
	Performance of assets
Ability to:	Optimize O&M activities
	Assess risk
	Identify and evaluate risk mitigation options
	Prioritize options within available budget
	Predict future demands
	Effectively manage information and employ decision support tools

The activities employed to arrive at the results presented in the section used many of the concepts detailed in the “Level of Service Categories” section below.

Asset Management Strategy

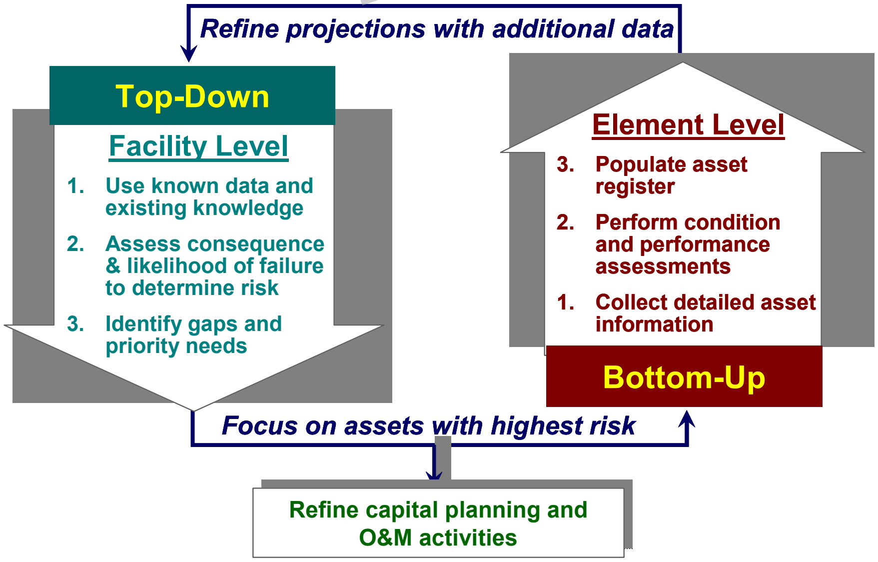
Asset management can be implemented using either of two approaches: “bottom-up” or “top-down.” Both focus on assessing risks, where risks are associated with not meeting established levels of service, and then identifying mitigation measures to reduce the identified risks. Explanations of asset management approaches and concepts were presented at each of the asset assessment workshops; the wastewater workshop presentation is included as Appendix P.

The bottom-up approach focuses first on collecting detailed data to analyze utility assets. The data collected include detailed characteristics of assets (e.g., age, material, manufacturer, size, and capacity), field condition assessments, estimation of remaining useful life, determination of asset replacement costs, and other detailed information. The project team performed a representative survey of utility assets to build a baseline condition assessment database. Critical assets, such as water tanks, were surveyed in their entirety. During workshops, this baseline proved useful by providing a comparison profile for similar assets with no assessment history. The project team activities used to build the complete list of assets are documented in the following sections of the Saipan Drinking Water and Wastewater Master Plans:

- Water Distribution System
- Water System Storage Tank Assessment
- Wastewater Collection System
- Slow Sand Filtration System
- Wastewater Treatment Plants
- Outfall Assessment and Mixing Zone
- Geographic Information System

The top-down approach first focuses on analysis at a system or facility level where institutional knowledge and existing data are readily available. The project team used both approaches for the water and wastewater risk assessment by using the information for the detailed assets field assessments and leveraging institutional knowledge from CUC staff to complete the risk analysis process. Figure 2.2.9-1 provides a high-level overview of the top-down, bottom-up interaction.

Figure 2.2.9-1. **Combining the Top-Down and Bottom-Up Asset Management Approaches**
Source: AMWA 2007



Goal of an Asset Management Program

Typically, the goal of an asset management program is to continue providing a targeted level of service to its customers while determining the lowest-cost methods of reducing risks of infrastructure failure. The primary goal of the asset management task performed by CUC was to understand the relative risks of infrastructure failure so that this information can be utilized to identify needed capital projects in the Master Plan. This section includes both CUC's "vertical assets" (e.g., aboveground structures such as wastewater treatment plants and pump stations) and "horizontal assets" (e.g., underground pipes for water distribution and sanitary sewer systems).

Asset Assessment Approaches

The project team used an industry-standard asset management approach, which included the following steps:

- Develop Level-of-Service categories
- Develop an Asset Hierarchy
- Develop Consequence of Asset Failure and Likelihood of Asset Failure scoring matrices
- Score relative risks of asset failure based on the matrices
- Rank assets by greatest risk

Each step is discussed in greater detail below.

Develop Level-of-Service Categories

Level of service (LOS) categories are based on CUC's mission and service goals and are established at a utility-wide level. Performance measures, on the other hand, are generally established at lower levels within the organization and are used to determine whether the LOS targets are being met. LOSs can be qualitative and quantitative and must align with customer expectations. LOSs must meet the following criteria and, above all, they must be:

- **Meaningful.** Provide a clear, meaningful picture of performance to staff and stakeholders
- **Measurable.** Be measurable either qualitatively or quantitatively
- **Consistent.** Be uniform and reproducible by others
- **Useful.** Assist with improved management of utility
- **Unique.** Be specific enough to describe an attribute that is distinct from other LOS criteria
- **Limited in number.** Prevent overlap and afford an overview of utility performance

LOS categories should be limited in number—to six or so—to keep them manageable and to effectively evaluate assets within the asset hierarchy. Each LOS category should have a clearly defined target LOS.

The project team established the LOS categories and corresponding target values shown in Table 2.2.9-2 with feedback from CUC. Once the LOS targets were established, CUC assigned a weighting factor, or a relative measure of importance, to each LOS category. The team then developed an asset hierarchy and scoring matrices for consequence and likelihood of failure of an asset.

CUC's mission statement, which was used to develop the LOS categories, is stated on the utility's website: *The Commonwealth Utilities Corporation is dedicated to providing reliable, environmentally sensitive and efficient Power, Water, and Wastewater Treatment services for the people of the CNMI at the lowest reasonable cost while providing safety to the public, employees, and the community.*

Table 2.2.9-2. **CUC Levels of Service**

Level of Service Category	Target Value
Financial Impact *Weighting Factor*: 20%	Water and wastewater: Less than $1,000 required to remediate the asset failure.
System Reliability *Weighting Factor*: 25%	Water: No loss of service. Would not cause widespread water discoloration, taste, or odors. No water leaks (maintain water conservation). Wastewater: No loss of service or impact on other services. No sewer structure or basement backups.
Regulatory Compliance/Health *Weighting Factor: 45%*	Water: Primary and secondary drinking water standards met. No federal permit violations. No potential adverse health effects. Wastewater: No permit violations. No potential adverse health effects to employees or public (no potential for sewage related health problems. Any SSOs can be contained without reaching receiving waters and no impact to groundwater.
Public Image and Customer Service *Weighting Factor: 10%*	Water: Would not trigger complaints or media coverage. Affects no more than one customer and no major customers. Fire protection not impacted. No traffic interruption. Wastewater: Would not trigger complaints or media coverage. Affects less than one customer and no major customers. Only local and temporary traffic interruption. Up to 1 odor complaint.

Develop an Asset Hierarchy

An asset hierarchy is a catalog of utility assets that illustrates how the assets are related. The relationships between assets are organized in a parent-child format (Figure 2.2.9-2). The parent-child relationship can be established based on location or function. An asset hierarchy does not need to be a complete inventory of all assets, but it should be developed to a level at which data are consistent, typically the fourth (subcomponent) or fifth (element) levels. Initially, an asset hierarchy should use available information as its basis, including staff knowledge and data collected to date. As more detailed asset data are gathered over time (bottom-up activities), the hierarchy should be refined to ensure its accuracy.

Figure 2.2.9-2. **Sample Asset Hierarchy**

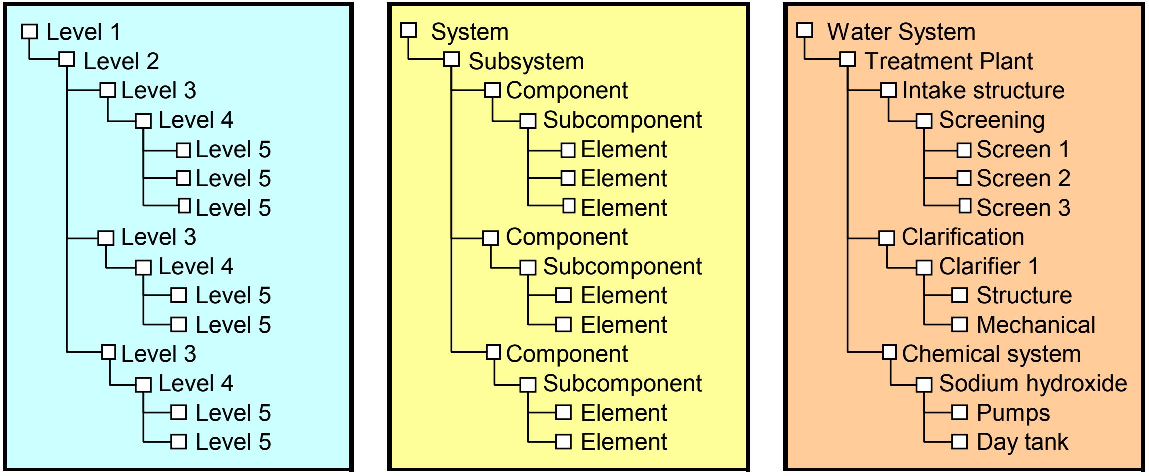
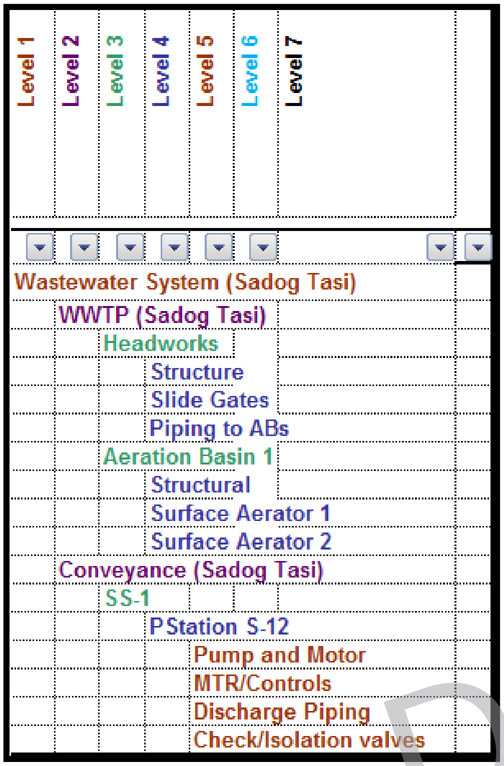


Figure 2.2.9-3 is a sample of the asset hierarchy for the Sadog Tasi Wastewater Treatment Plant. The full asset hierarchy is included as Appendix Q. The project team determined those assets that should be developed to a fourth level of detail based on available information.

Figure 2.2.9-3. **Sadog Tasi Wastewater Treatment Plant Asset Hierarchy**



- Wastewater System (Sadog Tasi)
  - WWTP (Sadog Tasi)
    - Headworks
      - Structure
      - Slide Gates
      - Piping to ABs
    - Aeration Basin 1
      - Structural
      - Surface Aerator 1
      - Surface Aerator 2
  - Conveyance (Sadog Tasi)
    - SS-1
      - PStation S-12
        - Pump and Motor
        - MTR/Controls
        - Discharge Piping
        - Check/Isolation valves

Develop Consequence of Asset Failure and Likelihood of Asset Failure Scoring Matrices

Risk assessment is key to a successful asset management program because it is the balancing point between minimizing cost and maintaining level of service. A decision to keep costs low, at any price, results in impacts to the level of service from failing infrastructure, just as a decision to provide an increased level of service with no regard to cost can result in inappropriate use of resources. Therefore, utilities must understand the risk associated with balancing service and cost.

Risk may be expressed as a function of the consequence and likelihood of an event. Consequence is the impact to different levels of service that results from an asset failure. For example, the consequence of a pump station failure could be insufficient capacity to convey sewage to the wastewater treatment plant, resulting in an overflow in the conveyance system. Likelihood of failure is the potential for an asset to fail. For example, an old, corroded pump would be more likely to fail than a new pump made from more reliable materials.

The simple mathematical calculation used in the risk-based evaluation of CUC assets is expressed as follows:

$$\text{Risk} = \text{Consequence} \times \text{Likelihood}$$

In assessing risk, consequence and likelihood are defined and quantified separately, then combined to calculate the risk of a specific asset. An asset that has a low consequence associated with its failure but a high likelihood of failure could have a lower overall risk compared to an asset that has a very high consequence of failure and a low likelihood of failure. In some cases, paying more attention to an asset or a group of assets in good condition could be of greater importance because failure might result in highly undesirable consequences, such as serious injury or loss of life.

Table 2.2.9-3 shows the consequence matrix and scoring system used to evaluate CUC wastewater assets. The consequences of the failure of an asset are expressed in terms of the LOS categories. Those categories include maintaining system reliability, complying with regulations (e.g., Health Hazard Criteria CNMI Safe Drinking Water Infrastructure Grant Program Documentation), maintaining safe conditions for the public and CUC employees, minimizing financial impacts, and maintaining the vitality of the island.

Table 2.2.9-4 is the likelihood of failure scoring matrix used to evaluate CUC assets. Similar to the consequence of failure matrix, likelihood-of-failure categories were developed to characterize the likelihood of failure of an asset. Physical condition, performance, and the ease or difficulty of performing O&M was used to assess the likelihood of failure. Scores ranging from 1 to 10 were assigned to each category of likelihood of failure. A score of 1 represented a negligible chance of failure. For example, a brand new pump would likely have a negligible chance of failure and would be given a score of 1 for likelihood of failure under physical condition. However, an old, corroded pump with a history of failures might be given a score of 10 under physical condition, indicating a high likelihood of failure. The weighting factor reflects the relative importance for each category.

Each category in the matrices was weighted by the project team according to its importance in meeting CUC goals. A numerical score ranging from 1 to 10 was assigned to each category. For all categories, a score of 1 (negligible) was given to the LOS target. If the LOS target was still met after an asset failure, then the consequence of the failure on that particular level of service category was deemed negligible. For example, when a health and safety LOS consequence has no potential for injuries or adverse health effects associated with an asset failure (that is, the target LOS), the asset received a score of 1. Conversely, if the potential existed for loss of life as the result of an asset failure, the score for the severe consequence was 10.

Score Relative Risks of Asset Failure Based on the Matrices

Using the consequence and likelihood categories, in conjunction with field data and institutional knowledge from CUC staff, the project team employed a Microsoft® Excel® spreadsheet to calculate relative risk scores for CUC's assets. The risk scoring process was used to evaluate assets objectively and comprehensively for the Wastewater Master Plan. To validate this process, the project team presented a summary overview of the preliminary risk scores to CUC staff in a workshop setting. CUC staff provided feedback about the relative risk profile of assets based on visual displays of risk scores that allowed comparison of related assets at a common hierarchical level. After validating nearly all of the scoring, CUC staff recalibrated underlying assumptions where results lay outside expectations. The scoring for those specific assets was adjusted and the new scores incorporated into the final tabulations. The end result was a high level of confidence in the asset risk ranking by CUC staff. Appendix Q contains the CUC asset hierarchy and risk scoring spreadsheet developed during the project. It illustrates how an asset's overall consequence score was calculated by multiplying the weighting factors by each associated consequence score to get an overall consequence score, ranging from a low of 1 to a maximum of 10. Similarly, the likelihood of failure score was calculated by multiplying the weighting factors and the associated likelihood of failure score to get an overall likelihood score.

Table 2.2.9-3. **Consequence of Failure Scoring Matrix: Water**

COF Category	Wt.	Negligible = 1	Low = 4	Moderate = 7	Severe = 10
Financial Impact	20%	<$1,000	Between $1,000 and $10,000	Between $10,000 and $50,000	Greater than $50,000
System Reliability	25%	No loss of service or impact on other services. No sewer structure or basement backups.	Minimal to some loss of service for up to 8 hours. No sewer structure or basement backups.	Some loss of service for more than 8 hours but less than 72 hours. May experience structure or basement backups.	Will cause loss of service for more than 72 hours. Most certain to cause structure or basement backups.
Regulatory Compliance/Health	45%	No permit violations. No potential adverse health effects to employees or public (no potential for sewage related health problems[1]). Any sanitary sewer overflows (SSOs) can be contained without reaching receiving waters and no impact to groundwater.	Technical permit violation. Possible notice of violation but enforcement action is unlikely for any SSO < 1,000 gallons. No to minor potential health effects to employees (e.g., working in traffic or confined space entry). Potential for suspected sewage-related health problems[1]. Potential to suspect effects on area waters.	Probable enforcement action but fines unlikely for any SSO ≥ 1,000 gallons and < 30,000 gallons. Minor potential health effects to employees (e.g., working in confined space entry). Intermittent to moderate sewage related health problems[1]. Intermittent to moderate effects on area waters.	Enforcement action with fines for any SSO > 30,000 gallons. Minor to major potential health effects to employees (e.g., working in confined space entry). Severe sewage-related health problems[1]. Severe effects on area waters.
Public Image and Customer Service	10%	Would not trigger complaints or media coverage. Affects less than one customer and no major customers. Only local and temporary traffic interruption. Up to one odor complaint.	Might trigger widespread complaints or media coverage. Affects 1 to 10 customers or one or two major customers. Generally local and temporary traffic interruption. Minimal odor complaints.	Likely to trigger widespread complaints or media coverage. Affects 10 to 50 customers or several major customers. Generally local but possibly major traffic interruption for days or weeks. Localized odor complaints.	Widespread complaints or media coverage. Affects > 50 customers or multiple major customers. Major extended traffic interruption for extended period. Widespread odor complaints.

1. Health hazard criteria from CNMI SDW Infrastructure Grant Program Documentation.

Table 2.2.9-4. **Likelihood of Failure Scoring Matrix: Wastewater**

Likelihood Category	Wt	1	2	4	7	10
Physical Condition	50%	Very good No corrective maintenance required	Good Few minor deficiencies and minimal corrective maintenance required	Fair Several minor deficiencies noted and corrective maintenance required	Poor Major deficiencies and significant corrective maintenance or rehabilitation required	Very poor Asset may be unserviceable, needs replacement or major rehabilitation
Performance	30%	Sufficient capacity to meet average and peak capacity requirements; appropriate utilization and function	Sufficient capacity to meet average and peak capacity requirements, but under-utilized or oversized resulting in inefficiencies	Sufficient capacity to meet current average capacity requirements but does not meet functional requirements or over-utilized	Able to meet current average capacity demands but not peak demands	Unable to meet current average capacity requirements
Ease/Difficulty of O&M	20%	Site is easily accessed; equipment is easily accessible; spares are available; CUC may do maintenance in-house	Site is easily accessed; equipment is easily accessibly; spares mostly available; CUC may do maintenance in-house	Site has some access constraints; equipment not easily accessed (requires mobilization of access equipment); some spares available; maintenance may require a third party	Site is difficult to access; equipment not easily accessed (requires mobilization of access equipment); no spares at CUC (but on island); maintenance likely to require a third party	Severely constrained site access; extremely difficult to access equipment (requires mobilization of access equipment); no spares at CUC or on island, maintenance requires a third party.

The asset risk score, then, is the product of the consequence score multiplied by the likelihood of failure score, with one (1) being the lowest possible score and 100 being the highest. For both the Consequence of Failure (COF) Table 2.2.9-3, as well as the Likelihood of Failure (LOF) Table 2.2.9-4:

COF *(or LOF)* = sum of (Wi x Si)

Where:

Wi = the weight for each LOF category (percentage)

Si = the score for each LOF category (scale of 1 to 10)

The maximum COF *(or LOF)* score is therefore 10. The risk score is derived from the Risk = COF × LOF (maximum score = 100).

The risk scoring took place at the CUC offices on the following days:

- Thursday, October 27, 2011 – Water facilities (Saipan, Rota, and Tinian)
- Friday, October 28, 2011 – Wastewater facilities (Saipan only)
- Thursday, November 3, 2011 – Water and wastewater facilities final scoring and adjustments

Note that Rota and Tinian wastewater facilities were not evaluated; Rota's small sewer system is not currently considered operational, and Tinian employs septic fields only.

Rank Assets by Greatest Risk

Figures 2.2.9-4 through 2.2.9-11 illustrate the risk scores for key groups of CUC wastewater assets. Upper and lower boundaries were defined for the three risk categories (i.e., low, medium, and high risk) based on the range and spread of risk scores for all of CUC's wastewater assets; analysis of a columnar array of the risk scores was performed to identify natural breaks in the risk scores that would help to determine the upper and lower boundaries. Identification of risk score boundaries also took into consideration the fact that a relatively small number of assets should be identified as "high risk"; otherwise it is unrealistic for CUC to focus on reducing the risk of these high-risk assets due to financial restrictions. These initial risk thresholds were then presented in a workshop with CUC personnel for verification. Table 2.2.9-5 summarizes the frequency distribution of wastewater asset risk scores within the three risk categories.

Table 2.2.9-5. **Frequency Distribution of CUC Wastewater Risk Scores**

	Frequency (n)	**Frequency (%)**
Risk ≤ 30	107	71.3%
30 < Risk < 49	35	23.3%
Risk ≥ 49	8	5.4%

Assets that have a risk score equal to or greater than 49 have been labeled as high risk assets and should be the top priorities for CUC in the immediate future. Those assets with a risk score between 30 and 49 are identified as medium risk assets, and assets with a risk score less than 30 are considered low risk assets. The categorization of CUC's assets into these three risk categories will aid CUC in implementing a long-term CIP, which will be addressed in the final phase of this project as part of the Master Plan Report. The high-, medium-, and low-risk assets are delineated in Figures 2.2.9-4 through 2.2.9-11. Red and yellow horizontal lines that break the assets into categorized risk groups: assets below the yellow line are considered low risk, assets between the yellow and red lines are considered medium risk, and assets above the red line are considered high risk.

As shown in Figures 2.2.9-4 and 2.2.9-5, the high-risk asset category in Saipan's wastewater collection system comprises generators and pump stations. None of the wastewater collection system or treatment plant assets is identified as a high-risk asset (see Figure 2.2.9-6). Ten of the 15 collection system assets, which include gravity pipes and force mains, are low-risk assets; the other five sub-sewershed collection system pipes are medium-risk assets with risk scores between 30 and 49. The Agingan and Sadog Tasi WWTP assets have relatively low risk scores in comparison to pump station, collection system, and generator assets with the exception of the plant outfalls and the secondary clarifier at Sadog Tasi, which are identified as medium-risk assets.

The pump stations in Figure 2.2.9-7 are categorized as high, medium, and low risk; pump stations that are perceived as troublesome assets either by CUC staff, or EPA and DEQ as indicated by requirements set forth in the Stipulated Order, are also identified in the exhibit. All but two of the perceived troublesome pump stations have a calculated risk score greater than 22, making the assets either a high- or medium-risk asset. This is a favorable outcome, indicating that the approach used by the project team to calculate asset risk scores will produce results in which CUC can have confidence with regard to identifying high-priority assets.

Most of the generators at the pump station sites are not operable, which resulted in more than half of the generators having a high or medium risk score (see Figure 2.2.9-8). Final recommendations to restore the generators to operable condition will be made in the Wastewater Collection System Condition Assessment section; the risk assessment analysis consistently identified generators as disproportionately high and medium risks compared to other asset types.

Few assets in the the WWTP risk assessments scored above the low range. The effluent outfall and secondary clarifier at the Sadog Tasi WWTP had medium risk (see Figure 2.9.9-9). The effluent outfall pipe at the Agingan WWTP was the only asset listed as at medium risk for the plant (see Figure 2.9.9-10).

Risk scores were also calculated for the heavy equipment (e.g., backhoes, fleet vehicles, etc.) on Saipan. The equipment used for wastewater O&M was scored separately from the equipment used for maintenance of the drinking water system. Figure 2.2.9-11 summarizes the risk scores for the wastewater system's heavy equipment. All of the heavy equipment was classified as low risk.

Figure 2.2.9-4. **Risk Scores for All Saipan Wastewater System Level 4 and Level 5 Assets – Part 1 (scores over 20)**

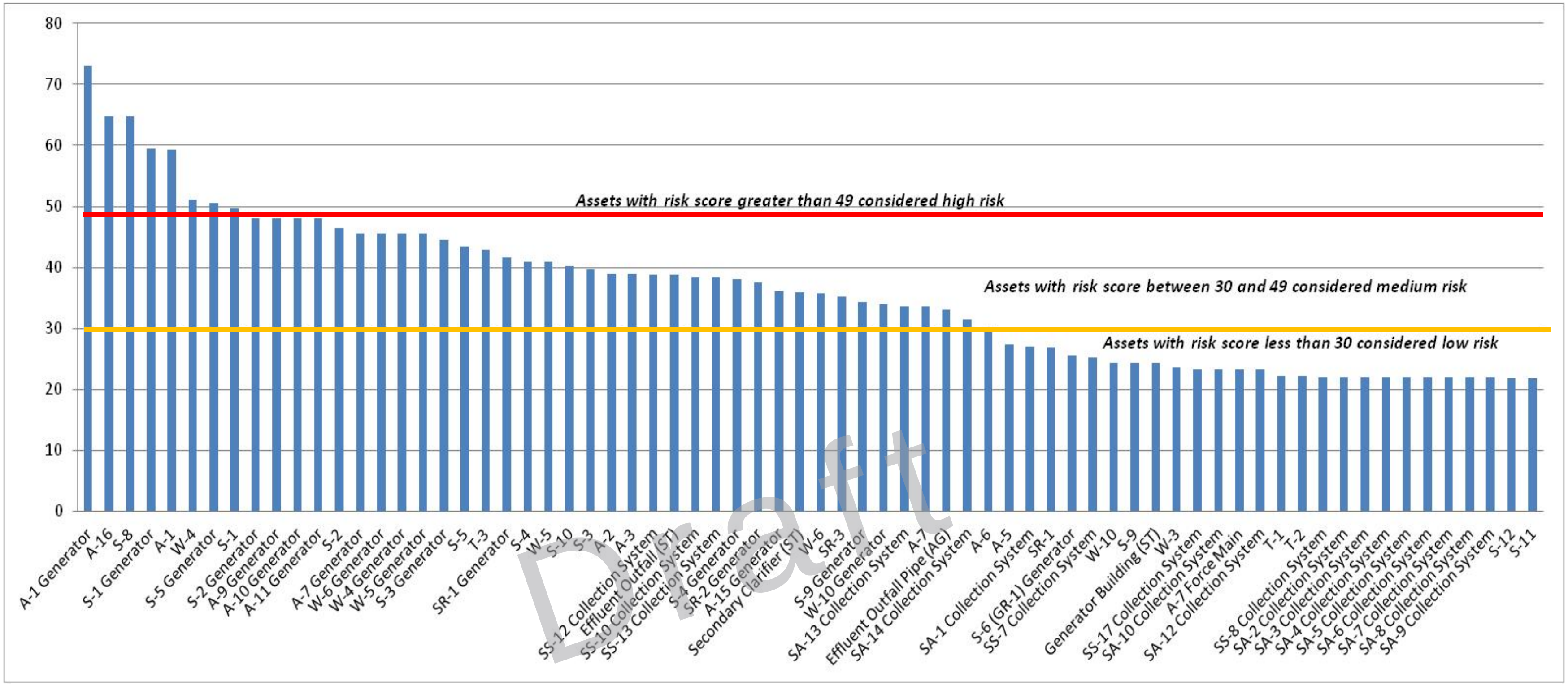


Figure 2.2.9-5. **Risk Scores for All Saipan Wastewater System Level 4 and Level 5 Assets – Part 2 (scores under 20)**

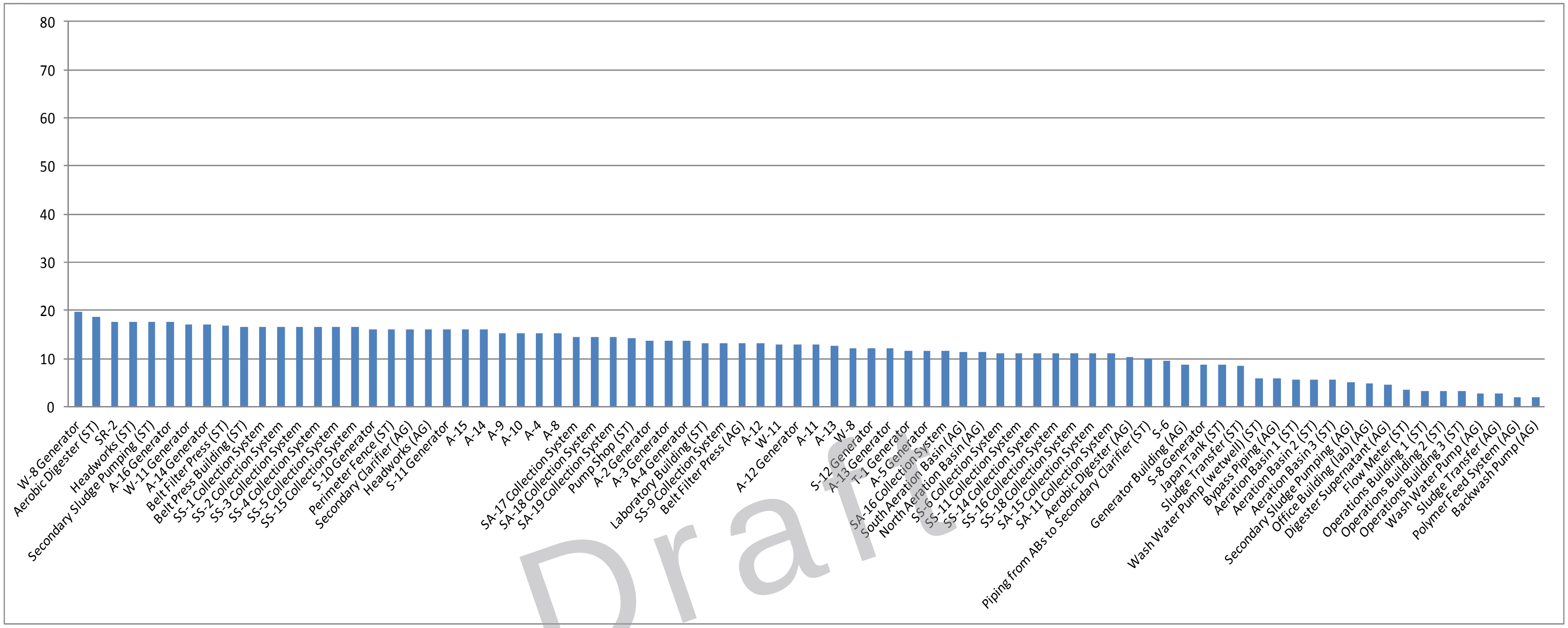


Figure 2.2.9-6. **Risk Scores for Saipan Wastewater Collection System Assets**

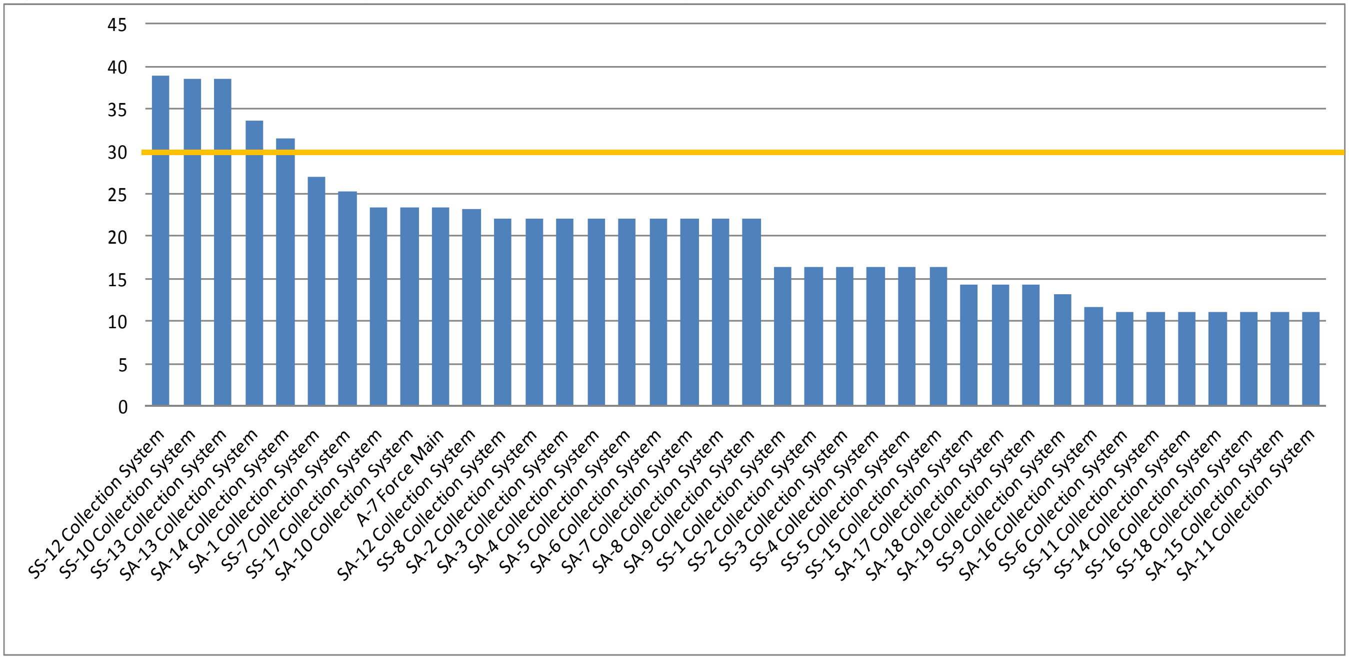


Figure 2.2.9-7. **Risk Scores for Saipan Wastewater System Pump Station Assets**

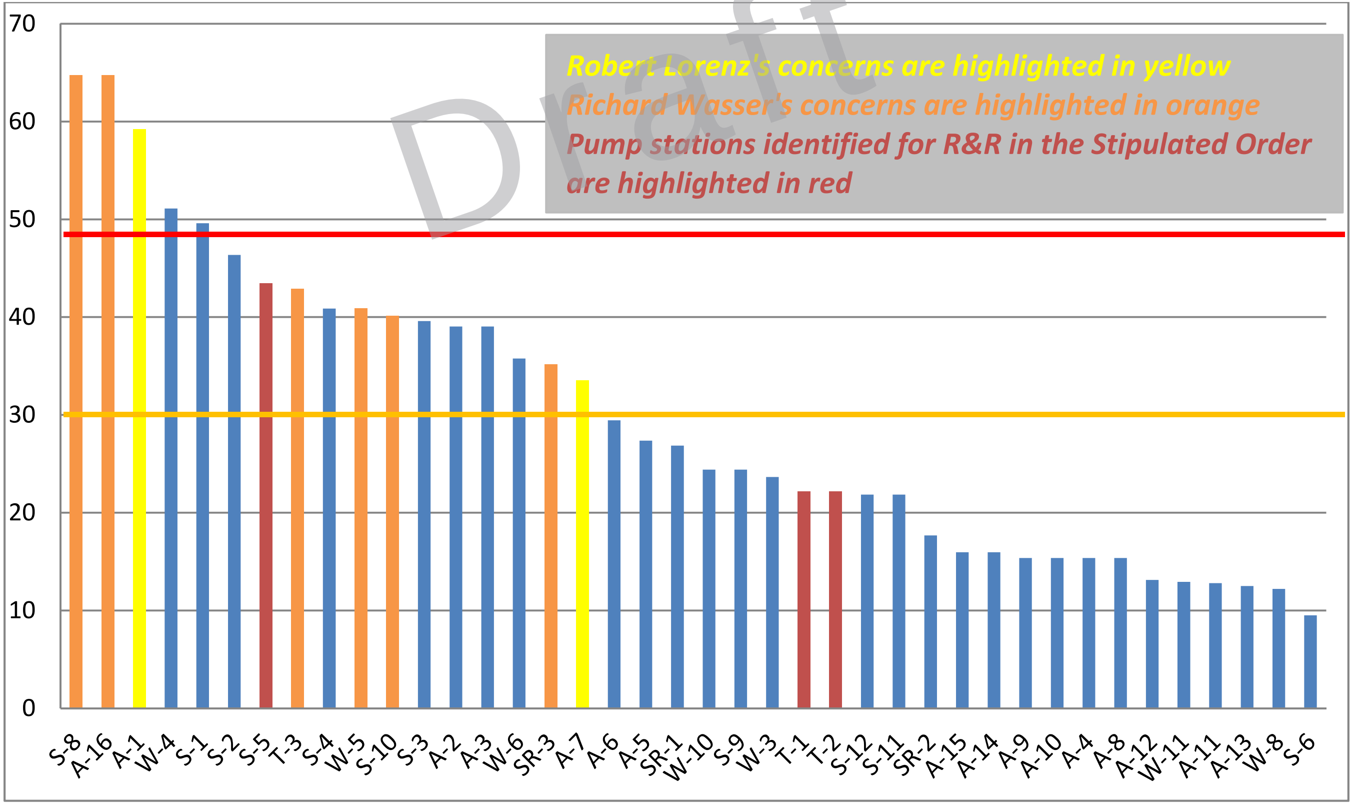


Figure 2.2.9-8. **Risk Scores for Saipan Wastewater System Generators**

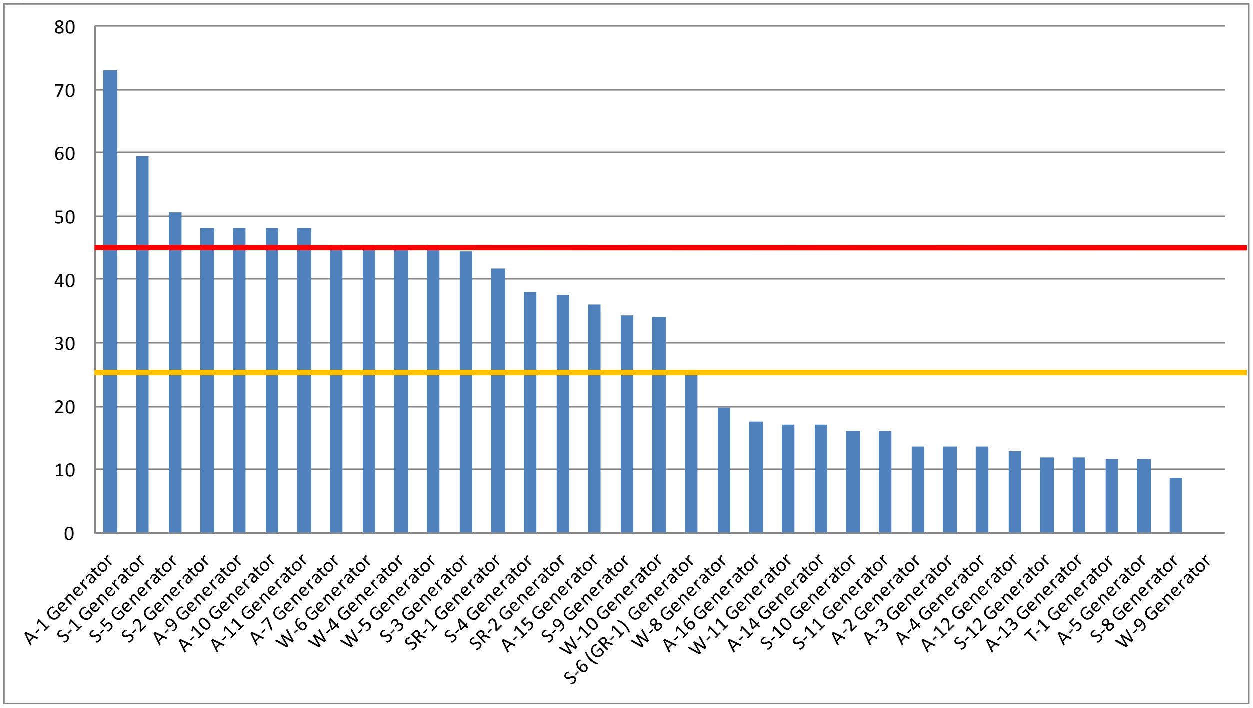


Figure 2.2.9-9. **Risk Scores for Saipan Sadog Tasi Wastewater Treatment Plant**

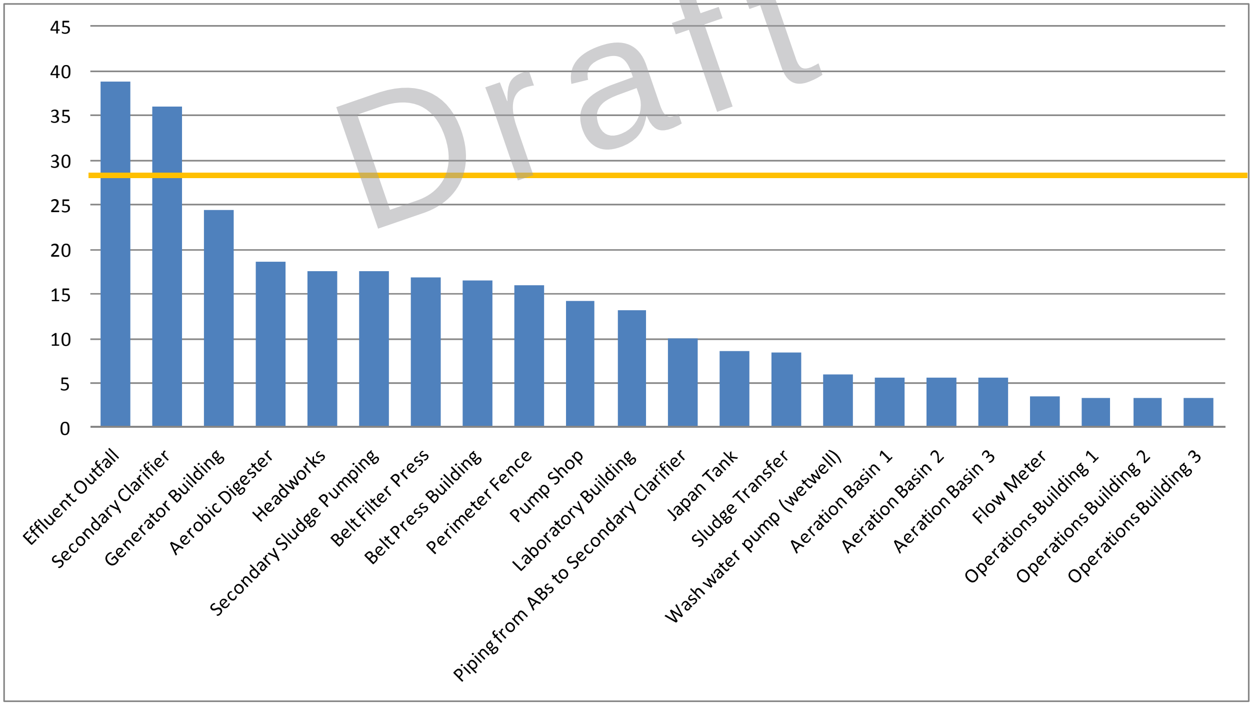


Figure 2.2.9-10. **Risk Scores for Saipan Agingan Wastewater Treatment Plant**

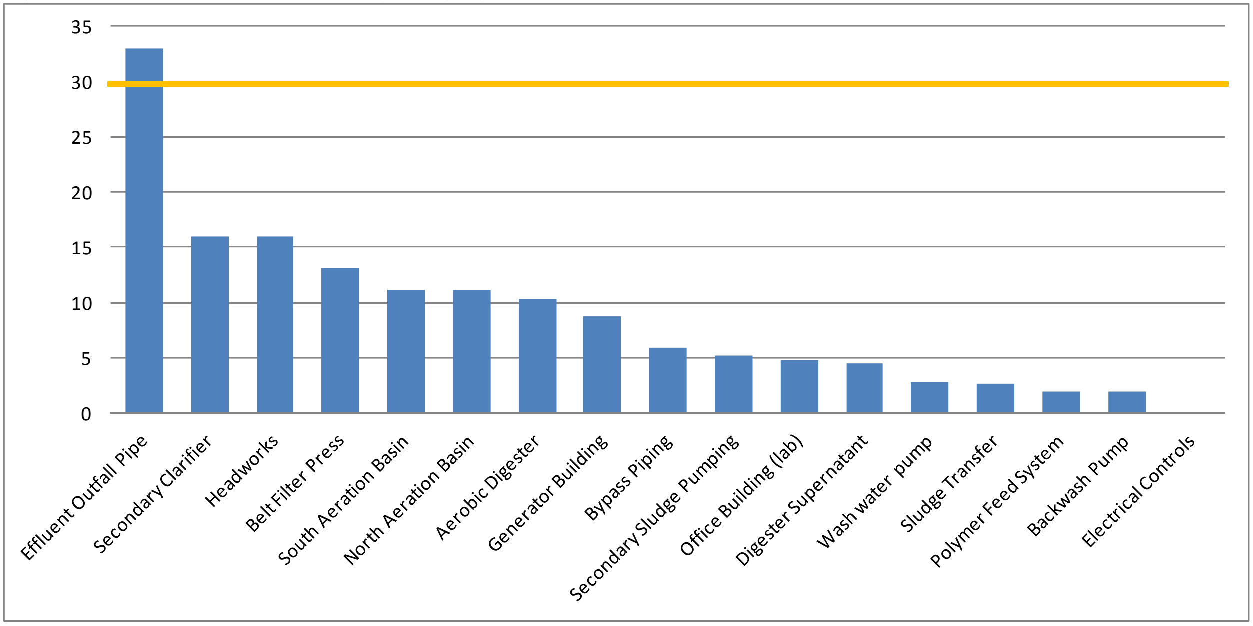
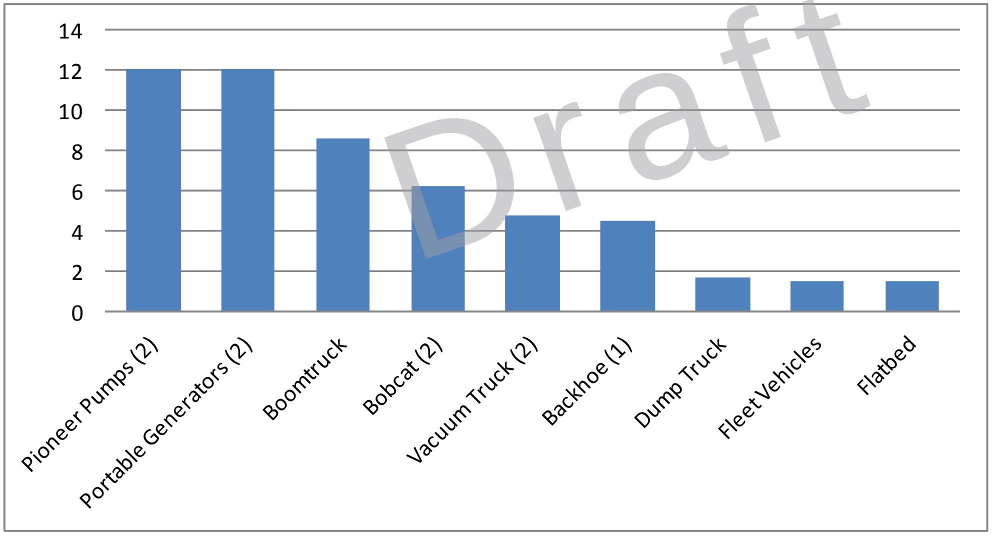


Figure 2.2.9-11. **Risk Scores for Saipan Wastewater System Heavy Equipment**



Summary of Risk Assessment Key Findings and Recommendations

The key information provided by the risk assessment exercise was the prioritization of assets based on relative risk scores and the identification of high-risk assets, which have been summarized in Table 2.2.9-6 for the wastewater system. This information was critical to the project team as it identified short-term and long-term capital improvement projects for the Master Plan. The project team analyzed the risk assessment results in conjunction with the condition assessment information, hydraulic modeling results, and CUC staff's knowledge of the systems to develop a list of projects, as well as O&M improvements, deemed necessary.

Table 2.2.9-6. **Saipan Wastewater System High-Risk Assets (Risk Score Greater than 49)**

Asset Name	Risk Score
A-1 Generator	73
S-8 Pump Station	65
A-16 Pump Station	65
S-1 Generator	60
A-1 Pump Station	59
W-4 Pump Station	51
S-5 Generator	51
S-1 Pump Station	50

Condition Assessment Recommendations

The risk assessment result can also be used to help guide condition assessment activities such as smoke testing and CCTV work. Those collection system conveyance pipes with the relatively highest risks (see Figure 2.2.9-6) should be considered for CCTV activities to identify the repairs and rehabilitation required to decrease the likelihood of pipe failure. Additional field condition assessments (e.g., smoke testing) should be considered in relatively higher-risk sub-sewersheds where I/I is suspected to be a cause of system overflows, resulting in high LOF scores.

Recommendations from Risk Assessment Workshops

Knowledge transfer is a concern among CUC staff, mainly due to the relatively high turnover rate of experienced technical and maintenance staff at CUC. The majority of CUC staff responsible for operating and maintaining the water and wastewater systems have been with the utility for a very brief time. Currently a vast amount of system knowledge is kept in the memory of specific employees and not necessarily recorded consistently. The risk assessment process was a good start to addressing the issue of knowledge transfer between the more experienced staff and newer employees. The development of the asset hierarchy was the first step in transferring all this knowledge from an individual’s memory to a document.

It is good practice to continue to ensure that critical system knowledge is written down, recorded, and stored such that any new employee can easily access and understand the information. Now that the asset hierarchy has been developed, this Excel®-based tool is a simple and effective way to manage assets. As new information is obtained, or as assets are improved upon or removed from the system, the asset hierarchy should be updated. It is recommended that the asset hierarchy be updated as these changes are made to the system. The asset hierarchy and LOF scores should be reviewed every year and revised as needed. The COF scores do not need to be updated as frequently; every 3 to 5 years the COF scoring matrix should be reviewed to ensure levels of service have not drastically changed.

SECTION 3

Master Planning Criteria

The contents of Section 3, "Master Planning Criteria" are as follows:

3.1 Twenty-Year Population Projections

These population projections for Saipan are intended for use in planning new and improved water infrastructure. Consequently, the data of primary concern are number of residents and where they will reside. Other situations that generate a temporary demand for water services, such as places of employment, other places of congregation, and tourist venues, are not analyzed.

Three factors will affect the population growth of Saipan:

- Natural growth rate through births and deaths.
- Immigration and emigration resulting from economic growth due to initiatives by the government of the CNMI and the local business community. This includes aliens as well as inter-island migration among residents.
- Immigration and emigration resulting from economic growth generated by external stimuli, such as that by the U.S federal government and international parties.

While some interrelationships exist among these factors, they can be analyzed separately for purposes of determining the affect that each exerts on population growth for the short term (2015), medium term (2020), and long term (2030). Further, each of the three factors will influence population growth somewhat differently for Saipan, Tinian, and Rota, the three islands for which population projections were prepared as part of the development of Drinking Water and WW System Master Plans for each island.

The basis for these population projections is the year 2010 census for CNMI and growth rates established by the U.S. Census Bureau, which have been adopted by the Central Statistics Division of the CNMI Department of Commerce (Andrew, 2013).

3.1.1 Estimating Saipan’s Current Population as of January 2012

Before population projections can be developed for Saipan, it is first necessary to determine the current population as of January 2012. Saipan has witnessed a remarkable decline in population over the past 12 years. As shown in Table 3.1.1-1, between 2000 and 2010 alone, population declined by 22.7 percent.

Table 3.1.1-1. **Population of Saipan from 2000 through 2010**

Year	Census	Change since 2000 (percent)	Source
2000	62,392	--	U.S. Census Bureau
2005	60,608	- 9.7	U.S. Department of Interior (2010)
2010	48,220	- 22.7	U.S. Census Bureau

Advancing the year 2010 population count to year 2012 is difficult because the last census count in April 2010 included approximately 21,000 aliens who were legal under the former CNMI immigration policies (see Table 3.1.1-2). That figure was estimated by the U.S. Department of Interior in a report issued the same month as the year 2010 census.

Table 3.1.1-2. **Legal Aliens in the Commonwealth of the Northern Mariana Islands as of April 2010**
Source. U.S. Department of the Interior, 2010

Category	**Number**
Alien Workers	16,304
Alien Business Owners and Investors	548
Alien Immediate Relatives of Aliens and U.S. Citizens	2,933
Alien Students	869
Subtotal Number of Legal Aliens	20,654
Illegal Aliens in the CNMI	205
Total Aliens Residing in the CNMI	**20,859**

Note: This tally does not include citizens of the Freely Associated States.

No data are available to allocate these aliens among Saipan, Tinian, and Rota. However, in discussions with officials from Tinian and Rota where the relatively small land area and low population permit empirical evidence, it is estimated that approximately 800 aliens (Liu, 2012) resided on Tinian and approximately 600 aliens (Mendiola, 2012) resided on Rota in 2012. However, it is impossible to determine a reliable estimate of aliens on Tinian and Rota in 2010. Therefore, in order not to underestimate the number of aliens on Saipan for the purposes of these projections, all 20,859 aliens are assumed to live on Saipan in 2010.

Since 2010, those 20,859 aliens have either left CNMI or are now in the process of transitioning from their former status under CNMI immigration law to complying with U.S. immigration regulations. Further, some unknown number of those aliens are dependents of aliens being petitioned, and those dependents must leave if the petition for the primary beneficiary is denied.

To establish a base year population in year 2012 for Saipan, it would be necessary to determine how many of those aliens have remained in Saipan since the Department of Interior report in 2010. Those data are unavailable. The .S. Citizenship and Immigration Services (USCIS) District Office for Hawaii, Guam, and the Northern Mariana Islands is unable to provide data regarding the number of aliens in the CNMI or in Saipan, Tinian, or Rota in April 2010 when the census was taken, the number of aliens currently in the CNMI or in Saipan, or the number of aliens who petitioned for continued residency in Saipan (Gulick, 2012).

Therefore, it is necessary to rely on a consensus of opinion regarding the number of former aliens who have remained in Saipan as of January 2012. Approximately 11,000 aliens have petitioned[2] for CNMI-Only Transitional Worker (CW) visa status as of December 2011 (Eugenio, 2012). This would likely include the estimated 800 from Tinian and 600 from Rota, leaving about 9,600 petitioners on Saipan. To those petitioners on Saipan an allowance must be made for dependents who would stay on Saipan in the event the primary petitioner is approved. For purposes of these projections, it is assumed that 15 percent of the aliens on Saipan have dependents (at one dependent per alien), amounting to 1,400 (9,600 x 0.15) dependent aliens. Consequently, the total number of aliens on Saipan as of January 2012 is estimated at 9,600 petitioners and 1,400 dependents, which equals 11,000 aliens on Saipan.

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[2] Note that the aliens are not "petitioners" per se but beneficiaries, inasmuch as it is the employers that petition USCIS. However, the common parlance is to refer to the aliens as petitioners, and that reference is carried in this report.

This conclusion indicates that approximately 10,000 have left Saipan or are unaccounted for (nearly 21,000 counted in 2010 less 11,000 petitioners and dependents), which more or less comports with the opinion of Governor Fitial, who stated that, "a lot of them <aliens> have already been going home or preparing to go home because they themselves know that they can't have it <legal residency>" (Erediano, 2011). It is likely that this reduction in alien population occurred primarily as a result of the recent economic downturn in construction and tourism coupled with the prospects for stricter requirements by USCIS for visas and fewer opportunities to be petitioned for employment.

For the purpose of this estimate of Saipan's current population as of January 2012, it is assumed that Saipan has approximately 37,220 residents (2010 census of 48,220 less 10,000 aliens who have left or who have not petitioned for residency). Of the residents remaining, approximately 11,000 are aliens and dependents who have petitioned USCIS for residency, leaving an approximate total of 26,220 non-alien (or permanent) residents on Saipan.

It should be noted that two tracts of legislation are now proposed to counter the USCIS application of a CNMI-Only Transitional Worker (CW) visa: one by Governor Fitial and one by CNMI Delegate Gregorio Kilili Sablan (H.R. 1466). It is beyond the scope of this report to assess the pros and cons of each piece of legislation as well as their potential for enactment. However, either proposal, if executed in part or in whole, would substantially affect the prospects for CNMI alien residency under the jurisdiction of USCIS. Consequently, any change to the current USCIS jurisdiction and regulations would necessitate a new analysis of these population projections.

Saipan has also experienced a loss of permanent population between the census in April 2010 and year 2012. Data released post-census by the U.S. Census Bureau to CNMI Department of Commerce estimate a decrease in population of 2.55 percent and 1.49 percent for years 2010 and 2011, respectively, for CNMI (no distinction among islands). This decline in population will be assigned to permanent residents, not to legal and illegal aliens, as the U.S. Census Bureau cannot be expected to have followed the CNMI immigration situation as closely as this master planning project. For purposes of this projection, the number of legal and illegal aliens on Saipan will be held without growth at 11,000 for the period between 2010 and 2012.

The natural decrease for permanent residents between years 2010 and 2012 yields a change in population calculated as follows:

- For year 2010, assume 27,400 permanent residents (2010 census of 48,220 less 20,859 aliens, rounded)
- For year 2011 = 27,400 less 2.55 percent (699) = 26,701
- For year 2012 = 26,701 less 1.49 percent (398) = 26,303

In sum, the estimated population on Saipan for January 2012 is 37,303 based on the following:

- Year 2010 permanent residents of 27,400 less years 2011 and 2012 decrease = 26,303
- Plus aliens of 11,000
- Therefore, 26,303 plus 11,000 = 37,303

3.1.2 Projecting Saipan's Population as a Result of Economic Growth through Business Initiatives by the CGCNMI and Local Businesses

The government of CNMI and the Saipan business community engage in several initiatives that promote economic development and, therefore, population growth through the need for workers beyond those available as residents of CNMI. Once the local labor market is exhausted due to either too few workers or unavailable skills, immigrant workers will be needed. These initiatives include tourism, Article 12 changes in land ownership, development of a casino, increased agricultural output, and Saipan as a venue for foreign retirees. Note that this report does not assess the direct and indirect economic benefits of each initiative nor evaluate the benefits and risks associated with each. Instead, this report summarizes the initiatives, estimates a timeline for implementation, and projects population growth as a result.

- ***Tourism.*** As Saipan's leading industry, tourism is the bedrock of economic growth for the Island. The relationship between tourist arrivals and workers in the tourism industry is both direct and indirect; as the industry expands and recedes, its workforce swells and shrinks proportionately. This workforce includes hotel workers as well as those employed by tourism support businesses such as airlines, ground transportation, tour operators, food and beverage suppliers at the retail and wholesale levels, various vendors for entertainment and maintenance, and construction and repair contractors.

  For the short term, CNMI tourism is tracking approximately 15 percent below previous activity and has declined 30 percent from 2005 to 2009.

  Looking forward, some additional flights from Korea and Hong Kong as well as other upgraded aircraft are expected to gradually increase tourist arrivals; Chinese and Russian tourists continue to arrive under the current visa waiver program for those countries. Also, Delta is entering the Korea-Saipan market for the first time, and Asiana Airlines recently boosted its Incheon-Saipan service from 10 to 14 weekly flights and has increased the size of its aircraft.

  Overall, however, the Marianas Visitors Bureau (MVA) is constrained from launching grand initiatives to dramatically improve tourism to its halcyon era of the mid-1990s or better. Local budgetary constraints and U.S. immigration regulations combine to restrict marketing programs by MVA for easy access and convenient airline connections by East Asian tourists, Saipan's prime market area. Inasmuch as neither of those constraints is likely to change, tourism will have only a minimal affect to population growth on Saipan for the short and medium term. However, its impact for the long term could be very significant if combined with other local initiatives and beneficial external stimuli.

  Saipan currently has 3,222 hotel rooms including the former Palms Resort, which is expected to re-open by year 2015. That inventory translates as 1,176,030 room nights per year. To operate marginally at a minimum of 62 percent occupancy, Saipan must fill at least 730,000 room nights. The average Saipan tourist stays 4 nights and shares a room with one other person (Russian tourists are an exception, staying longer). Consequently, Saipan must attract at least 365,000 tourists per year for the tourism industry to succeed financially. From 2005 through 2009, CNMI averaged about 354,000 tourists per year. In 2010 about 379,000 tourists arrived, but in 2011 tourist arrivals declined to 338,106, primarily as a result of the crippling affect to Japanese tourism resulting from that country's triple disaster in March 2011.

Inasmuch as tourist arrivals have been hovering around the breakeven or lower threshold for almost a decade, it is unlikely that new hotel development, spurring increased population through immigrant workers, will occur in the short-, medium-, or long-term time frames. With existing hotel room capacity and an occupancy jump from 62 percent to 85 percent, for example, an additional 135,000 tourists per year could be absorbed, or about 42 percent (Taitano, 2012) more than arrived in 2011. Even with a gradual increase over time, prospective hotel developers are likely to look for saturation on a multi-year, consistent basis before investing in a new hotel. Consequently, no additional population is projected as a result of tourism for the 2015, 2020, and 2030 horizons.

- ***Article 12.*** Changes in Article 12 of the CNMI constitution are proposed to open the ownership of land to other than CNMI citizens. This initiative will likely spur economic growth among several business sectors by allowing foreign investors to own and develop real estate. While this initiative is still in its infancy of deliberation and of uncertain outcome with neither details nor timeline yet established, it is unlikely to have any effect for the short term or medium term. However, it could definitely create the type of economic growth that will increase population in the long term by affording opportunities for second homes or retirement homes to aliens with commensurate visa privileges. While owners of second homes would not, by definition, be full-time residents, they would likely live on Saipan several months of the year. Owners of a home for retirement would be considered as permanent residents. As to the possibility of alien ownership of hotel properties, however, population growth would not occur without a dramatic change in the tourist arrivals, as discussed previously. Even if Article 12 amendments did occur, the timeline would be long and the likely impact would be modest. Overall, no additional population is expected through this initiative for the year 2015 and 2020 horizons; however, relaxed requirements for land ownership could affect the year 2030 projections (Garrett, 2004)***.*** The Saipan casino initiative has also been under serious discussion as a local initiative to spur economic development. This contentious initiative is unlikely to have an impact by either the 2015 or the 2020 horizon dates. While a casino would undoubtedly create employment, it is likely that most employees would be local hires. However, most casino jobs require some skill, be it accounting, dealing cards, security, or other expertise (Garrett, 2004). Such specialty employees, including others such as slot techs, undercover surveillance, and managers, all on a 24/7 schedule, would add to Saipan's population, probably in the range of 200 by year 2030.
- ***Agriculture Exports.*** Saipan has a strong potential for agriculture exports, and with current initiatives for less expensive but reliable transportation, this industry could spur economic growth. However, agricultural employees are already available on Saipan, so this initiative would have only a negligible impact to future population growth.
- ***Retirement Venue for Foreigners.*** By taking advantage of the island's relaxed pace of life, U.S. security, and vivid natural beauty as backdrop, Saipan is being recommended as venue for retirement residence by foreigners. The Saipan Chamber of Commerce goal is 20,000 retiree residents by 2020, with or without changes in Article 12 to permit land ownership. However viable the feasibility and stiff the competition may be, this initiative relies on favorable visa opportunities for long-term residency, corollary services such as adequate medical and local transportation options, and major investment in adequate housing with senior citizen amenities. All that does not seem possible to set in place by year 2020; however, this initiative could impact population by 2030.

3.1.3 Projecting Saipan's Population as a Result Economic Growth Generated by External Stimuli

In addition to local initiatives to generate economic development that might increase population, CNMI's economy, and Saipan's in particular, may also benefit from external stimuli such as changes to U.S. federal financial support, international trade policies, immigration regulations, foreign currency fluctuations, and similar circumstances that are largely out of the Commonwealth's control.

With respect to impacts resulting from the relationship between the government of CNMI and the U.S. federal government, the most likely areas of dramatic influence include increased (or reduced) annual federal funding, exceptions to immigration laws and regulations, new foreign trade treaties, changes in international and interstate commerce laws and regulations, and flow-over from the proposed military build-up on Guam. These types of events are generally slow to materialize and impossible to predict years in advance. Inasmuch as annual federal funding has been stable, the USCIS has just recently taken control in the CNMI, tourist visa waivers for Chinese and Russians are in place, and changes in foreign and interstate policies take years to formulate and become effective, no dramatic impact to population is reasonably expected from these potential stimuli by either 2015 or 2020, but change may emerge by 2030. Although the military build-up on Guam is likely to occur before 2020, analyses by others indicates that such prosperity on Guam and the resultant availability of jobs there would probably draw workers (and possibly their families) away from the CNMI.

Other external stimuli to CNMI's economy and population growth as a result of international influence include changes in the U.S. dollar and foreign currency exchange that could prompt major investment and travel, and some form of favored-island status granted by another country that could lead to foreign investment and population growth through either alien residents and/or employment. None of these forms of external stimuli are likely to result in additional population by either 2015 or 2020, but could materialize by 2030.

In summary, local initiatives and external stimuli can be expected to account for the population increases listed in Table 3.1.3-1.

Table 3.1.3-1. **Likelihood of Population Increases Due to Various Factors by 2015, 2020, and 2030**

	By 2015	By 2020	By 2030
Tourism	0	0	0
Article 12	0	0	Possible (1,000)
Casino	0	0	Possible (200)
Agriculture	0	0	0
Retirement Venue	0	0	0
U.S Federal Government Stimuli	0	0	Possible (300)
International Stimuli	0	0	Possible (1,000)

To account for the possibility of increase in population by year 2030 for the Article 12 and casino initiatives as well as U.S. federal and international stimuli, an additional 2,500 in population will be projected on the basis that all these local initiatives and external stimuli are re-examined before year 2020.

There is also some evidence of inter-island migration among Saipan, Tinian, and Rota for both employment and family reasons; however, the net change appears to be inconsequential.

3.1.4 Projecting Saipan's Population for Year 2015

Inasmuch as neither local initiatives nor external stimuli are expected to affect Saipan's population between year 2012 and year 2015, the island's population will be affected by only two factors: natural growth rate of permanent residents and aliens, and the disposition of some 11,000 aliens, whose applications for residency will be adjudicated by USCIS.

The natural growth rate for CNMI was projected by the U.S. Census Bureau for CNMI (no distinction among islands) for years 2013, 2014, and 2015 as -0.44 percent, 0.61 percent, and 1.66 percent, respectively. This represents a 1.83 percent cumulative growth between 2012 and 2015. This minimal increase in population will be assigned to permanent residents, not to legal and illegal aliens, as the U.S. Census Bureau cannot be expected to have followed the CNMI immigration situation as closely as this master planning project.

Permanent Saipan residents in 2012 number 26,303. Cumulative growth of 1.83 percent (or 481 people) over 3 years results in a total of 26,784 in 2015. For purposes of this projection and in reflection of the minimal growth by permanent residents, legal and illegal aliens will be held to be without growth between 2013 and 2015 at 11,000.

No data are available to estimate the number of aliens who will be approved for residency: it could be all 11,000 or none (although it is unlikely that no applications will be approved). For purposes of this projection, therefore, a high and low range of projections is offered:

- **High Range.** Permanent residents at a natural growth rate of 1.83 percent or the years 2012 to 2015 plus all 11,000 of the alien applications are approved, with no natural growth rate for aliens.
- **Low Range.** Permanent residents at a natural growth rate of 1.83 percent for the years 2012 to 2015 plus one-quarter (2,750) of the applications are approved, with no natural growth rate for aliens.

With these assumptions, the population projections for Saipan for year 2015 are as follows:

- Year 2015 high range: 37,784
  - Year 2012 permanent residents of 26,303 plus cumulative growth of 1.83 percent (481) for 3 years = 26,784
  - Year 2012 aliens of 11,000 at no natural growth
  - Therefore, 26,784 plus 11,000 = 37,784
- Year 2015 low range: 29,534
  - Year 2012 permanent residents of 26,303 plus cumulative growth of 1.83 percent (481) for 3 years = 26,784
  - Year 2012 aliens of 2,750 at no natural growth
  - Therefore, 26,784 plus 2,750 = 29,534

With these assumptions, the population projections for Saipan for year 2015 are as follows:

- Year 2015 high range: 37,784
- Year 2015 low range: 29,534

With respect to the variance in permanent residents between the 2010 census and the 2015 estimate, the component of Saipan's population declined by 2.25 percent (48,220 census less 20,859 aliens = 27,400 permanent residents [rounded] in the year 2010 versus 26,784 in year 2015).

3.1.5 Projecting Saipan's Population for Year 2020

The natural growth rate for CNMI was projected by the U.S. Census Bureau for CNMI (no distinction among islands) for years 2016 through 2020 as:

- 2015 – 2016 @ 2.12 percent
- 2016 – 2017 @ 2.02 percent
- 2017 – 2018 @ 1.93 percent
- 2018 – 2019 @ 1.84 percent
- 2019 – 2020 @ 1.76 percent (Andrew, 2013) for a 5-year average growth of 1.93 percent

There is no ostensible reason to expect CNMI's population to grow that quickly. With immigration now permanently under the control of the U.S. federal government and prospects for robust economic growth still elusive, it is unlikely that CNMI's natural growth rate could grow at a pace approaching population stability (i.e., 2.1 percent). Indeed, 97 percent of the world's population live in countries that *are* seeing fertility decline, and the Total Fertility Rate (TFR, i.e., the number of babies the average woman would bear over the course of her life if she were to survive until the end of her reproductive years) for the United States is also 1.93 percent (Andrew, 2013). While the U.S. Census average growth rate and the TFR are not interchangeable indices, they do offer a valuable perspective. Based on empirical reasoning alone, it is more likely that CNMI's growth rate will occur between 1.5 percent and 1.75 percent for these next 5 years of projections.

Nonetheless, in the absence of evidence to the contrary and the precaution to overestimate rather than underestimate for purposes of planning long-term infrastructure improvements, the U.S. Census Bureau projections will be used for this report.

With respect to natural growth rates for aliens, U.S. Citizenship and Immigration Service regulations have resulted in controlled stays within the CNMI for visa holders, thereby greatly reducing the opportunity for long-term residency and the attendant likelihood of family-making. Further, because the process of applying the new CW visa to aliens is still underway and the estimated number of aliens in the CNMI was always speculative, any natural increase attributed to aliens would be de minimis. Consequently, this segment of Saipan's population is not projected to grow.

The natural increase for permanent residents between years 2016 and 2020 yields a change in population of:

- For year 2016 = 26,784 plus 2.12 percent (568) = 27,352
- For year 2017 = 27,352 plus 2.02 percent (553) = 27,905
- For year 2018 = 27,905 plus 1.93 percent (539) = 28,444
- For year 2019 = 28,444 plus 1.84 percent (523) = 28,967
- For year 2020 = 28,967 plus 1.76 percent (510) = 29,477

The permanent resident population increase for this 5-year period represents a cumulative 10.05 percent or 2,693 people. The variance in permanent residents between the 2010 census and the 2020 estimate, this component of Saipan's population increased by 7.58 percent (48,220 census less 20,859 aliens = 27,400 permanent residents [rounded] in the year 2010 versus 29,477 in year 2020).

With these assumptions, the population projections for Saipan for year 2020 are as follows:

- Year 2020 high range: 40,477
  - Year 2020 permanent residents of 29,477
  - Year 2020 aliens of 11,000
  - Therefore, 29,477 plus 11,000 = 40,477
- Year 2020 low range: 32,227
  - Year 2020 permanent residents of 29,477
  - Year 2020 aliens of 2,750
  - Therefore, 29,477 plus 2,750 = 32,227

With these assumptions, the population projections for Saipan for Year 2020 are as follows:

- Year 2020 high range: 40,477
- Year 2020 low range: 32,227

3.1.6 Projecting Saipan's Population for Year 2030

The natural growth rate for CNMI was projected by the U.S. Census Bureau for CNMI (no distinction among islands) for years 2016 through 2030 as:

- 2020 – 2021 @ 1.65 percent
- 2021 – 2022 @ 1.53 percent
- 2022 – 2023 @ 1.43 percent
- 2023 – 2024 @ 1.34 percent
- 2024 – 2025 @ 1.27 percent
- 2025 – 2026 @ 1.21 percent
- 2026 – 2027 @ 1.17 percent
- 2027 – 2028 @ 1.13 percent
- 2028 – 2029 @ 1.09 percent
- 2029 – 2030 @ 1.07 percent (Andrew, 2013) for a 10-year average growth of 1.29 percent

Subject to the additional population expected as a result of local initiatives and external stimuli, these projections reflect likely growth rates for permanent residents.

The natural increase for permanent residents between years 2021 and 2030 yields a change in population of:

- For year 2021 = 29,477 plus 1.65 percent (486) = 29,963
- For year 2022 = 29,963 plus 1.53 percent (458) = 30,421
- For year 2023 = 30,421 plus 1.43 percent (435) = 30,856
- For year 2024 = 30,856 plus 1.34 percent (414) = 31,270
- For year 2025 = 31,270 plus 1.27 percent (397) = 31,667
- For year 2026 = 31,667 plus 1.21 percent (383) = 32,050
- For year 2027 = 32,050 plus 1.17 percent (375) = 32,425
- For year 2028 = 32,425 plus 1.13 percent (366) = 32,791
- For year 2029 = 32,791 plus 1.09 percent (357) = 33,148
- For year 2030 = 33,148 plus 1.07 percent (355) = 33,503

The permanent resident population increase for this 10-year period represents a cumulative 13.66 percent or 4,026 people; the difference since the 2010 census for permanent residents is an increase of 22.27 percent (48,220 census less 20,859 aliens = 27,400 [rounded] permanent residents in year 2010 versus 33,503 in year 2030).

With respect to natural growth rates for aliens, U.S. Citizenship and Immigration Service regulations are expected to continue to control the stays within the CNMI for visa holders, thereby greatly reducing the opportunity for long-term residency and the attendant likelihood of family-making. Any natural increase attributed to aliens would be de minimis. Consequently, this segment of Saipan's population is not projected to grow.

With these assumptions, the population projections for Saipan for year 2030 are as follows:

- Year 2030 high range: 47,003
  - Year 2030 permanent residents of 33,503
  - Year 2030 aliens of 11,000
  - Year 2030 new growth from local initiatives and external stimuli of 2,500
  - Therefore, 33,503 plus 11,000 plus 2,500 = 47,003
- Year 2030 low range: 38,753
  - Year 2030 permanent residents of 33,503
  - Year 2030 aliens of 2,750
  - Year 2030 new growth from local initiatives and external stimuli of 2,500
  - Therefore, 33,503 plus 2,750 plus 2,500 = 38,753

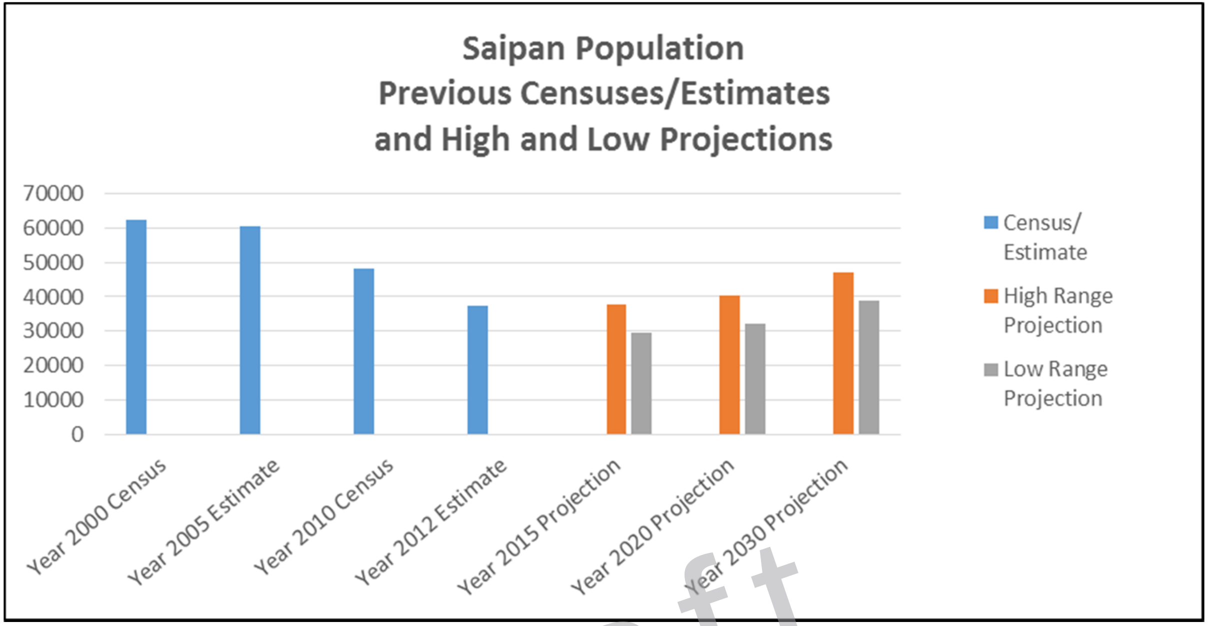
With these assumptions, the population projections for Saipan for Year 2030 are as follows:

- Year 2030 high range: 47,003
- Year 2030 low range: 38,753

3.1.7 Summary of Actual and Estimated Population Data for 2000 through 2030

Figure 3.1.7-1 presents a comparison of Saipan's population from previous census and estimate data with projections for high range, medium range, and low range for year 2015, year 2020, and year 2030.

Figure 3.1.7-1. **Actual, Estimated, and Projected Population Data from 2000 through 2030**



3.1.8 Allocating Saipan Islandwide Population Projections among Census Designated Places for Year 2015

With the high and low ranges of population projections established islandwide for Saipan, these figures must be allocated among the island's 77 Census Designated Places (CDPs). The following methodology was employed for this allocation for the year 2015 projections, which are as follows: High Range at 37,784 and Low Range at 29,534.

- The High Range population for year 2015 is 37,784 or 10,436 less than the year 2010 census of 48,220. To allocate this decrease of 10,436, the following projections were made:
  - First reduce by 30 percent the population from known concentrations of group quarters and alien residences (listed below):

    Afetnas
    Agingan
    As Palacios
    Chalan Kanoa I
    Chalan Kanoa III
    Chalan Kanoa IV
    Chalan Rueda
    China Town
    Dan Dan
    Garapan
    Gualo Rai
    I Liyang
    Kagman III
    Kannat Tabla
    Koblerville
    Laulau Bay
    Marpi
    Maturana Hill
    San Antonio
    San Roque
    San Vicente
    Susupe
    Talofofo

  - Second, reduce by 6.74 percent population in all other CDPs to reflect decline of permanent resident population between 2010 census and 2015 (see “Projecting Saipan’s Population for Year 2015” earlier in this section and Table 3.1.8-1, Saipan Population Projections for Year 2015 by Census Designated Place - High Range at the end of this section).

- The Low Range population for year 2015 is 29,534 or 18,686 less than the year 2010 census of 48,220. To allocate this decrease of 18,686, the following projections were made:
  - First reduce by 60 percent the population from known concentrations of group quarters and alien residences (listed below):

    Afetnas
    Agingan
    As Palacios
    Chalan Kanoa I
    Chalan Kanoa III
    Chalan Kanoa IV
    Chalan Rueda
    China Town
    Dan Dan
    Garapan
    Gualo Rai
    I Liyang
    Kagman III
    Kannat Tabla
    Koblerville
    Laulau Bay
    Marpi
    Maturana Hill
    San Antonio
    San Roque
    San Vicente
    Susupe
    Talofofo

  - Second, reduce by 6.74 percent population in all other CDPs to reflect decline of permanent resident population between 2010 census and 2015 (see “Projecting Saipan’s Population for Year 2015” earlier in this section and Table 3.1.8-2, Saipan Population Projections for Year 2015 by CDP - Low Range at the end of this section).

3.1.9 Allocating Saipan Islandwide Population Projections among Census Designated Places for Year 2020

The following methodology was employed for this allocation for the year 2020 projections, which are as follows: High Range at 40,477 and Low Range at 32,227.

- The High Range population for year 2020 is 40,477 or 7,743 less than the year 2010 census of 48,220. To allocate this decrease of 7,743, the following projections were made:
  - First reduce by 30 percent the population from known concentrations of group quarters and alien residences (listed below):

    Afetnas
    Agingan
    As Palacios
    Chalan Kanoa I
    Chalan Kanoa III
    Chalan Kanoa IV
    Chalan Rueda
    China Town
    Dan Dan
    Garapan
    Gualo Rai
    I Liyang
    Kagman III
    Kannat Tabla
    Koblerville
    Laulau Bay
    Marpi
    Maturana Hill
    San Antonio
    San Roque
    San Vicente
    Susupe
    Talofofo

  - Second, increase by 2.64 percent population in all other CDPs to reflect increase of permanent resident population between 2010 census and 2020 (see “Projecting Saipan’s Population for Year 2020” earlier in this section).
  - Third, add population to CDPs where village homesteads are ready for expansion and new development (see Column 5 of Table 3.1.8-3, Saipan Population Projections for Year 2020 by

CDP - High Range, at the end of this section). These CDPs are Capitol Hill (People's Park) at 300 units, Kagman IV at 100 units, and As Gonna (in the Koblerville area) at 232 units. Also, add population at Chalan Kanoa IV CDP where the privately constructed Sandy Beach condominiums (60 units) were recently completed.

- The Low Range population for year 2020 is 32,227 or 15,993 less than the year 2010 census of 48,220. To allocate this decrease of 15,993, the following projections were made:
  - First reduce by 60 percent the population from known concentrations of group quarters and alien residences (see listing below).
    - Afetnas
    - Agingan
    - As Palacios
    - Chalan Kanoa I
    - Chalan Kanoa III
    - Chalan Kanoa IV
    - Chalan Rueda
    - China Town
    - Dan Dan
    - Garapan
    - Gualo Rai
    - I Liyang
    - Kagman III
    - Kannat Tabla
    - Koblerville
    - Laulau Bay
    - Marpi
    - Maturana Hill
    - San Antonio
    - San Roque
    - San Vicente
    - Susupe
    - Talofofo
  - Second, increase by 2.64 percent population in all other CDPs to reflect increase of permanent resident population between 2010 census and 2020 (see "Projecting Saipan's Population for Year 2020" earlier in this section).
  - Third, add population to CDPs where village homesteads are ready for expansion and new development (see Column 5 of Table 3.1.8-4, Saipan Population Projections for Year 2020 by CDP - High Range, at the end of this section). These CDPs are Capitol Hill (People's Park) at 300 units, Kagman IV at 100 units, and As Gonna (in the Koblerville area) at 232 units. Also, add population at Chalan Kanoa IV CDP where the privately constructed Sandy Beach condos (60 units) were recently completed.

3.1.10 Allocating Saipan Islandwide Population Projections among Census Designated Places for Year 2030

The following methodology was employed for this allocation for the year 2030 projections, which are as follows: High Range at 47,005 and Low Range at 38,755.

- The High Range population for year 2030 is 39,753 or 1,217 less than the year 2010 census of 48,220. To allocate this decrease of 1,217, the following projections were made:
  - First reduce by 35 percent the population from known concentrations of group quarters and alien residences (listed below):
    - Afetnas
    - Agingan
    - As Palacios
    - Chalan Kanoa I
    - Chalan Kanoa III
    - Chalan Kanoa IV
    - Chalan Rueda
    - China Town
    - Dan Dan
    - Garapan
    - Gualo Rai
    - I Liyang
    - Kagman III
    - Kannat Tabla
    - Koblerville
    - Laulau Bay
    - Marpi
    - Maturana Hill
    - San Antonio
    - San Roque
    - San Vicente
    - Susupe
    - Talofofo

  - Second, increase by 16.66 percent the population in all other CDPs to reflect increase of permanent resident population between 2010 census and 2030 (see “Projecting Saipan’s Population for Year 2030” earlier in this section).
  - Third, add population to CDPs where village homesteads are ready for expansion and new development (see Column 6 of Table 3.1.8-5, Saipan Population Projections for Year 2030 by CDP - High Range, at the end of this section). These CDPs are Capitol Hill (People’s Park) at 300 units, Kagman IV at 100 units, and As Gonna (in the Koblerville area) at 232 units. Also, add population at Chalan Kanoa IV CDP, where the privately constructed Sandy Beach condos (60 units) were recently completed.
  - Fourth, over time, certain CDPs are expected to grow faster than others due to their convenient location, availability to utilities, relative ease to develop, and similar characteristics that promote growth. These areas and their CDPs are prioritized as follows (see Columns 7 through 10 of Table 3.1.8-5).

Priority 1 – Southern Saipan CDPs (population increase of 800)	**Priority 2 – West Central Saipan CDPs (population increase by 700)**	**Priority 3 – North West Saipan CDPs (population increase by 600)**	**Priority 4 – North Central Saipan CDPs (population increase by 400)**
Kannat Tabla	Garapan	San Roque	As Akina
San Vicente	Fananganan	Achugao	Sadog Tasi
Finasisu	I Liyang	Tanapag	As Rabagao
Dagu	Gualo Rai	As Mahetog	Capitol Hill
Dan Dan	Chalan Laulau		
As Perdido	Chalan Rueda		
Tottotville			
As Lito			

- The Low Range population for year 2030 is 38,753 or 9,467 more than the year 2010 census of 48,220. To allocate this increase of 9,467 from the year 2010 census, the following projections were made:
  - First reduce by 60 percent the population from known concentrations of group quarters and alien residences (listed below):

Afetnas
Agingan
As Palacios
Chalan Kanoa I
Chalan Kanoa III
Chalan Kanoa IV
Chalan Rueda
China Town
Dan Dan
Garapan
Gualo Rai
I Liyang
Kagman III
Kannat Tabla
Koblerville
Laulau Bay
Marpi
Maturana Hill
San Antonio
San Roque
San Vicente
Susupe
Talofofo

- Second, increase by 16.66 percent population in all other CDPs to reflect increase of permanent resident population between 2010 census and 2030 (see “Projecting Saipan’s Population for Year 2030” earlier in this section).
- Third, add population to CDPs where village homesteads are ready for expansion and new development (see Column 5 of Table 3.1.8-6, Saipan Population Projections for Year 2030 by CDP - Low Range at the end of this section). These CDPs are Capitol Hill (People’s Park) at 300 units, Kagman IV at 100 units, and As Gonna (in the Koblerville area) at 232 units. Also, add population at Chalan Kanoa IV CDP, where the privately constructed Sandy Beach condos (60 units) were recently completed.

Table 3.1.8-1. **Saipan Population Projections for Year 2015 by Census Designated Place - High Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2015 BY CDP - HIGH RANGE

2015 HIGH RANGE TARGET PROJECTION = 37,784 THIS PROJECTION =38,236

Census Designated Place	**2010 = 48,220**	**2015 High Range**	**CDPs with Decline of Permanent Residents @ 6.74% Cumulative Since year 2010**	**CDPs with Decline of Aliens @ 30% from Barracks and Other Alien Residences**
Achugao village	209	195	195	
Afetnas village	1,486	1,040		1,040
Agingan village	308	216		216
American Memorial Park village	-	-	-	
As Akina village	99	92	92	
As Falipe village	6	6	6	
As Gonna village	157	146	146	
As Lito village	920	858	858	
As Mahetog village	304	284	284	
As Matuis village	596	556	556	
As Palacios village	718	503		503
As Perdido village	238	222	222	
As Rabagao village	677	631	631	
As Teo village	317	296	296	
As Terlaje village	282	263	263	
Banaderu village	-	-	-	
Bird Island village	-	-	-	
Capitol Hill village	1,028	959	959	
Chacha village	65	61	61	
Chalan Galaide village	178	166	166	
Chalan Kanoa I village	1,304	913		913
Chalan Kanoa II village	921	859	859	
Chalan Kanoa III village	794	556		556
Chalan Kanoa IV village	631	442		442
Chalan Kiya village	1,062	990	990	
Chalan Laulau village	1,096	1,022	1,022	
Chalan Piao village	1,282	1,196	1.196	
Chalan Rueda village	257	180		180
China Town village	1,274	892		892
Dagu village	780	727	727	
Dan Dan village	3,280	2,296		2,296
Fananganan village	1,201	1,120	1,120	
Fanonchuluyan village	-	-	-	
Finasisu village	2,451	2,286	2,286	
Forbidden Island village	-	-	-	
Garapan village	3,983	2,788		2,788
Gualo Rai village	1,660	1,162		1,162
Hilaihai village	35	33	33	
I Akgak village	327	305	305	
I Denni village	27	25	25	
I Fadang village	-	-	-	
I Liyang village	917	642		642
I Maddok village	-	-	-	
I Naftan village	36	34	34	
I Pitot village	54	50	50	
Kagman village	92	86	86	
Kagman I village	358	334	334	
Kagman II village	918	856	856	
Kagman III village	2,402	1,681		1,681
Kagman IV village	456	425	425	
Kalabera village	-	-	-	
Kannat Tabla village	874	612		612
Koblerville village	2,493	1,745		1,745
Laulau Bay village	226	158		158
Lower Base village	50	47	47	
Managaha village	-	-	-	
Marpi village	85	60		60
Matansa village	65	61	61	
Maturana Hill village	161	113		113
Nanasu village	40	37	37	
Navy Hill village	260	242	242	
Opyan village	20	19	19	
Papago village	380	354	354	
Pidos Kahalo village	-	-	-	
Puerto Rico village	-	-	-	
Sabaneta village	-	-	-	
Sadog Tasi village	115	107	107	
San Antonio village	1,149	804		804
San Jose (Oleai) village	954	890	890	
San Roque village	741	519		519
San Vicente village	2,091	1,464		1,464
Susupe village	2,078	1,455		1,455
Talofofo village	41	29		29
Tanapag village	829	773	773	
Tangke village	-	-	-	
Tapochao village	124	116	116	
Tottotville village	258	241	241	

Table 3.1.8-2. **Saipan Population Projections for Year 2015 by Census Designated Place - Low Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2015 BY CDP - LOW RANGE

2015 LOW RANGE TARGET PROJECTION = 29,534 THIS PROJECTION = 29,550

Census Designated Place	2010 = 48,220	2015 Low Range	CDPs with Decline of Permanent Residents @ 6.74% Cumulative Since Year 2010	CDPs with Decline of Aliens @ 60% from Barracks and Other Alien Residences
Achugao village	209	195	195	
Afetnas village	1,486	594		594
Agingan village	308	123		123
American Memorial Park village.	-	-	-	
As Akina village	99	92	92	
As Falipe village	6	6	6	
As Gonna village	157	146	146	
As Lito village	920	858	858	
As Mahetog village	304	284	284	
As Matuis village	596	556	556	
As Palacios village	718	287		287
As Perdido village	238	222	222	
As Rabagao village	677	631	631	
As Teo village	317	296	296	
As Terlaje village	282	263	263	
Banaderu village	-	-	-	
Bird Island village	-	-	-	
Capitol Hill village	1,028	959	959	
Chacha village	65	61	61	
Chalan Galaide village	178	166	166	
Chalan Kanoa I village	1,304	522		522
Chalan Kanoa II village	921	859	859	
Chalan Kanoa III village	794	318		318
Chalan Kanoa IV village	631	252		252
Chalan Kiya village	1,062	990	990	
Chalan Laulau village	1,096	1,022	1,022	
Chalan Piao village	1,282	1,196	1,196	
Chalan Rueda village	257	103		103
China Town village	1,274	510		510
Dagu village	780	727	727	
Dan Dan village	3,280	1,312		1,312
Fananganan village	1,201	1,120	1,120	
Fanonchuluyan village	-	-	-	
Finasisu village	2,451	2,286	2,286	
Forbidden Island village	-	-	-	
Garapan village	3,983	1,593		1,593
Gualo Rai village	1,660	664		664
Hilaihai village	35	33	33	
I Akgak village	327	305	305	
I Denni village	27	25	25	
I Fadang village	-	-	-	
I Liyang village	917	367		367
I Maddok village	-	-	-	
I Naftan village	36	34	34	
I Pitot village	54	50	50	
Kagman village	92	86	86	
Kagman I village	358	334	334	
Kagman II village	918	856	856	
Kagman III village	2,402	961		961
Kagman IV village	456	425	425	
Kalabera village	-	-	-	
Kannat Tabla village	874	350		350
Koblerville village	2,493	997		997
Laulau Bay village	226	90		90
Lower Base village	50	47	47	
Managaha village	-	-	-	
Marpi village	85	34		34
Matansa village	65	61	61	
Maturana Hill village	161	64		64
Nanasu village	40	37	37	
Navy Hill village	260	242	242	
Opyan village	20	19	19	
Papago village	380	354	354	
Pidos Kahalo village	-	-	-	
Puerto Rico village	-	-	-	
Sabaneta village	-	-	-	
Sadog Tasi village	115	107	107	
San Antonio village	1,149	460		460
San Jose (Oleai) village	954	890	890	
San Roque village	741	296		296
San Vicente village	2,091	836		836
Susupe village	2,078	831		831
Talofofo village	41	16		16
Tanapag village	829	773	773	
Tangke village	-	-	-	
Tapochao village	124	116	116	
Tottotville village	258	241	241	

Table 3.1.8-3. **Saipan Population Projections for Year 2020 by Census Designated Place - High Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2020 BY CDP - HIGH RANGE

2020 HIGH RANGE TARGET PROJECTION = 40,477 THIS PROJECTION = 42,015

Census Designated Place	2010 = 48,220	2020 High Range	CDPs with Increase of Permanent Residents @ 2.64% Cumulative Since Year 2010	CDPs with Decline of Aliens @ 30% from Barracks and Other Alien Residences	CDPs with Expanded and New Homesteads and Private Housing
Achugao village	209	215	215		
Afetnas village	1,486	1,040		1,040	
Agingan village	308	216		216	
American Memorial Park village	-	-	-		
As Akina village	99	102	102		
As Falipe village	6	6	6		
As Gonna village	157	161	161		
As Lito village	920	944	944		
As Mahetog village	304	312	312		
As Matuis village	596	612	612		
As Palacios village	718	503		503	
As Perdido village	238	244	244		
As Rabagao village	677	695	695		
As Teo village	317	325	325		
As Terlaje village	282	289	289		
Banaderu village	-	-	-		
Bird Island village	-	-	-		
Capitol Hill village	1,028	1,816	1,216		600
Chacha village.	65	67	67		
Chalan Galaide village	178	183	183		
Chalan Kanoa I village	1,304	913		913	
Chalan Kanoa II village	921	945	945		
Chalan Kanoa III village	794	556		556	
Chalan Kanoa IV village	631	682		442	240
Chalan Kiya village	1,062	1,090	1,090		
Chalan Laulau village.	1,096	1,125	1,125		
Chalan Piao village	1,282	1,316	1,316		
Chalan Rueda village	257	180		180	
China Town village	1,274	892		892	
Dagu village	780	801	801		
Dan Dan village	3,280	2,296		2,296	
Fananganan village	1,201	1,233	1,233		
Fanonchuluyan village	-	-	-		
Finasisu village	2,451	2,516	2,516		
Forbidden Island village	-	-	-		
Garapan village	3,983	2,788		2,788	
Gualo Rai village	1,660	1,162		1,162	
Hilaihai village	35	36	36		
I Akgak village	327	336	336		
I Denni village	27	28	28		
I Fadang village	-	-	-		
I Liyang village	917	642		642	
I Maddok village	-	-	-		
I Naftan village	36	37	37		
I Pitot village	54	55	55		
Kagman village	92	94	94		
Kagman I village	358	367	367		
Kagman II village	918	942	942		
Kagman III village	2,402	1,681		1,681	
Kagman IV village	456	1,039	539		500
Kalabera village	-	-	-		
Kannat Tabla village	874	612		612	
Koblerville village	2,493	2,145		1,745	400
Laulau Bay village	226	158		158	
Lower Base village	50	51	51		
Managaha village	-	-	-		
Marpi village	85	60		60	
Matansa village	65	67	67		
Maturana Hill village	161	113		113	
Nanasu village	40	41	41		
Navy Hill village	260	267	267		
Opyan village	20	21	21		
Papago village	380	390	390		
Pidos Kahalo village	-	-	-		
Puerto Rico village	-	-	-		
Sabaneta village	-	-	-		
Sadog Tasi village	115	118	118		
San Antonio village	1,149	804		804	
San Jose (Oleai) village	954	979	979		
San Roque village.	741	519		519	
San Vicente village	2,091	1,464		1,464	
Susupe village	2,078	1,455		1,455	
Talofofo village	41	29		29	
Tanapag village	829	851	851		
Tangke village	-	-	-		
Tapochao village	124	127	127		
Tottotville village	258	265	265		

Table 3.1.8-4. **Saipan Population Projections for Year 2020 by Census Designated Place - Low Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2020 BY CDP - LOW RANGE				
2020 LOW RANGE TARGET PROJECTION = 32,227 THIS PROJECTION = 31,357				
Census Designated Place	**2010 = 48,220**	**2020 Low Range**	**CDPs with Increase of Permanent Residents @ 2.64% Cumulative Since Year 2010**	**CDPs with Decline of Aliens @ 60% from Barracks and Other Alien Residences**
Achugao village	209	215	215	
Afetnas village	1,486	594		594
Agingan village	308	123		123
American Memorial Park village	---	-	-	
As Akina village	99	102	102	
As Falipe village	6	6	6	
As Gonna village	157	161	161	
As Lito village	920	944	944	
As Mahetog village	304	312	312	
As Matuis village	596	612	612	
As Palacios village	718	287		287
As Perdido village	238	244	244	
As Rabagao village	677	695	695	
As Teo village	317	325	325	
As Terlaje village	282	289	289	
Banaderu village	-	-	-	
Bird Island village	-	-	-	
Capitol Hill village	1,028	1,055	1,055	
Chacha village	65	67	67	
Chalan Galaide village	178	183	183	
Chalan Kanoa I village	1,304	522		522
Chalan Kanoa II village	921	945	945	
Chalan Kanoa III village	794	319		318
Chalan Kanoa IV village	631	252		252
Chalan Kiya village	1,062	1,090	1,090	
Chalan Laulau village	1,096	1,125	1,125	
Chalan Piao village	1,282	1,316	1,316	
Chalan Rueda village	257	103		103
China Town village	1,274	510		510
Dagu village	780	801	801	
Dan Dan village	3,280	1,312		1,312
Fananganan village	1,201	1,233	1,233	
Fanonchuluyan village	-	-	-	
Finasisu village	2,451	2,516	2,516	
Forbidden Island village	-	-	-	
Garapan village	3,983	1,593		1,593
Gualo Rai village	1,660	664		664
Hilaihai village	35	36	36	
I Akgak village	327	336	336	
I Denni village	27	28	28	
I Fadang village	-	-	-	
I Liyang village	917	367		367
I Maddok village	-	-	-	
I Naftan village	36	37	37	
I Pitot village	54	55	55	
Kagman village	92	94	94	
Kagman I village	358	367	367	
Kagman II village	918	942	942	
Kagman III village.	2,402	961		961
Kagman IV village	456	468	468	
Kalabera village	-	-	-	
Kannat Tabla village	874	350		350
Koblerville village	2,493	997		997
Laulau Bay village	226	90		90
Lower Base village	50	51	51	
Managaha village	-	-	-	
Marpi village	85	34		34
Matansa village	65	67	67	
Maturana Hill village	161	64		64
Nanasu village	40	41	41	
Navy Hill village	260	267	267	
Opyan village	20	21	21	
Papago village	380	390	390	
Pidos Kahalo village	-	-	-	
Puerto Rico village	-	-	-	
Sabaneta village	-	-	-	
Sadog Tasi village	115	118	118	
San Antonio village	1,149	460		460
San Jose (Oleai) village	954	979	979	
San Roque village	741	296		296
San Vicente village	2,091	836		836
Susupe village	2,078	831		831
Talofofo village	41	16		16
Tanapag village	829	851	851	
Tangke village	-	-	-	
Tapochao village	124	127	127	
Tottotville village	258	265	265	

Table 3.1.8-5. **Saipan Population Projections for Year 2030 by Census Designated Place - High Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP – HIGH RANGE

2020 High Range Target Projection = 47,003 This Projection = 47,196

Census Designated Place	2010 = 48,220	2030 High Range	CDPs with Increase of Permanent Residents @ 16.66% Cumulative Since Year 2010	CDPs with Decline of Aliens @ 35% from Barracks and Other Alien Residences	CDPs with Expanded and New Homesteads and Private Housing	CDPs Expected to Grow Faster than Others Priority 1	CDPs Expected to Grow Faster than Others Priority 2	CDPs Expected to Grow Faster than Others Priority 3	CDPs Expected to Grow Faster than Others Priority 4
Achugao village	209	394	244					150	
Afetnas village	1,486	966		966					
Agingan village	308	200		200					
American Memorial Park village.	-	-	-						
As Akina village	99	215	115						100
As Falipe village	6	7	7						
As Gonna village	157	183	183						
As Lito village	920	1,173	1,073			100			
As Mahetog village	304	505	355					150	
As Matuis village	596	695	695						
As Palacios village	718	467		467					
As Perdido village	238	378	278			100			
As Rabagao village	677	890	790						100
As Teo village	317	370	370						
As Terlaje village	282	329	329						
Banaderu village	-	-	-						
Bird Island village	-	-	-						
Capitol Hill village	1,028	2,799	1,199		1,500				100
Chacha village	65	76	76						
Chalan Galaide village	178	208	208						
Chalan Kanoa I village	1,304	848		848					
Chalan Kanoa II village	921	1,074	1,074						
Chalan Kanoa III village	794	516		516					
Chalan Kanoa IV village	631	650		410	240				
Chalan Kiya village	1,062	1,239	1,239						
Chalan Laulau village	1,096	1,379	1,279				100		
Chalan Piao village	1,282	1,496	1,496						
Chalan Rueda village.	257	267		167			100		
China Town village	1,274	828		828					
Dagu village	780	1,010	910			100			
Dan Dan village	3,280	2,232		2,132		100			
Fananganan village	1,201	1,501	1,401				100		
Fanonchuluyan village	-	-	-						
Finasisu village	2,451	2,959	2,859			100			
Forbidden Island village	-	-	-						
Garapan village.	3,983	2,789		2,859			200		
Gualo Rai village	1,660	1,179		1,079			100		
Hilaihai village	35	41	41						
I Akgak village	327	381	381						
I Denni village	27	31	31						
I Fadang village	-	-	-						
I Liyang village	917	696		596			100		
I Maddok village	-	-	-						
I Naftan village	36	42	42						
I Pitot village	54	63	63						
Kagman village	92	107	107						

Table 3.1.8-5. **Saipan Population Projections for Year 2030 by Census Designated Place - High Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP – HIGH RANGE

2020 High Range Target Projection = 47,005 This Projection = 47,196

Census Designated Place	2010 = 48,220	2030 High Range	CDPs with Increase of Permanent Residents @ 16.66% Cumulative Since Year 2010	CDPs with Decline of Aliens @ 35% from Barracks and Other Alien Residences	CDPs with Expanded and New Homesteads and Private Housing	CDPs Expected to Grow Faster than Others Priority 1	CDPs Expected to Grow Faster than Others Priority 2	CDPs Expected to Grow Faster than Others Priority 3	CDPs Expected to Grow Faster than Others Priority 4
Kagman I village	358	418	418						
Kagman II village	918	1,071	1,071						
Kagman III village	2,402	1,561		1,561					
Kagman IV village	456	1,032	532		500				
Kalabera village	-	-	-						
Kannat Tabla village	874	668		568		100			
Koblerville village	2,493	2,780		1,620	1,160				
Laulau Bay village	226	147		147					
Lower Base village	50	58	58						
Managaha village	-	-	-						
Marpi village	85	55		55					
Matansa village	65	76	76						
Maturana Hill village	161	105		105					
Nanasu village	40	47	47						
Navy Hill village	260	303	303						
Opyan village	20	23	23						
Papago village	380	443	443						
Pidos Kahalo village	-	-	-						
Puerto Rico village	-	-	-						
Sabaneta village	-	-	-						
Sadog Tasi village	115	234	134						100
San Antonio village	1,149	747		747					
San Jose (Oleai) village	954	1,113	1,113						
San Roque village	741	632		482				150	
San Vicente village	2,091	1,459		1,359		100			
Susupe village	2,078	1,351		1,351					
Talofofo village	41	27		27					
Tanapag village	829	1,117	967					150	
Tangke village	---	-	-						
Tapochao village	124	145	145						
Tottotville village	258	401	301			100			

Table 3.1.8-6. **Saipan Population Projections for Year 2030 by Census Designated Place - Low Range**

SAIPAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP - LOW RANGE

2030 LOW RANGE TARGET PROJECTION = 38,753 THIS PROJECTION = 35,878

Census Designated Place	2010 = 48,220	2030 Low Range	CDPs with Increase of Permanent Residents @ 16.66% Cumulative Since Year 2010	CDPs with Decline of Aliens @ 60% from Barracks and Other Alien Residences	CDPs with Expanded and New Homesteads and Private Housing
Achugao village	209	244	244		
Afetnas village	1,486	594		594	
Agingan village	308	123		123	
American Memorial Park village	-	-	-		
As Akina village	99	115	115		
As Falipe village	6	7	7		
As Gonna village	157	183	183		
As Lito village	920	1,073	1,073		
As Mahetog village	304	355	355		
As Matuis village	596	695	695		
As Palacios village	718	287		287	
As Perdido village	238	278	278		
As Rabagao village	677	790	790		
As Teo village	317	370	370		
As Terlaje village	282	329	329		
Banaderu village	-	-	-		
Bird Island village	-	-	-		
Capitol Hill village	1,028	1,949	1,199		750
Chacha village	65	76	76		
Chalan Galaide village	178	208	208		
Chalan Kanoa I village	1,304	522		532	
Chalan Kanoa II village	921	1,074	1,074		
Chalan Kanoa III village	794	318		318	
Chalan Kanoa IV village	631	492		252	240
Chalan Kiya village	1,062	1,239	1,239		
Chalan Laulau village	1,096	1,279	1,279		
Chalan Piao village	1,282	1,496	1,496		
Chalan Rueda village	257	103		103	
China Town village	1,274	510		510	
Dagu village	780	910	910		
Dan Dan village	3,280	1,312		1,312	
Fananganan village	1,201	1,401	1,401		
Fanonchuluyan village.	-	-	-		
Finasisu village	2,451	2,859	2,859		
Forbidden Island village	-	-	-		
Garapan village	3,983	1,593		1,593	
Gualo Rai village	1,660	664		664	
Hilaihai village	35	41	41		
I Akgak village	327	381	381		
I Denni village	27	31	31		
I Fadang village	-	-	-		
I Liyang village	917	367		367	
I Maddok village	-	-	-		
I Naftan village	36	42	42		
I Pitot village	54	63	63		
Kagman village	92	107	107		
Kagman I village	358	418	418		
Kagman II village	918	1,071	1,071		
Kagman III village	2,402	961		961	
Kagman IV village	456	782	532		250
Kalabera village	-	-	-		
Kannat Tabla village	874	350		350	
Koblerville village	2,493	1,577		997	580
Laulau Bay village	226	90		90	
Lower Base village	50	58	58		
Managaha village	-	-	-		
Marpi village	85	34		34	
Matansa village	65	76	76		
Maturana Hill village	161	64		64	
Nanasu village	40	47	47		
Navy Hill village	260	303	303		
Opyan village	20	23	23		
Papago village	380	443	443		
Pidos Kahalo village	-	-	-		
Puerto Rico village	-	-	-		
Sabaneta village	-	-	-		
Sadog Tasi village	115	134	134		
San Antonio village	1,149	460		480	
San Jose (Oleai) village	954	1,113	1,113		
San Roque village	741	296		296	
San Vicente village	2,091	836		836	
Susupe village	2,078	831		831	
Talofofo village	41	16		16	
Tanapag village	829	967	967		
Tangke village	-	-	-		
Tapochao village	124	145	145		
Tottotville village	258	301	301		

3.1.11 Population by Saipan Sewersheds for Years 2015, 2020, and 2030 for High and Low Ranges

The population within Saipan's Sewersheds was calculated by the same methodology used to calculate the population within Saipan's Water Regions. Using the population projections by CDPs for all three horizon years and the high and low ranges, population can be allocated among Saipan's 37 Sewersheds. This allocation is based on a digital rooftop survey of aerial photogrammetry of the island. The size of a typical residential roof was determined and used for a rooftop count in each CDP. Large roofs (commercial, industrial and governmental buildings) as well as small roofs (livestock and storage) were ignored. Multi-family residences, where known, were calculated. The boundaries of all Sewersheds were then superimposed on the CDPs, and residential rooftops from each CDP were assigned to the Sewersheds. The population assigned to each Sewershed is directly proportional to number of residential rooftops in each Sewershed.

The number of rooftops in each Sewershed (Rooftops in SS column) is compared to the total number of rooftops in the overlying CDP (Rooftops in CDP column) to determine the percent distribution of rooftops in that Sewershed (Percent Distribution of Rooftops by CDP column). That percent distribution of rooftops is applied to the total number of people in the CDP (100-percent CDP column) to determine the number of people in the Sewershed (This SS column). This calculation is repeated for the High and Low projections for years 2015, 2020, and 2030 (see Figure 3.1.11-1).

In Tables 3.1.11-1, 3.1.11-2, and 3.1.11-3, the high and low population projections for years 2015, 2020, and 2030 are allocated in proportion to the rooftops in each CDP to determine the projected population for each of Saipan's Sewersheds.

Figure 3.1.11-1. **Map of Saipan Census Designated Places and Rooftops**

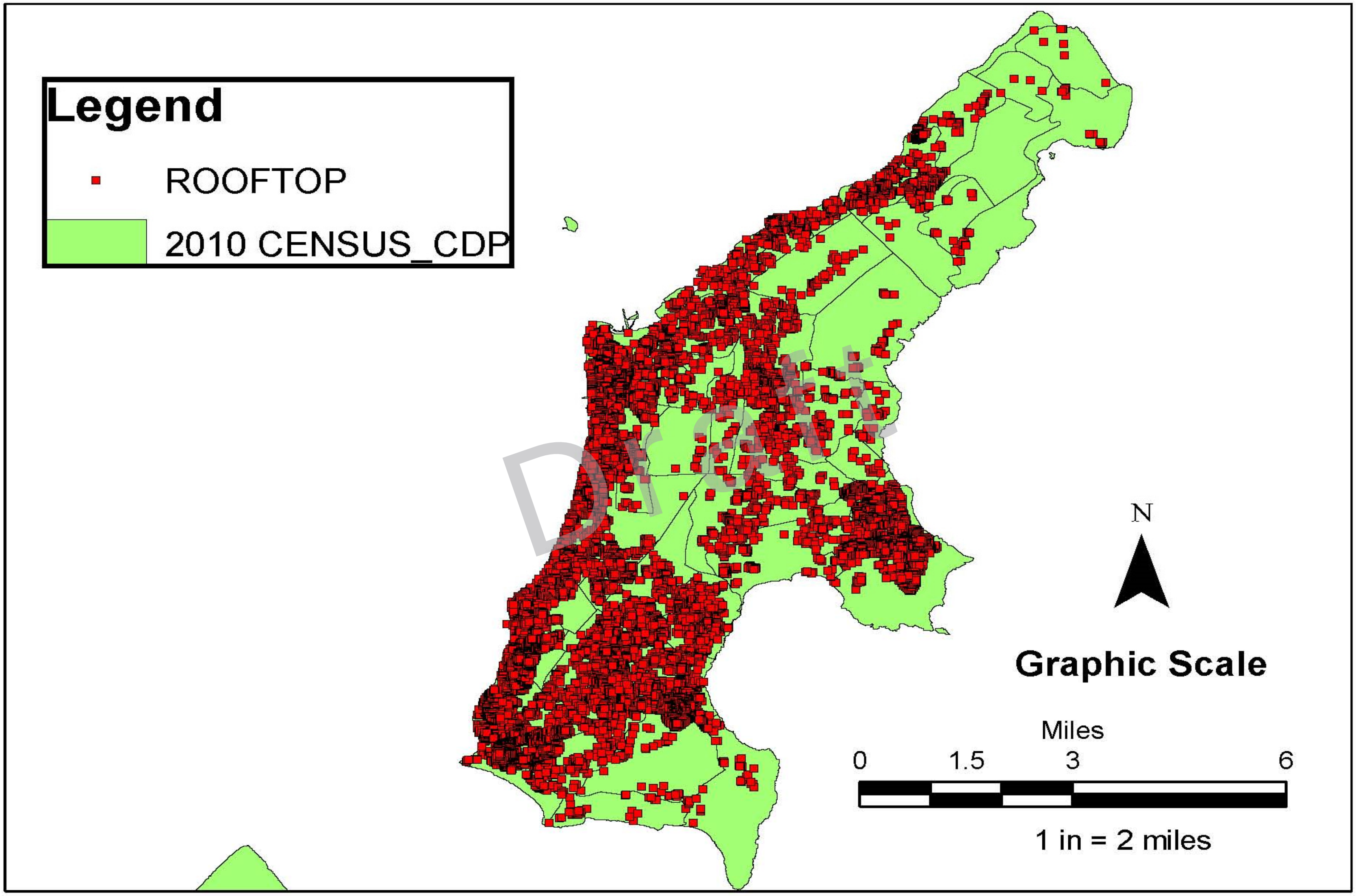


Table 3.1.11-1. Allocation of Projected Population by Sewershed for Year 2015

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2015			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-1	Afetnas	84	347	24.21%	1,040	252	594	144
SA-1	Agingan	34	158	21.52%	216	46	123	26
SA-1	As Perdido	17	84	20.24%	222	45	222	45
SA-1	Koblerville	232	524	44.27%	1,745	773	997	441
SA-1	Tottotville	7	68	10.29%	241	25	241	25
TOTAL POPULATION, SA-1						1,141		681
SA-10	San Jose (Oleai)	1	208	0.48%	890	4	890	4
SA-10	Susupe	146	458	31.88%	1,455	464	831	265
TOTAL POPULATION, SA-10						468		269
SA-11	Chalan Laulau	8	286	2.80%	1,022	29	1,022	29
SA-11	San Jose (Oleai)	196	208	94.23%	890	839	890	839
SA-11	Susupe	11	458	2.40%	1,455	35	831	20
TOTAL POPULATION, SA-11						902		887
SA-12	As Terlaje	45	76	59.21%	263	156	263	156
SA-12	Chalan Kiya	91	362	25.14%	990	249	990	249
SA-12	Finasisu	160	671	23.85%	2,286	545	2,286	545
SA-12	Kannat Tabla	65	233	27.90%	612	171	350	98
TOTAL POPULATION, SA-12						1,120		1,047
SA-13	Chalan Kiya	152	362	41.99%	990	416	990	416
SA-13	San Jose (Oleai)	8	208	3.85%	890	34	890	34
TOTAL POPULATION, SA-13						450		450
SA-14	Chalan Kiya	30	362	8.29%	990	82	990	82
SA-14	Chalan Laulau	56	286	19.58%	1,022	200	1,022	200
SA-14	Chalan Rueda	27	96	28.13%	180	51	103	29
TOTAL POPULATION, SA-14						333		311
SA-15	Agingan	71	158	44.94%	216	97	123	55
SA-15	As Gonna	18	95	18.95%	146	28	146	28
SA-15	Koblerville	278	524	53.05%	1,745	926	997	529
SA-15	Tottotville	5	68	7.35%	241	18	241	18
TOTAL POPULATION, SA-15						1,068		630
SA-16	As Gonna	5	95	5.26%	146	8	146	8
SA-16	Koblerville	5	524	0.95%	1,745	17	997	10
TOTAL POPULATION, SA-16						24		17

Table 3.1.11-1. Allocation of Projected Population by Sewershed for Year 2015

					Year 2015			
					High		Low	
Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	100% CDP	This SS	100% CDP	This SS
SA-17	As Lito	64	251	25.50%	858	219	858	219
SA-17	As Perdido	26	84	30.95%	222	69	222	69
SA-17	Dagu	124	255	48.63%	727	354	727	354
SA-17	Finasisu	128	671	19.08%	2,286	436	2,286	436
SA-17	Kannat Tabla	16	233	6.87%	612	42	350	24
SA-17	San Vicente	33	589	5.60%	1,464	82	836	47
SA-17	Tottotville	10	68	14.71%	241	35	241	35
TOTAL POPULATION, SA-17						1,237		1,183
SA-18	Dagu	56	255	21.96%	727	160	727	160
SA-18	Dan Dan	31	914	3.39%	2,296	78	1,312	44
SA-18	San Vicente	6	589	1.02%	1,464	15	836	9
TOTAL POPULATION, SA-18						252		213
SA-19	As Lito	65	251	25.90%	858	222	858	222
SA-19	Dagu	7	255	2.75%	727	20	727	20
SA-19	Dan Dan	108	914	11.82%	2,296	271	1,312	155
SA-19	I Fadang	23	53	43.40%	-	-	-	-
TOTAL POPULATION, SA-19						513		397
SA-2	Afetnas	171	347	49.28%	1,040	513	594	293
SA-2	Chalan Piao	89	319	27.90%	1,196	334	1,196	334
SA-2	San Antonio	194	198	97.98%	804	788	460	451
TOTAL POPULATION, SA-2						1,634		1,077
SA-3	Chalan Kanoa IV	8	131	6.11%	442	27	252	15
SA-3	Chalan Piao	129	319	40.44%	1,196	484	1,196	484
TOTAL POPULATION, SA-3						511		499
SA-4	Chalan Kanoa II	40	206	19.42%	859	167	859	167
SA-4	Chalan Kanoa III	17	127	13.39%	556	74	318	43
SA-4	Chalan Kanoa IV	114	131	87.02%	442	385	252	219
SA-4	Chalan Piao	6	319	1.88%	1,196	22	1,196	22
TOTAL POPULATION, SA-4						648		451
SA-5	Chalan Kanoa I	20	259	7.72%	913	71	522	40
SA-5	Chalan Kanoa III	97	127	76.38%	556	425	318	243
SA-5	Chalan Kanoa IV	9	131	6.87%	442	30	252	17
TOTAL POPULATION, SA-5						526		301
SA-6	Chalan Kanoa II	152	206	73.79%	859	634	859	634
SA-6	Chalan Kanoa III	12	127	9.45%	556	53	318	30
TOTAL POPULATION, SA-6						686		664

Table 3.1.11-1. Allocation of Projected Population by Sewershed for Year 2015

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2015			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-7	Chalan Kanoa I	182	259	70.27%	913	642	522	367
SA-7	Chalan Kanoa II	1	206	0.49%	859	4	859	4
SA-7	Chalan Kanoa III	1	127	0.79%	556	4	318	3
TOTAL POPULATION, SA-7						650		373
SA-8	Chalan Kanoa II	13	206	6.31%	859	54	859	54
SA-8	Susupe	214	458	46.72%	1,455	680	318	388
TOTAL POPULATION, SA-8						734		442
SA-9	Chalan Kanoa I	50	259	19.31%	913	176	522	101
SA-9	Susupe	39	458	8.52%	1,455	124	831	71
TOTAL POPULATION, SA-1						300		172
SS-1	Chalan Laulau	93	286	32.52%	1,022	332	1,022	332
TOTAL POPULATION, SS-1						332		332
SS-10	As Palacios	4	112	3.57%	503	18	287	10
SS-10	Chalan Galaide	1	46	2.17%	166	4	166	4
SS-10	China Town	94	216	43.52%	892	388	510	222
SS-10	Fananganan	235	280	83.93%	1,120	940	1,120	940
SS-10	Garapan	80	702	11.40%	2,788	318	1,593	182
SS-10	Maturana Hill	12	65	18.46%	113	21	64	12
SS-10	Navy Hill	67	110	60.91%	242	147	242	147
TOTAL POPULATION, SS-10						1,836		1,517
SS-11	As Palacios	71	112	63.39%	503	319	287	182
TOTAL POPULATION, SS-11						319		182
SS-12	As Palacios	2	112	1.79%	503	9	287	5
SS-12	As Rabagau	17	240	7.08%	631	45	631	45
SS-12	Puerto Rico	43	49	87.76%	-	-	-	-
TOTAL POPULATION, SS-12						54		50
SS-13	As Rabagau	39	240	16.25%	631	103	631	103
SS-13	Capitol Hill	194	421	46.08%	959	442	959	442
SS-13	Lower Base	17	94	18.09%	47	8	47	8
SS-13	Puerto Rico	1	49	2.04%	-	-	-	-
SS-13	Sadog Tasi	39	51	76.47%	107	82	107	82
TOTAL POPULATION, SS-13						635		635
SS-14	Lower Base	59	94	62.77%	47	29	47	29
SS-14	Tanapag	59	214	27.57%	773	213	773	213
TOTAL POPULATION, SS-14						243		243

Table 3.1.11-1. Allocation of Projected Population by Sewershed for Year 2015

					Year 2015			
					High		Low	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**	**Percent Distribution of Rooftops by CDP**	**100% CDP**	**This SS**	**100% CDP**	**This SS**
SS-15	Achugao	19	97	19.59%	195	38	195	38
SS-15	As Mahetog	41	120	34.17%	284	97	284	97
SS-15	Tanapag	142	214	66.36%	773	513	773	513
TOTAL POPULATION, SS-15						648		648
SS-16	Achugao	13	97	13.40%	195	26	195	26
SS-16	San Roque	18	279	6.45%	519	33	296	19
TOTAL POPULATION, SS-16						60		45
SS-17	As Matuis	9	233	3.86%	556	21	556	21
SS-17	Matansa	3	44	6.82%	61	4	61	4
SS-17	San Roque	186	279	66.67%	519	346	296	197
TOTAL POPULATION, SS-17						372		223
SS-18	Marpi	89	119	74.79%	60	45	34	25
SS-18	Matansa	27	44	61.36%	61	37	61	37
TOTAL POPULATION, SS-18						82		63
SS-2	Chalan Laulau	89	286	31.12%	1,022	318	1,022	318
SS-2	Chalan Rueda	21	96	21.88%	180	39	103	23
SS-2	Gualo Rai	1	492	0.20%	1,162	2	664	1
SS-2	I Liyang	34	188	18.09%	642	116	367	66
TOTAL POPULATION, SS-2						476		408
SS-3	Gualo Rai	263	492	53.46%	1,162	621	664	355
SS-3	I Liyang	59	188	31.38%	642	201	367	115
TOTAL POPULATION, SS-3						823		470
SS-4	China Town	19	216	8.80%	892	78	510	45
SS-4	Fananganan	5	280	1.79%	1,120	20	1,120	20
SS-4	Garapan	147	702	20.94%	2,788	584	1,593	334
SS-4	Gualo Rai	67	492	13.62%	1,162	158	664	90
SS-4	I Liyang	95	188	50.53%	642	324	367	185
TOTAL POPULATION, SS-4						1,165		674
SS-5	China Town	1	216	0.46%	892	4	510	2
SS-5	Garapan	253	702	36.04%	2,788	1,005	1,593	574
TOTAL POPULATION, SS-5					892	1,009		576
SS-6	China Town	102	216	47.22%		421	510	241
SS-6	Fananganan	25	280	8.93%	1,120	100	1,120	100
TOTAL POPULATION, SS-6						521		341
SS-7	Garapan	58	702	8.26%	2,788	230	1,593	132
TOTAL POPULATION, SS-7						230		132

Table 3.1.11-1. Allocation of Projected Population by Sewershed for Year 2015

					Year 2015			
					High		**Low**	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**	**Percent Distribution of Rooftops by CDP**	**100% CDP**	**This SS**	**100% CDP**	**This SS**
SS-8	American Memorial Park	2	44	4.55%	-	-	-	-
SS-8	Garapan	59	702	8.40%	2,788	234	1,593	134
TOTAL POPULATION, SS-8						234		134
SS-9	American Memorial Park	1	44	2.27%	-	-	-	-
SS-9	Garapan	103	702	14.67%	2,788	409	1,593	234
TOTAL POPULATION, SS-9						409		234

Table 3.1.11-2. Saipan Allocation of Population Projections by Sewershed for Year 2020

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2020			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-1	Afetnas	84	347	24.21%	1,040	252	594	144
SA-1	Agingan	34	158	21.52%	216	46	123	26
SA-1	As Perdido	17	84	20.24%	244	49	244	49
SA-1	Koblerville	232	524	44.27%	2,145	950	997	441
SA-1	Tottotville	7	68	10.29%	265	27	265	27
TOTAL POPULATION, SA-1						1,325		688
SA-10	San Jose (Oleai)	1	208	0.48%	979	5	979	5
SA-10	Susupe	146	458	31.88%	1,455	464	831	265
TOTAL POPULATION, SA-10						469		270
SA-11	Chalan Laulau	8	286	2.80%	1,125	31	1,125	31
SA-11	San Jose (Oleai)	196	208	94.23%	979	923	979	923
SA-11	Susupe	11	458	2.40%	1,455	35	831	20
TOTAL POPULATION, SA-11						989		974
SA-12	As Terlaje	45	76	59.21%	289	171	289	171
SA-12	Chalan Kiya	91	362	25.14%	1,090	274	1,090	274
SA-12	Finasisu	160	671	23.85%	2,516	600	2,516	600
SA-12	Kannat Tabla	65	233	27.90%	612	171	350	98
TOTAL POPULATION, SA-12						1,216		1,143
SA-13	Chalan Kiya	152	362	41.99%	1,090	458	1,090	458
SA-13	San Jose (Oleai)	8	208	3.85%	979	38	979	38
TOTAL POPULATION, SA-13						495		495
SA-14	Chalan Kiya	30	362	8.29%	1,090	90	1,090	90
SA-14	Chalan Laulau	56	286	19.58%	1,125	220	1,125	220
SA-14	Chalan Rueda	27	96	28.13%	180	51	103	29
TOTAL POPULATION, SA-14						361		340
SA-15	Agingan	71	158	44.94%	216	97	123	55
SA-15	As Gonna	18	95	18.95%	161	31	161	31
SA-15	Koblerville	278	524	53.05%	2,145	1,138	997	529
SA-15	Tottotville	5	68	7.35%	265	19	265	19
TOTAL POPULATION, SA-15						1,285		634
SA-16	As Gonna	5	95	5.26%	161	8	161	8
SA-16	Koblerville	5	524	0.95%	2,145	20	997	10
TOTAL POPULATION, SA-16						29		18

Table 3.1.11-2. Saipan Allocation of Population Projections by Sewershed for Year 2020

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2020			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-17	As Lito	64	251	25.50%	944	241	944	241
SA-17	As Perdido	26	84	30.95%	244	76	244	76
SA-17	Dagu	124	255	48.63%	801	390	801	390
SA-17	Finasisu	128	671	19.08%	2,516	480	2,516	480
SA-17	Kannat Tabla	16	233	6.87%	612	42	350	24
SA-17	San Vicente	33	589	5.60%	1,464	82	836	47
SA-17	Tottotville	10	68	14.71%	265	39	265	39
TOTAL POPULATION, SA-17						1,349		1,296
SA-18	Dagu	56	255	21.96%	801	176	801	176
SA-18	Dan Dan	31	914	3.39%	2,296	78	1,312	44
SA-18	San Vicente	6	589	1.02%	1,464	15	836	9
TOTAL POPULATION, SA-18						269		229
SA-19	As Lito	65	251	25.90%	944	244	944	244
SA-19	Dagu	7	255	2.75%	801	22	801	22
SA-19	Dan Dan	108	914	11.82%	2,296	271	1,312	155
SA-19	I Fadang	23	53	43.40%	-	-	-	-
TOTAL POPULATION, SA-19						538		421
SA-2	Afetnas	171	347	49.28%	1,040	513	594	293
SA-2	Chalan Piao	89	319	27.90%	1,316	367	1,316	367
SA-2	San Antonio	194	198	97.98%	804	788	460	451
TOTAL POPULATION, SA-2						1,667		1,111
SA-3	Chalan Kanoa IV	8	131	6.11%	682	42	252	15
SA-3	Chalan Piao	129	319	40.44%	1,316	532	1,316	532
TOTAL POPULATION, SA-3						574		548
SA-4	Chalan Kanoa II	40	206	19.42%	945	183	945	183
SA-4	Chalan Kanoa III	17	127	13.39%	556	74	318	43
SA-4	Chalan Kanoa IV	114	131	87.02%	682	593	252	219
SA-4	Chalan Piao	6	319	1.88%	1,316	25	1,316	25
TOTAL POPULATION, SA-4						876		470
SA-5	Chalan Kanoa I	20	259	7.72%	913	71	522	40
SA-5	Chalan Kanoa III	97	127	76.38%	556	425	318	243
SA-5	Chalan Kanoa IV	9	131	6.87%	682	47	252	17
TOTAL POPULATION, SA-5						542		301
SA-6	Chalan Kanoa II	152	206	73.79%	945	697	945	697
SA-6	Chalan Kanoa III	12	127	9.45%	556	53	318	30
TOTAL POPULATION, SA-6						750		727

Table 3.1.11-2. Saipan Allocation of Population Projections by Sewershed for Year 2020

					Year 2020			
					High		Low	
Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	100% CDP	This SS	100% CDP	This SS
SA-7	Chalan Kanoa I	182	259	70.27%	913	642	522	367
SA-7	Chalan Kanoa II	1	206	0.49%	945	5	945	5
SA-7	Chalan Kanoa III	1	127	0.79%	556	4	318	3
TOTAL POPULATION, SA-7						651		374
SA-8	Chalan Kanoa II	13	206	6.31%	945	60	945	60
SA-8	Susupe	214	458	46.72%	1,455	680	831	388
TOTAL POPULATION, SA-8						739		448
SA-9	Chalan Kanoa I	50	259	19.31%	913	176	522	101
SA-9	Susupe	39	458	8.52%	1,455	124	831	71
TOTAL POPULATION, SA-1						300		172
SS-1	Chalan Laulau	93	286	32.52%	1,125	366	1,125	366
TOTAL POPULATION, SS-1						366		366
SS-10	As Palacios	4	112	3.57%	503	18	287	10
SS-10	Chalan Galaide	1	46	2.17%	183	4	183	4
SS-10	China Town	94	216	43.52%	892	388	510	222
SS-10	Fananganan	235	280	83.93%	1,233	1,035	1,233	1,035
SS-10	Garapan	80	702	11.40%	2,788	318	1,593	182
SS-10	Maturana Hill	12	65	18.46%	113	21	64	12
SS-10	Navy Hill	67	110	60.91%	267	163	267	163
TOTAL POPULATION, SS-10						1,946		1,627
SS-11	As Palacios	71	112	63.39%	503	319	287	182
TOTAL POPULATION, SS-11						319		182
SS-12	As Palacios	2	112	1.79%	503	9	287	5
SS-12	As Rabagau	17	240	7.08%	695	49	695	49
SS-12	Puerto Rico	43	49	87.76%	-	-	-	-
TOTAL POPULATION, SS-12						58		54
SS-13	As Rabagau	39	240	16.25%	695	113	695	113
SS-13	Capitol Hill	194	421	46.08%	1,816	837	1,055	486
SS-13	Lower Base	17	94	18.09%	51	9	51	9
SS-13	Puerto Rico	1	49	2.04%	-	-	-	-
SS-13	Sadog Tasi	39	51	76.47%	118	90	118	90
TOTAL POPULATION, SS-13						1,049		699
SS-14	Lower Base	59	94	62.77%	51	32	51	32
SS-14	Tanapag	59	214	27.57%	851	235	851	235
TOTAL POPULATION, SS-14						267		267

Table 3.1.11-2. Saipan Allocation of Population Projections by Sewershed for Year 2020

				Percent Distribution of Rooftops by CDP	Year 2020			
					High		Low	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**		**100% CDP**	**This SS**	**100% CDP**	**This SS**
SS-15	Achugao	19	97	19.59%	215	42	215	42
SS-15	As Mahetog	41	120	34.17%	312	107	312	107
SS-15	Tanapag	142	214	66.36%	851	565	851	565
TOTAL POPULATION, SS-15						713		713
SS-16	Achugao	13	97	13.40%	215	29	215	29
SS-16	San Roque	18	279	6.45%	519	33	296	19
TOTAL POPULATION, SS-16						62		48
SS-17	As Matuis	9	233	3.86%	612	24	612	24
SS-17	Matansa	3	44	6.82%	67	5	67	5
SS-17	San Roque	186	279	66.67%	519	346	296	197
TOTAL POPULATION, SS-17						374		226
SS-18	Marpi	89	119	74.79%	60	45	34	25
SS-18	Matansa	27	44	61.36%	67	41	67	41
TOTAL POPULATION, SS-18						86		67
SS-2	Chalan Laulau	89	286	31.12%	1,125	350	1,125	350
SS-2	Chalan Rueda	21	96	21.88%	180	39	103	23
SS-2	Gualo Rai	1	492	0.20%	1,162	2	664	1
SS-2	I Liyang	34	188	18.09%	642	116	367	66
TOTAL POPULATION, SS-2						508		440
SS-3	Gualo Rai	263	492	53.46%	1,162	621	664	355
SS-3	I Liyang	59	188	31.38%	642	201	367	115
TOTAL POPULATION, SS-3						823		470
SS-4	China Town	19	216	8.80%	892	78	510	45
SS-4	Fananganan	5	280	1.79%	1,233	22	1,233	22
SS-4	Garapan	147	702	20.94%	2,788	584	1,593	334
SS-4	Gualo Rai	67	492	13.62%	1,162	158	664	90
SS-4	I Liyang	95	188	50.53%	642	324	367	185
TOTAL POPULATION, SS-4						1,167		676
SS-5	China Town	1	216	0.46%	892	4	510	2
SS-5	Garapan	253	702	36.04%	2,788	1,005	1,593	574
TOTAL POPULATION, SS-5						1,009		576
SS-6	China Town	102	216	47.22%	892	421	510	241
SS-6	Fananganan	25	280	8.93%	1,233	110	1,233	110
TOTAL POPULATION, SS-6						531		351
SS-7	Garapan	58	702	8.26%	2,788	230	1,593	132
TOTAL POPULATION, SS-7						230		132

Table 3.1.11-2. Saipan Allocation of Population Projections by Sewershed for Year 2020

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2020			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SS-8	American Memorial Park	2	44	4.55%	-	-	-	-
SS-8	Garapan	59	702	8.40%	2,788	234	1,593	134
TOTAL POPULATION, SS-8						234		134
SS-9	American Memorial Park	1	44	2.27%	-	-	-	-
SS-9	Garapan	103	702	14.67%	2,788	409	1,593	234
TOTAL POPULATION, SS-9						409		234

Table 3.1.11.-3. Saipan Allocation of Population Projections by Sewershed for Year 2030

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2030			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-1	Afetnas	84	347	24.21%	966	234	594	144
SA-1	Agingan	34	158	21.52%	200	43	123	26
SA-1	As Perdido	17	84	20.24%	378	76	278	56
SA-1	Koblerville	232	524	44.27%	2,780	1,231	1,577	698
SA-1	Tottotville	7	68	10.29%	401	41	301	31
TOTAL POPULATION, SA-1						1,625		956
SA-10	San Jose (Oleai)	1	208	0.48%	1,113	5	1,113	5
SA-10	Susupe	146	458	31.88%	1,351	431	831	265
TOTAL POPULATION, SA-10						436		270
SA-11	Chalan Laulau	8	286	2.80%	1,379	39	1,279	36
SA-11	San Jose (Oleai)	196	208	94.23%	1,113	1,049	1,113	1,049
SA-11	Susupe	11	458	2.40%	1,351	32	831	20
TOTAL POPULATION, SA-11						1,120		1,105
SA-12	As Terlaje	45	76	59.21%	329	195	329	195
SA-12	Chalan Kiya	91	362	25.14%	1,239	311	1,239	311
SA-12	Finasisu	160	671	23.85%	2,959	706	2,859	682
SA-12	Kannat Tabla	65	233	27.90%	668	186	350	98
TOTAL POPULATION, SA-12						1,398		1,286
SA-13	Chalan Kiya	152	362	41.99%	1,239	520	1,239	520
SA-13	San Jose (Oleai)	8	208	3.85%	1,113	43	1,113	43
TOTAL POPULATION, SA-13						563		563
SA-14	Chalan Kiya	30	362	8.29%	1,239	103	1,239	103
SA-14	Chalan Laulau	56	286	19.58%	1,379	270	1,279	250
SA-14	Chalan Rueda	27	96	28.13%	267	75	103	29
TOTAL POPULATION, SA-14						448		382
SA-15	Agingan	71	158	44.94%	200	90	123	55
SA-15	As Gonna	18	95	18.95%	183	35	183	35
SA-15	Koblerville	278	524	53.05%	2,780	1,475	1,577	837
SA-15	Tottotville	5	68	7.35%	401	29	301	22
TOTAL POPULATION, SA-15						1,629		949
SA-16	As Gonna	5	95	5.26%	183	10	183	10
SA-16	Koblerville	5	524	0.95%	2,780	27	1,577	15
TOTAL POPULATION, SA-16						36		25

Table 3.1.11.-3. Saipan Allocation of Population Projections by Sewershed for Year 2030

				Percent Distribution of Rooftops by CDP	Year 2030			
					High		Low	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**		**100% CDP**	**This SS**	**100% CDP**	**This SS**
SA-17	As Lito	64	251	25.50%	1,173	299	1,073	274
SA-17	As Perdido	26	84	30.95%	378	117	278	86
SA-17	Dagu	124	255	48.63%	1,010	491	910	443
SA-17	Finasisu	128	671	19.08%	2,959	564	2,859	545
SA-17	Kannat Tabla	16	233	6.87%	668	46	350	24
SA-17	San Vicente	33	589	5.60%	1,459	82	836	47
SA-17	Tottotville	10	68	14.71%	401	59	301	44
TOTAL POPULATION, SA-17						1,658		1,463
SA-18	Dagu	56	255	21.96%	1,010	222	910	200
SA-18	Dan Dan	31	914	3.39%	2,232	76	1,312	44
SA-18	San Vicente	6	589	1.02%	1,459	15	836	9
TOTAL POPULATION, SA-18						312		253
SA-19	As Lito	65	251	25.90%	1,173	304	1,073	278
SA-19	Dagu	7	255	2.75%	1,010	28	910	25
SA-19	Dan Dan	108	914	11.82%	2,232	264	1,312	155
SA-19	I Fadang	23	53	43.40%	-	-	-	-
TOTAL POPULATION, SA-19						595		458
SA-2	Afetnas	171	347	49.28%	966	476	594	293
SA-2	Chalan Piao	89	319	27.90%	1,496	417	1,496	417
SA-2	San Antonio	194	198	97.98%	747	732	460	451
TOTAL POPULATION, SA-2						1,625		1,161
SA-3	Chalan Kanoa IV	8	131	6.11%	650	40	492	30
SA-3	Chalan Piao	129	319	40.44%	1,496	605	1,496	605
TOTAL POPULATION, SA-3						645		635
SA-4	Chalan Kanoa II	40	206	19.42%	1,074	209	1,074	209
SA-4	Chalan Kanoa III	17	127	13.39%	516	69	318	43
SA-4	Chalan Kanoa IV	114	131	87.02%	650	566	492	428
SA-4	Chalan Piao	6	319	1.88%	1,496	28	1,496	28
TOTAL POPULATION, SA-4						871		707
SA-5	Chalan Kanoa I	20	259	7.72%	848	65	522	40
SA-5	Chalan Kanoa III	97	127	76.38%	516	394	318	243
SA-5	Chalan Kanoa IV	9	131	6.87%	650	45	492	34
TOTAL POPULATION, SA-5						504		317
SA-6	Chalan Kanoa II	152	206	73.79%	1,074	792	1,074	792
SA-6	Chalan Kanoa III	12	127	9.45%	516	49	318	30
TOTAL POPULATION, SA-6						841		823

Table 3.1.11.-3. Saipan Allocation of Population Projections by Sewershed for Year 2030

Sewershed	CDP	Rooftops in SS	Rooftops in CDP	Percent Distribution of Rooftops by CDP	Year 2030			
					High		Low	
					100% CDP	This SS	100% CDP	This SS
SA-7	Chalan Kanoa I	182	259	70.27%	848	596	522	367
SA-7	Chalan Kanoa II	1	206	0.49%	1,074	5	1,074	5
SA-7	Chalan Kanoa III	1	127	0.79%	516	4	318	3
TOTAL POPULATION, SA-7						605		375
SA-8	Chalan Kanoa II	13	206	6.31%	1,074	68	1,074	68
SA-8	Susupe	214	458	46.72%	1,351	631	831	388
TOTAL POPULATION, SA-8						699		456
SA-9	Chalan Kanoa I	50	259	19.31%	848	164	522	101
SA-9	Susupe	39	458	8.52%	1,351	115	831	71
TOTAL POPULATION, SA-9						279		172
SS-1	Chalan Laulau	93	286	32.52%	1,379	448	1,279	416
TOTAL POPULATION, SS-1						448		416
SS-10	As Palacios	4	112	3.57%	467	17	287	10
SS-10	Chalan Galaide	1	46	2.17%	208	5	208	5
SS-10	China Town	94	216	43.52%	828	360	510	222
SS-10	Fananganan	235	280	83.93%	1,501	1,260	1,401	1,176
SS-10	Garapan	80	702	11.40%	2,789	318	1,593	182
SS-10	Maturana Hill	12	65	18.46%	105	19	64	12
SS-10	Navy Hill	67	110	60.91%	303	185	303	185
TOTAL POPULATION, SS-10						2,163		1,790
SS-11	As Palacios	71	112	63.39%	467	296	287	182
TOTAL POPULATION, SS-11						296		182
SS-12	As Palacios	2	112	1.79%	467	8	287	5
SS-12	As Rabagau	17	240	7.08%	890	63	790	56
SS-12	Puerto Rico	43	49	87.76%	-	-	-	-
TOTAL POPULATION, SS-12						71		61
SS-13	As Rabagau	39	240	16.25%	890	145	790	128
SS-13	Capitol Hill	194	421	46.08%	2,799	1,290	1,949	898
SS-13	Lower Base	17	94	18.09%	58	10	58	10
SS-13	Puerto Rico	1	49	2.04%	-	-	-	-
SS-13	Sadog Tasi	39	51	76.47%	234	179	134	102
TOTAL POPULATION, SS-13						1,624		1,139
SS-14	Lower Base	59	94	62.77%	58	36	58	36
SS-14	Tanapag	59	214	27.57%	1,117	308	967	267
TOTAL POPULATION, SS-14						344		303

Table 3.1.11.-3. Saipan Allocation of Population Projections by Sewershed for Year 2030

					Year 2030			
					High		Low	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**	**Percent Distribution of Rooftops by CDP**	**100% CDP**	**This SS**	**100% CDP**	**This SS**
SS-15	Achugao	19	97	19.59%	394	77	244	48
SS-15	As Mahetog	41	120	34.17%	505	173	355	121
SS-15	Tanapag	142	214	66.36%	1,117	741	967	642
TOTAL POPULATION, SS-15						991		811
SS-16	Achugao	13	97	13.40%	394	53	244	33
SS-16	San Roque	18	279	6.45%	632	41	296	19
TOTAL POPULATION, SS-16						94		52
SS-17	As Matuis	9	233	3.86%	695	27	695	27
SS-17	Matansa	3	44	6.82%	76	5	76	5
SS-17	San Roque	186	279	66.67%	632	421	296	197
TOTAL POPULATION, SS-17						453		229
SS-18	Marpi	89	119	74.79%	55	41	34	25
SS-18	Matansa	27	44	61.36%	76	47	76	47
TOTAL POPULATION, SS-18						88		72
SS-2	Chalan Laulau	89	286	31.12%	1,379	429	1,279	398
SS-2	Chalan Rueda	21	96	21.88%	267	58	103	23
SS-2	Gualo Rai	1	492	0.20%	1,179	2	664	1
SS-2	I Liyang	34	188	18.09%	696	126	367	66
TOTAL POPULATION, SS-2						616		488
SS-3	Gualo Rai	263	492	53.46%	1,179	630	664	355
SS-3	I Liyang	59	188	31.38%	696	218	367	115
TOTAL POPULATION, SS-3						849		470
SS-4	China Town	19	216	8.80%	828	73	510	45
SS-4	Fananganan	5	280	1.79%	1,501	27	1,401	25
SS-4	Garapan	147	702	20.94%	2,789	584	1,593	334
SS-4	Gualo Rai	67	492	13.62%	1,179	161	664	90
SS-4	I Liyang	95	188	50.53%	696	352	376	185
TOTAL POPULATION, SS-4						1,196		679
SS-5	China Town	1	216	0.46%	828	4	510	2
SS-5	Garapan	253	702	36.04%	2,789	1,005	1,593	574
TOTAL POPULATION, SS-5						1,009		576
SS-6	China Town	102	216	47.22%	828	391	510	241
SS-6	Fananganan	25	280	8.93%	1,501	134	1,401	125
TOTAL POPULATION, SS-6						525		366
SS-7	Garapan	58	702	8.26%	2,789	230	1,593	132
TOTAL POPULATION, SS-7						230		132

Table 3.1.11.-3. Saipan Allocation of Population Projections by Sewershed for Year 2030

					Year 2030			
					High		**Low**	
Sewershed	**CDP**	**Rooftops in SS**	**Rooftops in CDP**	**Percent Distribution of Rooftops by CDP**	**100% CDP**	**This SS**	**100% CDP**	**This SS**
SS-8	American Memorial Park	2	44	4.55%	-	-	-	-
SS-8	Garapan	59	702	8.40%	2,789	234	1,593	134
TOTAL POPULATION, SS-8						234		134
SS-9	American Memorial Park	1	44	2.27%	-	-	-	-
SS-9	Garapan	103	702	14.67%	2,789	409	1,593	234
TOTAL POPULATION, SS-9						409		234

3.2 Wastewater Flows and Loadings 20-Year Projection

Per capita use is the estimated average volume of water utilized per person, per day. The current per capita use rate that will be used for the island of Saipan and used for this Master Plan is shown in Table 3.2-1. This per capita use rate was developed by comparisons of low meter data and other data collected in the field throughout this study. The rates for residential and government are within common industry values. The commercial and hotel rates are higher. This is like dues to discharge of brine from reverse osmosis systems and I/I.

Table 3.2-1. **Current Per Capita Use Rate**

Use	Load	Unit
Residential	90	gpd/capita
Commercial	130	gpd/capita
Hotel	130	gpd/capita
Government	65	gpd/capita
Airport	65	gpd/capita

3.2.1 Sewershed Population Projections

Estimates for per capita use rates for CNMI for this Master Plan were determined by taking the 2010 population data and fitting it into the sewersheds. The loading rates presented in Table 3.2.1-1 were multiplied by the 2010 population within each sewershed, providing the average daily flow per sewershed.

Sewer loading is not a direct measure of population, but instead a measurement of who is connected. This Master Plan recommends that CUC connect all customers within the existing collection system. In fact, this is a requirement set forth in CUC regulations. A conservative estimate assumes 67 percent of persons are connected to the existing collection system. This value was increased by 4 percent over each of the next 20 years for a resulting value of 71 percent in 2030. This 71-percent value was used as the percentage of the population projection for 2030 that will be connected to sewer. This value was distributed throughout the sewersheds using the same ratios used in the 2010 estimate.

It is noted that not all customers are connected to the sewer system. Further discussion on this matter is provided in the “Unsewered Areas” section of this Master Plan. The approach provided below is considered conservative as it assumes all customers are connected to the sewer system. Figure 2.2.6-4 Saipan Wastewater Sewersheds and Populations provides the location of each sewershed. Tables 3.2.1-1 and 3.2.1-2 present the 2010 population and projections for the Sadog Tasi and Agingan sewersheds, respectively. The projections were estimated using the methodology described below.

Table 3.2.1-1. **Population Projections by Sadog Tasi Sewershed**

Sewershed	2010 Population	2015 Projection	2020 Projection	2030 Projection
SS-1	356	366	486	604
SS-2	566	582	773	961
SS-3	1175	1209	1604	1994
SS-4	1657	1704	2262	2812
SS-5	1441	1482	1967	2446
SS-6	709	729	968	1203
SS-7	329	338	449	558
SS-8	335	345	457	569
SS-9	584	601	797	991
SS-10	2234	2298	3049	3791
SS-11	455	468	621	772
SS-12	61	63	83	104
SS-13	681	701	930	1156
SS-14	260	267	355	441
SS-15	695	715	949	1180
SS-16	76	78	104	129
SS-17	521	536	711	884
SS-18	103	106	141	175

Table 3.2.1-2. **Population Projections by Agingan Sewershed**

Sewershed	2010 Population	2015 Projection	2020 Projection	2030 Projection
SA-2	2216	2280	3025	3761
SA-3	557	573	760	945
SA-4	858	883	1171	1456
SA-5	750	771	1024	1273
SA-6	755	777	1031	1281
SA-7	927	954	1265	1573
SA-8	1029	1058	1405	1746
SA-9	429	441	586	728
SA-10	667	686	910	1132
SA-11	980	1008	1338	1663
SA-12	1262	1298	1723	2142
SA-13	483	497	659	820
SA-14	375	386	512	636
SA-1	1604	1650	2189	2722
SA-15	1510	1553	2061	2563
SA-16	32	33	44	54
SA-17	1370	1409	1870	2325
SA-18	304	313	415	516
SA-19	647	666	883	1098

3.2.2 Sewershed Loading Projections

Using the unit demand and population projections, the average loading for 2015, 2020, and 2030 may be calculated; Tables 3.2.1-3 and 3.2.1-4 presents the projected sewer loading per sewershed for Sadog Tasi and Agingan, respectively. The high estimate for population growth has been used to present a conservative development approach and to not undersize and future upgrades. These data will be used to evaluate to existing capacity of the collection system and treatment plants. It is expected that the village of Dan Dan will be partially sewered by the year 2020. Approximately 50 percent of the projected population of Dan Dan is presented in the year 2020.

Table 3.2.1-3. **Projected Loading per Sadog Tasi Sewershed**

Sewershed	Use	Loading	GPD (2015)	GPD (2020)	GPD (2030)
SS-1	Residential/Commercial	130	47,606	63,169	78,545
SS-2	Residential/Commercial	130	75,689	100,432	124,878
SS-3	Residential/Commercial	130	157,127	208,494	259,243
SS-4	Residential/Commercial	130	221,583	294,021	365,588
SS-5	Commercial/Hotel	130	192,698	255,693	317,931
SS-6	Residential/Commercial	130	94,811	125,806	156,428
SS-7	Commercial/Hotel	130	43,996	58,378	72,588
SS-8	Commercial/Hotel	130	44,798	59,443	73,912
SS-9	Commercial	130	78,096	103,626	128,849
SS-10	Residential/Commercial	130	298,743	396,404	492,893
SS-11	Residential/Commercial	130	60,845	80,736	100,388
SS-12	Residential/Commercial	130	8,157	10,824	13,459
SS-13	Residential/Government	90	63,046	83,657	104,020
SS-14	Commercial/Government	90	24,071	31,939	39,714
SS-15	Residential/Commercial	90	64,343	85,377	106,158
SS-16	Residential/Commercial	90	7,036	9,336	11,609
SS-17	Residential/Commercial	90	48,234	64,002	79,580
SS-18	Residential/Commercial	90	9,536	12,653	15,733

Table 3.2.1-4. **Projected Loading per Agingan Sewershed**

Sewershed	Use	Loading	GPD (2015)	GPD (2020)	GPD (2030)
SA-2	Commercial/Hotel	65	148,168	196,605	244,461
SA-3	Commercial/Hotel	65	37,243	49,417	61,446
SA-4	Residential/Commercial	65	57,368	76,122	94,651
SA-5	Residential	65	50,147	66,541	82,737
SA-6	Residential	65	50,481	66,984	83,289
SA-7	Residential	65	61,982	82,244	102,263
SA-8	Residential/Commercial	65	68,802	91,294	113,515
SA-9	Residential	65	28,684	38,061	47,326
SA-10	Residential/Commercial	65	44,597	59,177	73,581
SA-11	Residential/Commercial	65	65,525	86,946	108,110
SA-12	Residential/Commercial	65	84,381	111,966	139,219
SA-13	Residential	65	32,295	42,852	53,283
SA-14	Residential/Commercial	65	25,074	33,270	41,369
SA-1	Residential	65	107,248	142,308	176,947
SA-15	Residential	65	100,963	133,968	166,578
SA-16	Residential	65	2,140	2,839	3,530
SA-17	Residential/Commercial	65	91,602	121,547	151,133
SA-18	Residential/Commercial	65	20,326	26,971	33,536
SA-19	Residential/Commercial/Airport	65	43,260	57,402	71,375

The values provided in Tables 3.2.1-3 and 3.2.1-4 are summarized in Table 3.2.1-5. These project loadings are a conservative value of the average and peak flows that may be expected at the Sadog Tasi and Agingan WWTPs.

Table 3.2.1-5. **Projected Average and Peak Loadings by Wastewater Treatment Plant (in million gallons per day)**

	2010	2015	2020	2030
Sadog Tasi (Average)	1.50	1.54	2.04	2.54
Agingan (Average)	1.09	1.12	1.64	2.00
Sadog Tasi (Peak)	3.19	3.28	4.35	5.41
Agingan (Peak)	2.18	2.24	3.27	4.01

3.3 Status of "Construction Works in Progress"

Table 3.3-1 lists the construction projects that are in progress or have been completed since 2011.

Table 3.3-1. **Saipan Wastewater System Construction Works in Progress**

Project Name	Project Status
Rehabilitation of Lift Station S-8 and Elimination of Lift Station S-2	Under Construction
Rehabilitation of Lift Station S-3	Under Construction
Improvements to Agingan WWTP	Under Construction
Sewer Service Connections	Under Construction
Lift Station Improvements and Maintenance Shop	Under Construction and In Design
Sewer Main Replacement	Under Construction and In Design
Lift Station Elimination	In Study Phase

3.4 Assessment of Current CUC Management Policies, Procedures, and Operating Rules and Regulations for the Wastewater System

This section summarizes the review of current CUC staffing, management policies, procedures, operating rules and regulations. The purpose of this review was to document the most prominent obstacles to CUC management in terms of its organizational structure, labor force issues, ability to comply with the Stipulated Order and, more importantly, to perform its mission to operate the CNMI water and WW infrastructure systems efficiently and in accord with governing laws and regulations. The information for this review was derived from four sources:

- Observations during the 18-month master planning period
- Specific requests to CUC for relevant documentation
- Workshop with CUC on December 13, 2012 to discuss management issues
- Discussions with the Water Task Force

This section is organized as follows:

- Management organization
- Workforce issues
- Automation and technology
- Recommendations

3.4.1 Management Organization

This subsection focuses on the overall CUC organization, the organization of the Engineering Department within CUC, and the Water Task Force.

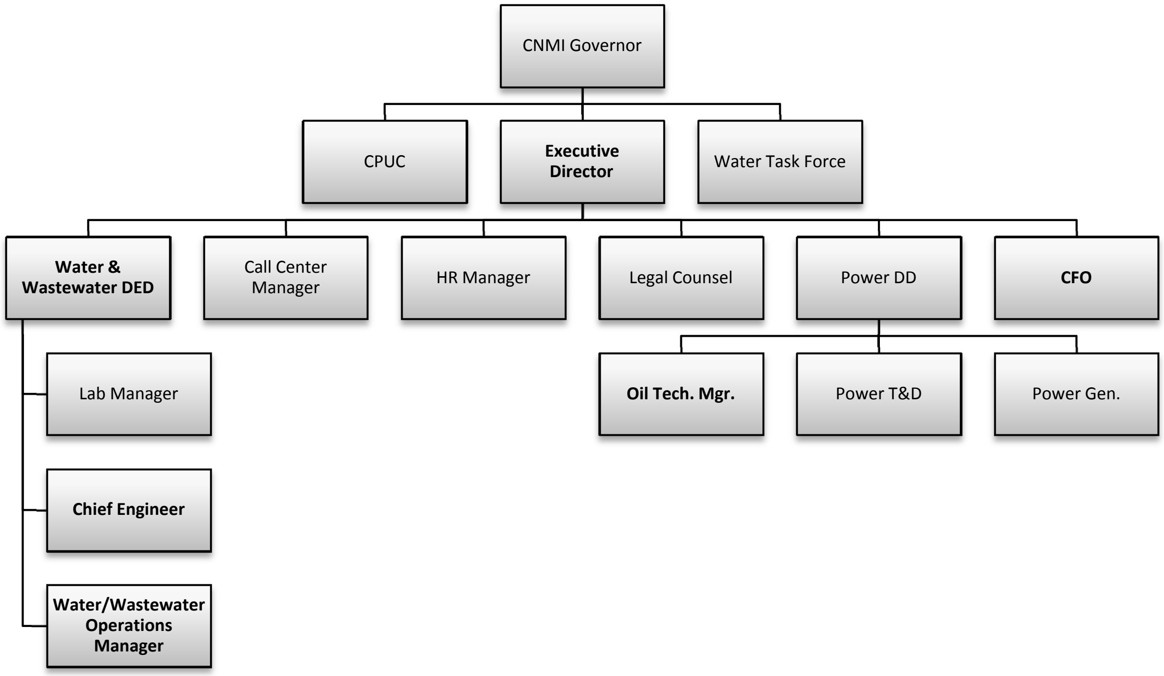
CUC Organizational Structure

The current upper management layer of CUC is shown in Figure 3.4.1-1.

The current structure of the organization is designed to comply with the requirements of the Stipulated Order. The management positions listed in bold text are required by the Stipulated Order. Additional positions not shown in Figure 3.4.1-1 include a Drinking Water and WW Division Manager and a Drinking Water and WW Associate Engineer. The positions dictated by the Stipulated Order have qualifications requirements that have been incorporated into the job description. These also serve as a safety mechanism to keep CUC from backsliding by preventing unqualified persons to become political appointments to critical positions, something that has been a problem in the past.

Though this organization structure meets current requirements, CUC expressed interest in evolving to a “flatter” organization, once Stipulated Order obligations have been satisfied, that reflects the current trend in the industry. This possible future restructuring would seek to reorient and streamline CUC engineering and operational functions. For example, the Stipulated Order requires a Deputy Executive Director, a Drinking Water and WW Division Manager, Chief Engineer, and a Drinking Water and WW Associate Engineer all possessing similar and redundant water and WW planning and engineering qualifications. A streamlined, but still effective CUC may eliminate a least one of these positions, if not more. At this point, however, there is no alternative organizational structure that is being requested for formal consideration by DEQ and EPA. Currently a number of these positons are vacant, including Deputy Director of Water and WW Operations and Deputy Executive Director, due to difficulty recruiting qualified staff.

Figure 3.4.1-1. **Commonwealth Utilities Corporation Upper Management Organizational Structure**



Engineering Organization within CUC

Traditionally, the Engineering Department has the responsibility for executing design and construction management of new and replacement Capital Improvement Projects, providing support to Operations, and managing specialized technologies (i.e., models, GIS).

Prior to the Master Plan implementation, engineering personnel have been called upon to investigate and act upon a wide range of operational issues in an ad-hoc manner, resulting in considerable time spent in the field designing water and WW system improvements to provide short-term operational fixes. This situation, plus the transition of several senior staff in and out of CUC, had led to a fragmented approach to project prioritization.

CUC’s Engineering Department has made significant strides in reversing these past practices. Strong leadership from the Chief Engineer has helped to redefine and reorganize the department’s mission to focus primarily on project management, systems analyses, implementation of capital improvements, and assuring that water and WW system operations are in concert with design and systems optimization initiatives. This focus is critical to implementing the Drinking Water and WW Master Plans, each which requires the CUC Engineering Department to oversee a myriad of capital improvement projects developed and prioritized during the master planning process to meet Stipulated Order requirements. Operational evaluations should be made by the Engineering Department in close consultation with Operations initially when events occur. Engineering support will be assigned by the Chief Engineer. As is human nature, individual and external interests will tempt staff to focus on short-term, or tactical, projects as opposed to taking a longer-term, strategic view of the Master Plan goals and objectives. It must be emphasized that these Master Plans and the fulfillment of the Stipulated Order are one and the same; failure to comply will have significant legal implications for CUC. This is a strategic function that is currently being directed by the Chief Engineer.

The Role of the Water Task Force

The Water Task Force occupies a unique role in the CNMI Government. Organizationally, WTF is identified as part of CUC; however, functionally and operationally, WTF operates with near autonomy. Consisting of a small staff and having direct political support from the Governor's Office, WTF has a single-purpose mission: improve the Saipan water system infrastructure to provide drinking water to the island community on a 24-hour basis. While 24-hour water is also a formal CUC priority, WTF pursues this goal independently and with minimal CUC coordination. Often the projects that are being implemented do not reflect the current thinking or needs of CUC as WTF continues to use the 2002 Master Plan, which is extremely dated.

With the projected availability of financial resources to fund water and WW infrastructure improvements dwindling, formally integrating the WTF staff and functions back into CUC will reduce costs by consolidating resources while at the same time enhancing the agency's ability to meet Stipulated Order requirements through implementation of the approved Master Plan. However, it will be important to keep intact the Water Task Force primary goal of achieving 24-hour water and its grant-writing expertise within CUC to maintain existing valuable relationships with funding agencies. The integration of WTF's contract procurement, contract administration, management, and engineering resources will strengthen CUC's ability to carry out its mandate to manage and operate the CNMI water and WW infrastructure systems efficiently and in accord with governing laws and regulations.

3.4.2 Workforce Issues

CUC faces a number of challenging workforce-related issues, including resident workforce development, training, absenteeism, and standard of care in performance of work.

Resident Professional and Technical Workforce Development

Over the past decades, the professional and technical personnel at CUC were predominantly contract employees and, more recently, U.S. Public Health Service (USPHS) personnel on temporary assignment. The assumption of the control of immigration by the U.S. federal government a few years ago has resulted in the mass termination of the services of contractual employees of alien status, with additional terminations anticipated unless immigration requirements are relaxed. In addition, the departure of many USPHS personnel of late has seriously reduced the number of qualified engineering and operations personnel. These concerns, coupled with Stipulated Order-mandated organizational requirements previously mentioned, have created at CUC a serious need to recruit and maintain a stable, qualified resident professional and technical workforce. Developing a qualified and efficient resident workforce will be an important goal for CUC. Until this is accomplished, CUC will need to continue to bring in recruits from the mainland for the key positions that are identified in the Stipulated Order.

Training

The need for training in a variety of contexts came up repeatedly in meetings with CUC management. Technical training is not readily available on the island, and it is costly to send staff to off-island training venues. As water and WW systems become more dependent on instrumentation, electronic controls, and equipment, providing technical training to CUC Engineering and Operations personnel must become an organizational objective. In addition, training will be a crucial component to developing a resident professional and technical workforce.

Absenteeism

Absenteeism, excused and unexcused, is substantially higher than that found at comparable utilities on the U.S. mainland. Several cultural elements play a part, including long-standing practices regarding extended bereavement leaves and time-off to attend to familial obligations. CUC management has attempted to control absenteeism in the past through policy enforcement communications, such as:

- Directive to All Departments, dated February 3, 2010, directs appropriate enforcement staff to review Personnel Regulations regarding annual leave hours.
- CUC Memorandum to All Employees, dated June 13, 2011, cites CUC Human Resources Rules, Section 12, specifically Section 12.12 – Unauthorized Absence.

These communications are provided in Appendix R. As evidenced in discussions with CUC senior management and in actual practice, HR policies, while in place, are not uniformly enforced, especially at the lower managerial levels.

Standard Level of Care at CUC Facilities

The “standard level of care” exercised by field personnel at certain CUC facilities needs to be improved. Pump stations, reservoirs and maintenance yards are often littered with junk and equipment parts. The unkempt state of CUC facilities hurts CUC’s public image and lowers the public’s expectation of the quality of CUC water and WW services.

3.4.3 Automation and Technology

The incorporation of automation and technology in CUC Operations and Engineering, if done effectively, will improve efficiency in managing and operating the water and WW systems, reduce costs, and increase productivity. Automation and technological initiatives are being applied to the SCADA system, the GIS, systems modeling, and a Computer Maintenance Management System (CMMS). The inclusion of the technologies discussed below will require that CUC identify champions who can be trained to properly maintain the functionalities. If this is not possible, CUC will need to have annual support contracts to provide this expertise.

SCADA System

Presently, CUC operates all of the wells, reservoirs, treatment (chlorination) systems and booster pump stations for their drinking water system manually because no SCADA system is in place. The lack of a SCADA system results in a very labor-intensive effort to check the operation of the drinking water system facilities daily to ensure proper operation. Installation and use of a robust SCADA system would decrease CUC Operations staff time required to inspect remote facilities on a daily basis, which would allow repurposing of staff for more pressing problems. In addition, SCADA alarms would provide an “early warning” if an operational issue was developing that would otherwise be unknown for hours or days. This benefit is of great value if the unattended operational issue could result in regulatory violations such as SSOs.

A pilot SCADA project is currently under final review for award to evaluate and test the performance of appropriate technologies. If the pilot program is successful, a detailed evaluation of the cost-benefit will be assessed prior to moving forward with a system-wide SCADA program. The SCADA Pilot project is further described and has been ranked in Section 4, but will be excluded from the CIP projects list as it is moving forward earlier than anticipated.

Though CUC leadership is optimistic that SCADA, once instituted, will significantly reduce water and WW systems operational costs in the long run, the initial acquisition, installation and maintenance of a systems-wide, integrated SCADA system will be costly. Furthermore, SCADA technology will require skilled, trained Instrument and Controls technicians to assure success. CUC must therefore develop a cost-effective strategy for the introduction, development and eventual system-wide use of SCADA in systems operations.

Geographic Information System

The master planning effort will develop and deliver to CUC a linked database and graphic system of the public water and WW systems assets. It is imperative that the GIS be maintained and updated as water and WW system improvements are added or components removed. The productive uses of a GIS program are numerous and include:

- Up-to-date inventory of all significant CUC water and WW assets
- Quick retrieval of data on the type, make, capacity and condition of system components
- Capability to create a graphic of water and WW infrastructure layouts on short notice
- Assistance in the scheduling of system maintenance and component replacement
- Interaction with computer-based models of the water and WW systems
- Extension of GIS capability to include other asset classes such as those associated with CUC power

CUC will need to dedicate an individual to champion the GIS to continue to receive value from the initial effort. Converting the desktop GIS to a web-based GIS would provide a cost-effective way for an outside contractor to perform system updates if internal resources are not available.

Water and Wastewater Systems Models

The master planning effort will also develop and deliver to CUC computer-based models of the water and WW systems. Updating these models is as important as the maintenance and updating of the GIS program. In fact, the GIS and systems-modeling programs are interlinked and inter-dependent in their function in that they operate using the same database of system components and conditions. The benefits of an accurate system model include:

- Planning tool for new capital and replacement projects
- Operational tool to assess the benefits and impacts of making large operational changes

The models developed for the Master Plan will need to be updated over time, and additional model calibrations conducted as the system evolves. This again can be done by a trained internal resource or by the same external group that would update the GIS.

Computer Maintenance Management System

The design and implementation of a Computer Maintenance Management System (CMMS) would enhance the ability of engineering, operation, and finance staff to properly schedule and track routine and non-routine maintenance activities, improve inventory control, track the financial cost of routine and non-routine system maintenance. These activities are presently done manually using multiple databases making the information difficult to share efficiently. The result of implementing a CMMS in conjunction with GIS would include more efficient use of staff time, historical documentation of system maintenance activities, and improved financial tracking of maintenance costs.

CUC is close to awarding a Task Order under the IDIQ to develop the first phase of a CMMS using VueWorks. The goal is to train CUC staff in the CMMS application and take them through a series of asset development tracks. After the initial training is conducted, the CUC team will continue to expand the CMMS capabilities for all of its water and WW assets.

3.4.4 Recommendations

The following are recommendations on reducing or minimizing the impediments to CUC management in terms of its organizational structure, workforce issues, and ability to comply with the Stipulated Order as well as perform its mission to operate the CNMI water and WW infrastructure systems efficiently and in accord with governing laws and regulations.

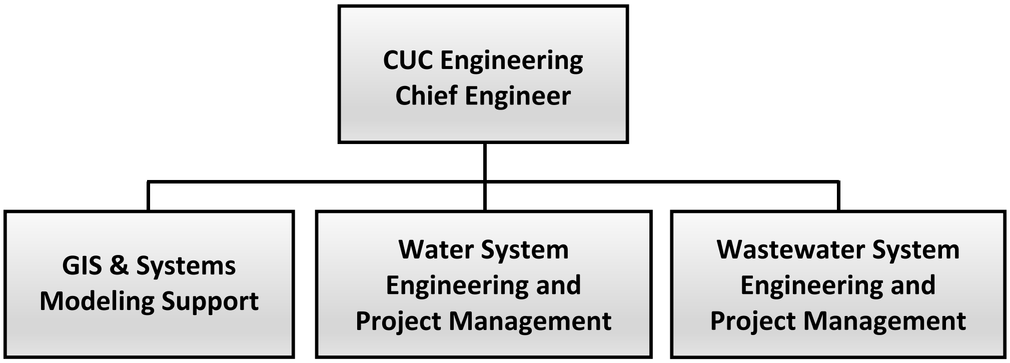
Management Structure: Engineering and the Integration of the Water Task Force, GIS, and Systems Modeling Under the Engineering Function

The Engineering branch of CUC should consider the proposed reorganization described below. The cost of the proposed reorganization would be relatively low since there would not be any additional staff required.

1. Continue to refine the Engineering function under the direction (and office) of the Chief Engineer. The current focus that the Chief Engineer has been implementing on project management, systems analyses, implementation of capital improvements, and assuring that water and WW systems operations are in concert with design and systems optimization initiatives is consistent with industry practices.
2. Integrate the Water Task Force into the water and WW engineering support groups under the Chief Engineer while maintaining as a key mission and goal of achieving 24-hour water service for all customers. The integration of the WTF's contract procurement, contract administration and grant writing expertise will strengthen CUC's ability to carry out its mandate to manage and operate the CNMI water and WW infrastructure systems.
3. Place the GIS and modeling functions under the direct supervision of the Chief Engineer and managed by one staff member trained in GIS and systems modeling and equipped with a dedicated, specialized work station. In addition, establish a new job classification of GIS/Computer Modeling Specialist to aid in the recruitment of qualified personnel as needed. The budget of the GIS and Modeling functions must be forward-looking to assure that software programs, licenses and attendant hardware are properly replaced or renewed.

Figure 3.4.4-1 is a proposed organization chart that reflects the above recommendations.

Figure 3.4.4-1. **Proposed Commonwealth Utilities Corporation Engineering Organization Chart**



Workforce Issues

The workforce issues described below will range from low-cost, low-hanging fruit (e.g., policy changes) to higher cost changes (e.g., training) that would need to be prioritized once the economic conditions for CUC improve and funds become available.

Resident Professional and Technical Workforce Development and Training

The following are suggestions and recommendations on recruitment and development of a stable professional and technical resident workforce at CUC:

1. Identify current CUC employees who have demonstrated a high potential for advancement to professional, technical or high-level operational positions required for the management and operation of CUC's water and WW systems and develop and implement a program customized for each candidate to pursue a targeted, high-level position. This program of in-house advancement must be accompanied by a policy giving preference to employee promotions vis-à-vis open recruitment.
2. Identify and contact professionals and technicians who were former CNMI residents and recruit those who indicate a desire to relocate back to the CNMI.
3. Track local islanders who are pursuing higher education on the U.S. Mainland or elsewhere and target them for incentivized recruitment efforts. For example, returning residents with engineering degrees may be offered paid temporary housing and air travel to the CNMI. Recruitment efforts must target candidates during the early years of their off-island education. This is already being done effectively by the CUC Engineering Department.
4. Offer internships to CNMI students seeking higher education abroad and who wish to spend summers in the CNMI in CUC Engineering and Operations.
5. Visit local high schools during "Career Day" to promote employment at CUC as a career opportunity under various professional, technical, and operations positions.
6. Approach NMC to develop a technical curriculum for current and prospective CUC employees.
7. Conduct periodic training workshops for all CUC engineers and engineering technicians on the capabilities and features of the GIS and System Modeling programs.

The following are several training-related suggestions to aid in building a technologically savvy resident work force:

- Budget to send key staff for off-island training.
- Reward "stars" with off-island technical training opportunities.
- Work with the local education entities (i.e., NMC) to develop apprenticeship programs. This has been done on Guam with modest success.
- Create and fund an effective water and WW systems operator training in preparation for pursuing certification program. Provide project management training for CUC engineering personnel.

Dealing with Absenteeism

The following are suggestions and recommendations on minimizing absenteeism:

1. Educate and support middle and lower level supervisors regarding attendance policies and enforcement.
2. Discontinue "sick leave" accruals and adopt the more common Paid Time Off or Personal Leave concept.
3. Revise the Reduction in Force (RIF) approach to favor/give preference to retaining employees based on merit rather than seniority.
4. Conduct "all hands" meetings to address common issues.

Elevating the Standard of Level of Care of CUC Facilities

We recommend that CUC develop and post written guidelines and performance standards defining the minimum level of care required at CUC facilities. These standards should typically describe house and grounds-keeping tasks, many of which will not involve significant expenditure. They should include such topics as:

- Yard maintenance
- Removal and disposal of unusable equipment
- Parts storage
- Security
- Maintenance of tools

Compliance with established Standard Level of Care of CUC facilities should be included in the duties and responsibilities of supervisory CUC personnel assigned to such facilities.

Automation

SCADA System

Conduct a pilot project to test the long-term viability of SCADA. If successful, a second step can be the implementation of a project to install SCADA to control a selected water service area. Create a new job classification of Instrument and Control Technician to support the second step in the overall SCADA development strategy.

Computer Maintenance Management System

Design and implement a CMMS for the water, WW, and power divisions under a single platform to reduce the cost of developing and maintaining multiple systems. As part of the CMMS implementation, develop process maps for different work activities being conducted and use the opportunity to brainstorm to identify ways to improve the efficiency for the workforce and remove redundancy where ever possible through the integration of activities. One example would be to integrate the WTF leak detection work with the CUC Operations Teams leak detection efforts.

SECTION 4

Wastewater System Master Plan

The contents of Section 4, “Wastewater System Master Plan" are as follows:

4.1 Stipulated Order Planning and Compliance Requirements for the Wastewater Master Plan

Table 4.1-1 lists the requirements of the Stipulated Order and the corresponding sections in the project team's scope of work and this Master Plan that comply with the requirements.

Table 4.1-1. **Stipulated Order Compliance**

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Saipan Wastewater Master Plan
III.B.50	Develop a Comprehensive Drinking Water and Wastewater Master Plan	A Master Plan in accordance with the Stipulated Order	CUC, DCA/ CH2M	3.5, 3.7	4.1, 4.2, 4.3, 4.4
III.B.B1.51	Wastewater Assessment	Wastewater Master Plan Section 2.2	CUC, DCA/ CH2M	3.2.1, 3.2.2, 3.2.3, 3.2.6	2.2.1, 2.2.2, 2.2.3
III.B.B1.52	Condition Assessment for the Wastewater Systems	Wastewater Master Plan Section 2.2	CUC, DCA/ CH2M	3.2.2, 3.2.6	2.2.2 2.2.3, 2.2.10
III.B.B1.57a	Hydraulic Capacity Assessment (Wastewater)	Wastewater Master Plan Section 2.2.6	CUC, DCA/ CH2M	3.2.3, 3.2.4	2.2.6
III.B.B1.58	Unsewered Areas Assessment	Assessment of potential hookups to existing, new, or expanded wastewater systems and alternatives for those that don't have access to a centralized system	CUC, DCA/ CH2M	3.5.1, 3.5.4, 3.5.5, 3.5.6	2.2.7
III.B.B1.59	Reliability Assessment	Assessment of reliability of wastewater system to ensure continuous operation	CUC, DCA/ CH2M	3.2.2, 3.2.3, 3.2.6, 3.5.5	4.2, 4.4
III.B.B2.60c	Develop Schedule for Repair, Rehabilitation, and Replacement	Priorities and schedules for Wastewater system components to provide continuous operation	CUC, DCA/ CH2M	3.5.6, 3.5.7	4.4.2
III.B.B2.61	Develop an Asset Inventory	Wastewater Master Plan Section 2.2.9	CUC, DCA/ CH2M	3.2.2	2.2, 2.7.1
III.B.B2.62	Development of a Geographic Information System (GIS)	Wastewater Master Plan Section 2.2.8	CUC, DCA/ CH2M	3.2.5	2.6
III.B.B2.63	Develop Recommendations for an Alternative Control System	Specific evaluations and recommendations for process control system improvements	CUC, DCA/ CH2M	3.3.7, 3.5.1, 3.5.4	3.4.3
III.B.B2.64b	Develop a Wastewater Infrastructure Improvement Plan	Wastewater Master Plan Section 4.3	CUC, DCA/ CH2M	3.2.6, 3.5.3, 3.5.6, 3.5.7, 3.6.3	4.3

Table 4.1-1. **Stipulated Order Compliance**

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Saipan Wastewater Master Plan
III.B.B2.65	Develop Final Financial Plan	Estimated Annual Budget for next 5-years; Revenue Plan for All Compliance Activities	CUC, DCA/ CH2M	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5	4.4.2, Financial Plan (separate document)
III.B.B3.66c	Drafts of Master Plan	See Wastewater Master Plan	CUC, DCA/ CH2M	3.7.1	
III.B.B3.66d	Final Draft of the Master Plan and Financial Plan	Master Plan and Financial Plan	CUC, DCA/ CH2M	3.7.2	
III.B.B3.66e	Public Comment on Master Plan	Press release and public notice in local newspaper	CUC, DCA/ CH2M	3.7.1	
III.B.B3.66f	Completion of Master Plan	Completed Master Plan addressing Public Comments	CUC, DCA/ CH2M	3.7.2	

4.2 Wastewater System Planning and Design Criteria

The following section provides wastewater system planners and designers with a guide for the planning and design of wastewater system infrastructure improvements. Information provided in this section was used as the basis for the recommended wastewater capital improvements plan (CIP). Factors such as design period, system demands, pipe velocities, and wastewater treatment are discussed in this section. The information and guidance provided herein may be referenced in the scopes of work for wastewater system design in the CNMI. Reference to the Great Lakes – Upper Mississippi River Board's 2012 Recommended Standards for Wastewater Facilities (10-States Standards) is made throughout this section. Site-specific data and confirmation of the criteria listed in this section must be reviewed and confirmed to be appropriate by the planners and/or engineers of record.

Various factors were taken in consideration when developing basic design criteria for the recommended wastewater system capital improvement projects such as current and projected future wastewater loading, period of design, financial capabilities of the CUC, etc. In general, the design criteria described herein are based on conformance to current standards and waterworks practices.

4.2.1 Design Period

The design period used for master planning of the water system improvements is 20 years. However, use of this design period for locating and sizing the wastewater system components does not imply that any of the components will be obsolete or will physically deteriorate and require replacement after 20 years.

The design periods assumed for specific wastewater system components are based on factors such as ease of expansion/upgrade, service life of the system, and the financial capabilities and resources of the CUC.

Piping and structural components of treatment plants and collection systems are normally expected to remain functional for 40 years or more, provided the components are properly maintained. These components may also be constructed in staged increments, depending on factors such as site conditions, projected rate of increase in wastewater loading, and financial capabilities of the CUC.

Wastewater collection systems are components that have a relatively high construction cost. However, once in place, collection systems cannot be readily expanded to meet increased demands. Installation of larger-sized pipes that exceed current demand requirements to account for future demand considerations can be accomplished at a minimal or modest increase in construction cost despite the possibility of solids deposition. The capital improvement projects recommended in this Master Plan call for the installation of wastewater collection mains that account for projected future demands.

4.2.2 Phased Upgrades

The mechanical components, such as pumps and motors, of treatment plants and lift stations are normally expected to remain functional for 10 to 20 years. When considering future requirements during design, mechanical equipment can be replaced with larger units to accommodate future demands, or the installations can be phased so that increased capacity can be installed at the appropriate times.

Phasing may also be considered when undertaking large capital improvements. Such improvements should take into account the usefulness of phasing and if the first phase can be integrated and placed online without subsequent phases occurring until further in the future. Construction of improvements intended to remain dormant should be discouraged because of rapid deterioration associated with systems being out of service.

4.2.3 Collection System

Open channel flow is defined as any flow confined to a channel and has a free surface. This includes typical sewer collection systems. The laws of open channel flow apply to sewer collection systems. The most common equation is the Manning Equation presented below:

$$V = 1.486/n \times (R)^{2/3} \times \sqrt{S}$$

Where:

V = velocity in ft/s

n = manning coefficient

R = hydraulic radius (ft)

S = pipe slope (ft/ft)

A minimum velocity of 2 ft/s at full or half full flow should be maintained or achieved during peak daily flows. While this is a common practice, the planner/designer must review the projected loading for both the immediate build and full build out of the area to be sewered. It is common that velocities less than 2 ft/s are to be experienced due to a slower build out. This condition can cause problems with solids deposition and accumulation. In such cases frequent cleaning of the collection line will be needed.

Most of the older CUC wastewater infrastructure consists of ACP and VCP. The ACP lines have been prone to failure and collapse. Existing VCP lines have performed well and appear to be in adequate condition. Plastic pipes such as PVC and HDPE have performed well and have excellent hydraulic properties. As such, plastic pipe such as PVC should be used as the material of choice for new sewer installations, upgrades and repairs. A common friction (Manning) coefficient use for PVC is 0.009.

The hydraulic radius of the pipe is a function of its size and operating level. Engineers/planner may adjust the pipe size to achieve the optimum results. Standard pipe sizes are listed below.

Table 4.2.3-1 presents the minimum slopes as recommended in the 10-States Standard. High ground water levels exist for collection systems located along the western coast line of Saipan. In the past, short shallow collection system runs have been used to avoid the water table. This design strategy made it necessary to install lift stations. Current construction practices in Saipan now allow for deeper collection system installation. It is recommended that collection system runs be maximized to reduce the need for any new lift stations.

Table 4.2.3-1. **Minimum Slopes Recommended in 10 States Standard**

Nominal Pipe Size (in)	Minimum Slope (ft/ft)
8	0.00400
10	0.00280
12	0.00220
14	0.00170
15	0.00150
16	0.00140
18	0.00120
21	0.00100
24	0.00080
27	0.00067
30	0.00058

Minimum Pipe Slopes

At a minimum, the requirements set in the 10 States Standards should be adopted for sewer collection system installation and rehabilitation.

4.2.4 Manholes

As with the collection system, CUC should adopt the requirements set by the 10 States Standard for manhole construction.

4.2.5 Wastewater Lift Stations

Pressurized flow occurs in the wastewater system when the pressure head is above the static water level. Such conditions exist at lift stations and where gravity lines are surcharged.

The wastewater lift stations located throughout Saipan typically consist of a wetwell, two submersible pumps (one main and one standby), a level control panel and generator. Limited information is available on existing pump sizes. Field assessment and desktop hydraulic analysis have indicated that the pump station size ranges between 40 and 500 gpm. Larger lift stations such as A-16 and S-3 have capacities over 800 gpm.

Lift stations with a capacity range of 40 to 250 gpm may be classified as a “small” lift station. Small lift stations may be wet wells with submersible pumps. A minimum of two pumps, each sized at 100 percent of peak load, should be provided.

Basket screens upstream of the pump stations have been problematic for CUC operators. Frequent cleaning is required to avoid a backup in the collection system. Pump selection for new lift stations and upgrades should consider selecting pumps with the ability to pass 3-inch solids to obviate the need to install problematic manual bar screens.

Upgraded and new lift station construction must have isolation and check valves located within a dedicated valve pit at grade where the valves can be readily accessible. With exception of S-3 and A-16, the lift stations within the CUC system are considered low head where issues with water hammer are small when compared to incidents of ragging and failed check valves. Full-port check valves with external indicators are recommended for any upgrade or new installation.

CUC has been upgrading lift station pump risers to Schedule 316 stainless steel. This upgrade has been effective, and it is recommended that CUC continue to use this standard for all new and refurbished riser pipes.

The minimum requirements set forth in the 10 States Standard for Wastewater Pumping stations should be adopted by CUC.

Pump Selection

Pump selection is essential to efficient operation of the lift station. There are many variables when it comes to selecting a pump, including the following:

- Average and peak inflow
- Wet Well size and level settings, and pump start/stop
- Force-main size, length and material type
- Static head

Information on average and peak flows is usually difficult to obtain. Unless a full hydraulic study is done where inflow is measured, there is limited data to use. In the absence of a full hydraulic study, planners/designers may use a population method for determining the average daily flow. The 10-States Standards provide guidance on how to select a peaking factor based on population. Use of this 10-States Standards methodology is recommended. Other measurements such as the number of pump starts and stops per hour and measurement of wet well rise and fall should be used to validate calculations of average and peak flows. To the extent possible, measurements should be done during wet weather events.

Calculated average and peak flow values should be cross-checked against operational and historical data for the sewer-shed (service area) and lift station. Values presented in the hydraulic section of this Master Plan may be used as a starting point, but must be further evaluated by CUC engineering.

The wet well size and level setting may be obtained from CUC as-builts or by field measurement. This information may be used for determining the number of starts and stops for pump selection for existing and/or new stations.

For new wet well construction the minimum requirements set forth in the 10-States Standards apply. In addition, guidance provided by the pump manufacturer should be used. A common value use for the number of starts and stops per hour is 15. The minimum number of starts and stops per hour should be 2 (this may be lower during periods of low to no flow). In some cases the number of starts and stops may be larger than that provided by the 10-States Standards depending on the pump manufacturer.

Existing force main size, type and length may be obtained from as-built review or field reconnaissance. A common friction value used for iron type force mains is C=100. CUC commonly uses iron pipe force main. It is recommended that CUC continue to follow this practice.

The static head is the elevation difference between the wet well level and the force main discharge point. Pump operation should be evaluated at both the pump start level and the pump stop level.

The information listed above may be used to generate a system curve. The system curve information may then be used to select the pump and to determine other operating points.

In all lift stations it is recommended to have one completely redundant pump available. This normally requires that two pumps be installed each sized at 100 percent of the peak load.

Variable speed drive or variable frequency drive (VFD) pump systems have been used more frequently in recent years. VFDs offer operational flexibility to handle a wide range of flows and are particularly useful in the following cases:

- Flow attenuation in cases where the downstream collection system or force-maim restricts the flow or high head losses exists. Flow attenuation can reduce the flow rate by increasing the pump time.
- Energy saving may be found in cases where the pump start and stops are excessive resulting in high power draws.

Pump Controls

CUC uses the Flygt^{tm} MultiTrode pump control system. This control system requires frequent cleaning to remove accumulated oil and grease. Buildup of oil and grease on the multiTrode results in erroneous wet well levels causing false starts and stops. Other “low tech” control options such as floats have similar operational issues.

In the short term, it is recommended that CUC continue to use the MultiTrode equipment, but with an increase in the frequency of cleaning. A pilot study on other control systems such as pressure transducers and ultrasonic levels is recommended as part of the overall “SCADA” pilot study.

Standby Generator

The availability of an alternate (back-up or standby) power source at lift stations plays a critical role in ensuring continuous operation of lift stations during power outages. During loss of electricity, especially during natural disasters such as typhoons, restoring wastewater services can become a major challenge and could create public health concerns.

A back-up generator system for wastewater lift stations should meet the following minimum requirements.

- Compliant with current EPA Tier 3 emissions requirements (for new generators only)
- Diesel engine
- Standby duty at 100 percent of the power rating of the engine-generator set
- Four-cycle engine
- Interior installation in a typhoon-proof enclosure that will allow the use of the generator during and immediately after a typhoon
- Generator set will be “tropicalized”
- Base-mounted tank or aboveground fuel tank (ConVault® type) with a fuel capacity based on a minimum of 72 hours of continuous operation
- Automatic operation via ATS
- Generator space heater
- Heavy-duty, maintenance-free, sealed, lead acid SAE Type D diesel engine starting batteries that are enclosed, automatic equalizing, dual-rate, solid state, and of constant voltage
- Installation on a concrete pad with vibration isolation system
- Residential class exhaust silencer

- Connection to the SCADA system, if available, for offsite control and monitoring of the generator system
- Adequate capacity necessary to achieve a maximum voltage dip of 25 percent during starting of motors
- Safety shutdown controls and alarms
- Engine-generator control panel with the following control panel-mounted devices and control features:
  - Engine control switch (manual start, off/reset, auto start)
  - Emergency stop pushbutton
  - Generator metering (ac voltage, current, frequency
  - Generator voltage adjust potentiometer
  - Engine instrumentation (engine oil pressure, engine coolant temperature, engine speed, and engine running hours)
  - LED indicating lamps (low engine lubricating oil pressure alarm, low engine lubricating oil pressure shutdown, high engine coolant temperature alarm, high engine coolant temperature shutdown, engine overcrank shutdown, engine overspeed shutdown, emergency stop shutdown, starting battery system trouble alarm, day tank low fuel shutdown, low engine coolant temperature, low coolant level shutdown)
  - Alarm horn

4.2.6 Wastewater Treatment

This section covers the review of the design criteria and standards used for planning and design of the wastewater treatment facilities.

Review of Design Criteria and Standards

The original design criteria for Sadog Tasi and Agingan Wastewater Treatment Plants tabulated in Section 2.2.3 (Tables 2.2.3-1 and 2.2.3-5) were obtained from the available documents provided by CUC. The key design parameters are provided in Table 4.2.5-1 for reference.

Table 4.2.5-1. **Design Criteria for Wastewater Characteristics**

Key Design Parameter	Sadog Tasi WWTP	Agingan WWTP
Influent Biochemical Oxygen Demand (BOD)	200 mg/L	200 mg/L
Influent Total Suspended Solids (TSS)	200 mg/L	200 mg/L
Influent Total Kjeldahl Nitrogen (TKN)	20 mg/L	20 mg/L
Effluent BOD Limit	30 mg/L	30 mg/L
Effluent TSS Limit	30 mg/L	30 mg/L
Effluent Ammonia Nitrogen (NH_3-N)	10 mg/L	2 mg/L

The design criteria for the two WWTPs are similar. A comparison of the design criteria and the observed historical operation data for each WWTP shows that the values are lower than the original design criteria. Therefore the current design criteria are still considered relevant and a revision of the individual WWTPs design criteria is not required.

4.3 Wastewater Collection, Transmission, and Treatment System Recommendations

This section of the Master Plan presents the methodology for identification of projects to be included in the CIPs, as well as the development of cost estimates and implementation schedule for the capital improvement projects.

4.3.1 Project Identification and Prioritization

This section presents the results of a series of project identification and prioritization workshops conducted in June 2012 for the Commonwealth Utilities Corporation (CUC). The objects of the workshops were the water and wastewater systems of the Commonwealth of the Northern Marianas Islands (CNMI), specifically the islands of Saipan, Tinian, and Rota. The workshop objectives were to develop a list of prioritized projects for all three islands, to aid in the development of the 2-year, 5-year, and 2-year CIPs.

Over the previous year, the project team worked extensively in the field and in workshop settings with CUC staff to catalog water and wastewater assets, assess their condition and risk, and develop hydraulic models for the water and wastewater systems. These activities produced a large volume of information that has been organized and analyzed with the intent of identifying projects for inclusion in the 5-year, 10-year, and 20-year CIPs.

This section describes the effort to identify all projects and rank them based on decision criteria that were developed specifically for CUC's wastewater system. This process is a completely separate ranking process from that documented in the Asset Risk Assessment section, which used likelihood of failure and consequence of failure scoring matrices to calculate the relative risk of failure for CUC's assets. This section is organized into the following sections:

- Project Identification – Development of a list of projects designed to rehabilitate and improve the wastewater system
- Project Ranking Criteria Development – Creation and refinement of project ranking criteria
- Criteria Weighting – Assignment of proportional values for each criterion
- Project Scoring – Scoring process for projects in terms of regulatory and CUC criteria
- Results Analysis – Presentation of project ranking results
- Project Ranking Confirmation – Process for confirming project rankings
- Selecting Projects for Cost Estimation – Methods or selecting projects to carry forward for cost estimation and potential inclusion in the CIPs

Each section is discussed in greater detail as follows.

Project Identification

The project team developed a master list of potential wastewater projects by aggregating projects from the following sources:

- Project Team
  - Condition assessment field reports
  - Risk Assessment-generated projects
  - Hydraulic model-generated projects

- State Revolving Fund (SRF)
  - CNMI Clean Watersheds Needs Survey (CWNS) Project Prioritization List
- CUC-Identified Projects

Each is discussed below.

Condition Assessment Generated Projects

Early in the project the project team performed condition assessments in the field of CUC's wastewater infrastructure, including both "vertical" assets (e.g., above-ground assets such as pump stations and wastewater treatment plants) and "linear" assets (e.g., below-ground assets such as collection system pipes). As the field condition assessment evaluations of CUC assets progressed, the project team began proposing projects to address both specific and general conditions regarding the wastewater system. Many of these proposed projects were documented in the condition assessment sections.

Risk Assessment Generated Projects

Risk assessment workshops were conducted in October 2011 with CUC staff where assets were organized into an asset hierarchy that facilitated scoring of similar assets in different locations as well as individual assets that formed a higher, "parent" asset. Each wastewater asset was evaluated based on likelihood of failure and consequence of failure scoring matrices. An important outcome of this exercise was the identification of CUC assets as high, medium, or low risk based on the workshop scores. The results of the risk assessment workshops are documented in the Asset Risk Assessment Section. The higher risk assets were reviewed to identify potential mitigation projects for inclusion in the master project list.

Hydraulic Model Generated Projects

Similar to above, the project team began identifying proposed project concepts based on software simulation model runs of the wastewater collection system. These proposed projects were appended to the master project list after undergoing review.

Clean Watersheds Needs Survey Projects

The EPA's Office of Wastewater Management, in partnership with states, territories and the District of Columbia, conducts the CWNS every 4 years. The CWNS is a comprehensive assessment of the capital needs to meet the water quality goals set in the Clean Water Act. There is scoring criteria developed by DEQ that must be used for all projects listed in CWNS. The CWNS projects and scores are reviewed by DEQ and EPA for final approval before they can be funded through SRF monies. CUC last completed CWNS in February 2012. Projects proposed by CUC and approved by DEQ and EPA—but not yet implemented—were added to the project list for further consideration and ranking.

CUC Projects

These projects were proposed by the CUC engineering group, but not previously identified in previous subsections.

Master Project List Development

Prior to the June workshops, the project team prepared the master project list, aggregating projects from all the sources listed above. The list was analyzed carefully in order to identify opportunities to remove redundant projects, combine related projects into a larger "program," and refine project definitions. The preliminary consolidated list of recommended projects was reviewed by both senior consultant team members and CUC project management for feasibility and completeness. The resulting master project list was provided to CUC for final approval for use in the June workshops.

During the June workshops, projects were added, changed, and deleted as necessary. The final project list that was used during the project scoring workshops is provided in Appendix S.

Scoring Criteria Development

Using a similar process to that employed at the asset risk assessment workshops, the project team proposed a set of criteria to help determine the relative merits of proposed wastewater projects. These criteria were further refined to distinguish the varying needs of Saipan, Tinian, and Rota. Each major criterion will be discussed separately.

Wastewater System Criteria

The primary consideration for potential wastewater projects was driven by the criteria DEQ employs under the CWNS framework. CUC project management elected to incorporate the CWNS criteria exactly as written in Appendix T. The CWNS criteria are grouped as follows into four major categories of criteria:

- Pollution abatement
  - NPDES permit requirements – meets treatment requirements
  - NPDS permit requirements – ability to obtain or maintain permit
  - Fulfills all or part of legal order
  - Existing pollution effects on area waters
  - Existing water quality standards violations
  - Improvements to existing wastewater system
- Environmental health improvement
  - Ability to correct existing sewer-related health problems
  - Population served
- Miscellaneous
  - Completes currently incomplete in-place system to provide service as intended
  - Qualifies for innovative or alternative system
  - Reduces complexity or reduces O&M
  - Project phasing requirements

In addition, CUC developed specific criteria to be used in conjunction with the EPA criteria:

- Energy savings
- Supports ERP
- Revenue enhancing

The CUC criteria were proposed and defined by CUC engineering and field staff. The CUC-identified criteria for wastewater projects are defined in further detail in Appendix U.

The CUC-identified criteria allow for additional differentiation between projects that would have equal scores using the SRF funding criteria and provide a methodology for additional prioritization.

Criteria Weighting

Combining EPA and non-EPA criteria into a single unified “scorecard” posed an issue to the project team: what relative “weight” should these criteria receive? CUC desired that the SRF/EPA funding criteria take precedence, yet, CUC-specific criteria was important to distinguish inter-island differences and overall utility benefit. The points for CWNS criteria were assigned based on the

CWNS criteria document drafted by DEQ (Appendix T). CUC management and staff provided the final weightings for CUC-identified criteria for the wastewater system. Criteria weightings were calculated based on the input from the CUC staff involved with the workshops; up to eight staff individually provided their written input on how they deemed the total allowable points should be distributed across the CUC-identified criteria. The average scores per category of everyone's collective input was calculated, and verified by the group to be acceptable. This "secret ballot" process was completed separately for water and wastewater systems to ensure that staff with appropriate expertise and experience was included in the process.

Wastewater System Criteria Weighting

The total possible wastewater project score was 532 points, each criteria contribution is discussed further:

- Pollution Abatement (EPA required) – 238 points: As dictated by CWNS requirements. Note the relatively high number of points, up to 150, available to the "Existing Pollution Effects on Area Waters" sub-criteria.
- Environmental Health Improvement (EPA required) – 104 points: As dictated by CWNS requirements.
- Miscellaneous (EPA required) – 90 points: As dictated by CWNS requirements.
- CUC Identified (not required) – 100 points: The individual points allotted among the three sub criteria were determined in workshops and reflect the importance of power conservation and revenue. There is no inter-island scoring distinction due to the relatively modest wastewater infrastructure on Rota and Tinian as compared to Saipan.

Table 4.3.1-1 summarizes the point distribution, or weighting, of the criteria and sub-criteria for the wastewater project scoring process.

Project Scoring

With the master project list finalized and the criteria defined and weighted, the full project group and stakeholders met over several workshops to "score" the wastewater projects. The process was identical for each project:

- The project description was read out loud as well as projected onto a wall.
- The project area was identified on a GIS map.
- Additional information was projected, such as tank survey photos, or model simulation.
- The project was discussed by attendees.
- The project team facilitated achieving group consensus for each score.
- Each score was immediately entered into a decision science software application (Criterion Decision Plus™).

Results Analysis and Project Ranking Confirmation

After the workshops, the project team compiled and analyzed the scoring results for the wastewater projects. The final results were presented in the final workshop, where a few minor adjustments were made and group confirmation was achieved. The confirmed scoring results were processed and ranked based on the total score, as shown in Figures 4.3.1-1, 4.3.1-2, and 4.3.1-3. Results for Saipan, Rota, and Tinian are presented here in this Master Plan together, so that the overall project scores can be compared against one another. The ranking of projects from all three islands, in conjunction with project cost estimates must be analyzed together for the development of the 2-year, 5-year, and 20-year CIPs due to the funding sources being tied together. For this reason, results of project ranking from Saipan, Rota, and Tinian are presented together in this Master Plan.

Table 4.3.1-1. **Wastewater Project Scoring Criteria and Weighting**

Category	**Criteria**	**Maximum Points**	**Sub-criteria**	**Maximum Points**
EPA Required				
	Pollution Abatement	238		
			NPDES Permit Requirements - meets treatment requirements	10
			NPDES Permit Requirements - ability to obtain or maintain permit	5
			Fulfills All or Part of Legal Order	5
			Existing Pollution Effects on Area Waters	150
			Existing Water Quality Standards Violations	10
			Improvements to Existing WW System	58
	Environmental Health Improvement	104		
			Ability to Correct Existing Sewer-Related Health Problems	25
			Population Served	79
	Miscellaneous	90		
			Completes Currently Incomplete In-place System to Provide Service as Intended	20
			Qualifies for Innovative or Alternative System	20
			Reduces Complexity or Reduces O&M	20
			Project Phasing Requirements	30
CUC Identified				
	CUC Identified	100		
			Energy Savings	43
			Supports ERP	26
			Revenue Enhancing	31
TOTAL		**532**		**532**

Figure 4.3.1-1. **Saipan Wastewater System Project Scores and Ranking**

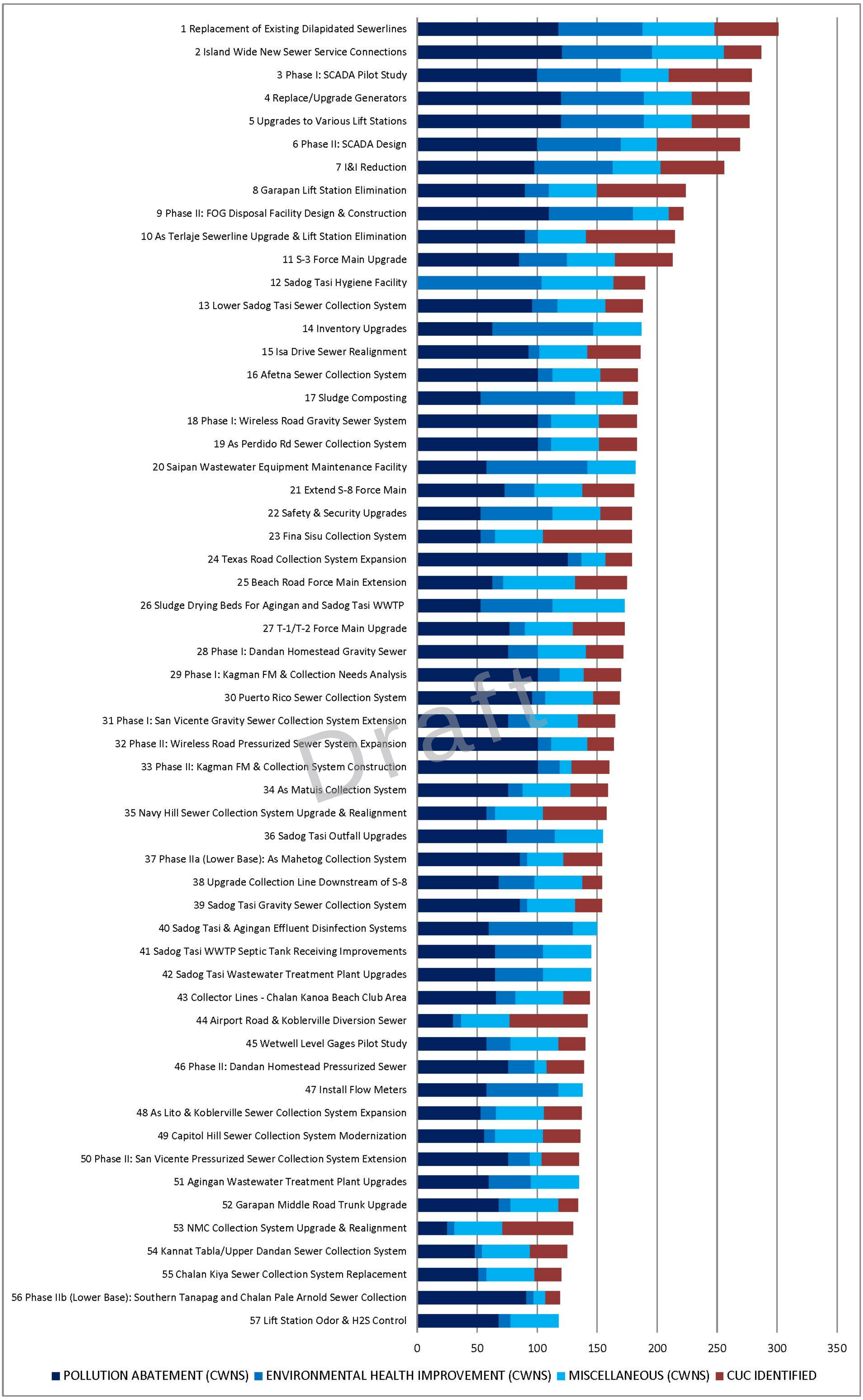


Figure 4.3.1-2. **Rota Wastewater System Project Scores and Ranking**

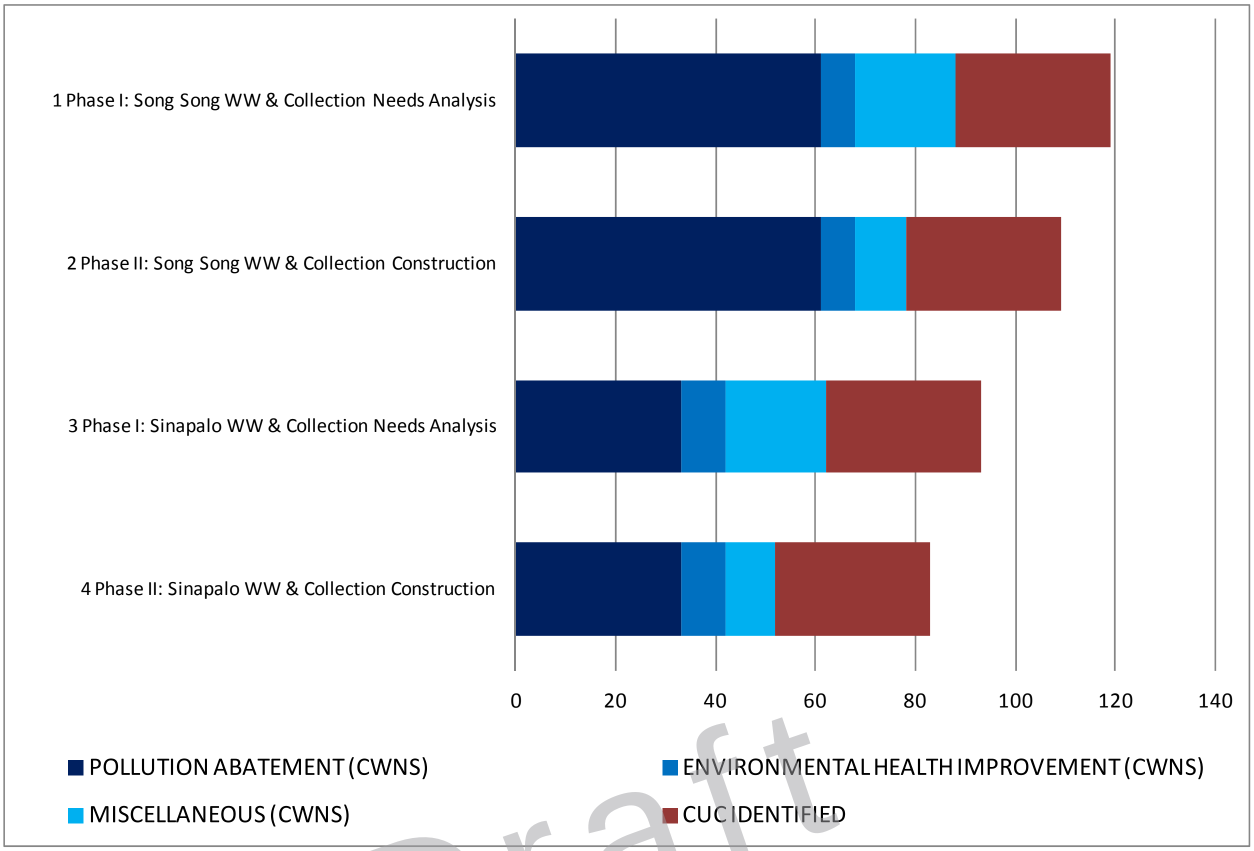
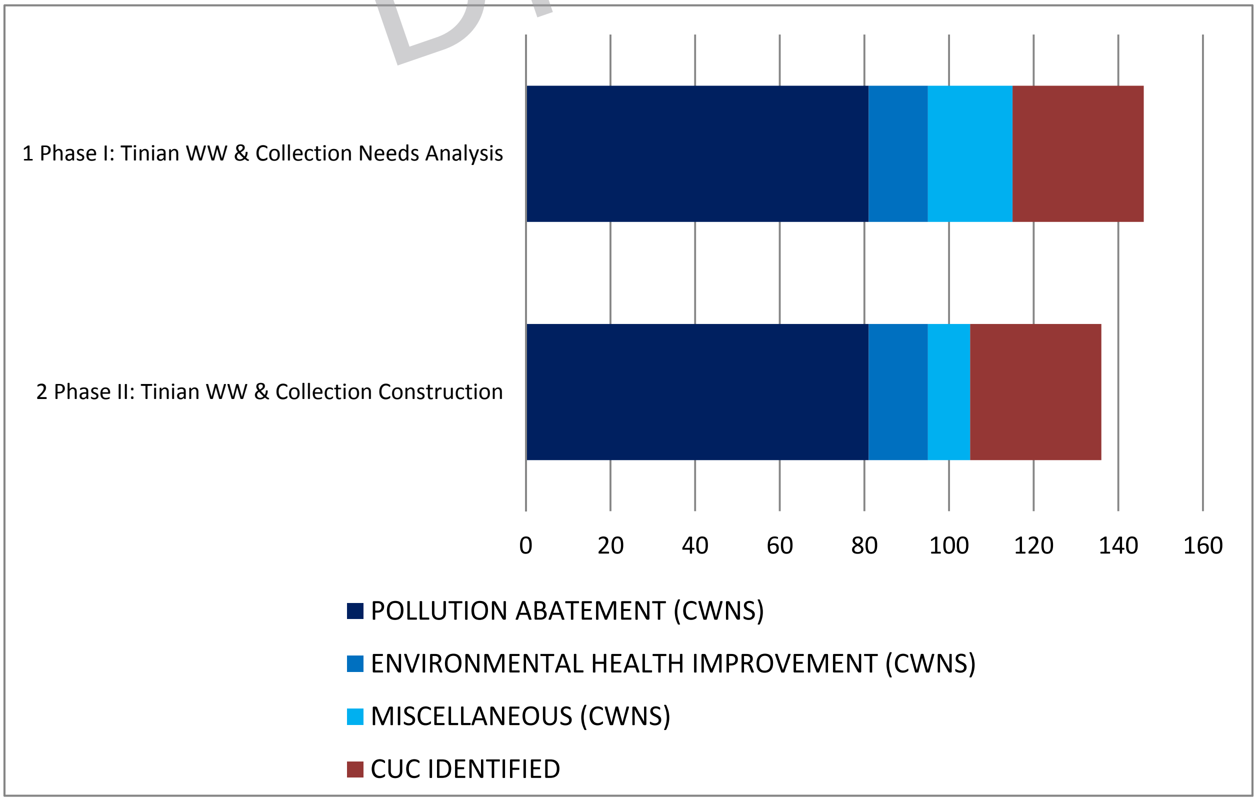


Figure 4.3.1-3. **Tinian Wastewater System Project Scores and Ranking**



Selecting Projects for Cost Estimation

The project ranking results are a crucial step in creating a defensible and grant-eligible CIP for CUC. With the projects being ranked in order of highest benefit to CUC for each island, the next step was to determine which projects would move forward in the process for cost estimation. Developing cost estimates for projects is a necessary step in developing an accurate and defensible CIP implementation plan.

Not all projects identified as part of the project identification process will be included in the CIPs due to budget and scheduling restraints; it is not feasible to be able to complete all 71 wastewater projects that were identified and scored within the 20-year CIP implementation period. The project team consulted with CUC management to identify which projects will be included in the cost estimation exercise based on the project scoring results shown in Figures 4.3.1-1, 4.3.1-2, and 4.3.1-3. The initial "cut-off points", as indicated by the data in the graphs, were determined separately for each island. The asset risk scores were also reviewed as part of this cost estimation project selection process to ensure projects associated with high risk assets were included in the cost estimation exercise, even if the project fell below the determined cut-off points.

The final projects selected for cost estimates for CUC's wastewater systems were as follows:

- Saipan wastewater: cost estimates provided for projects 1 through 35 (CMMS Project) on the ranked project list
- Rota wastewater: cost estimates provided for the phase I studies, not the phase II construction projects. Developing cost estimates for the phase II construction projects is not possible until the results of the studies are available.
- Tinian wastewater: cost estimates provided for the phase I studies, not the phase II construction projects. Developing cost estimates for the phase II construction projects is not possible until the results of the studies are available.

4.3.2 Cost Estimation of Wastewater System Capital Improvement Projects

This section and the associated appendices present the cost estimates and cost estimating approach for the projects identified in the Project Identification and Prioritization section of this Master Plan. The cost estimates will be used, in conjunction with the project prioritizations, to develop the 2-year, 5-year, and 20-year CIPs as required by the Stipulated Order.

Over the previous year, the project team worked extensively in the field and in workshop settings with CUC staff to catalog wastewater assets, assess asset condition and risk, and develop hydraulic models for the wastewater systems. These activities produced a large volume of information that has been organized and analyzed to identify projects for inclusion in the 2-year, 5-year and 20-year CIPs.

This section summarizes the results of the cost estimating effort for those projects chosen for inclusion in the CIPs. This section is organized into the following sections:

- Cost Estimating Classification and Terminology – Assignment of an American Association of Cost Engineers (AACE) Cost Classification
- Cost Estimating Assumptions – Description of Cost Estimating Assumptions and Sources of Information

- Project Cost Estimation – Assign a CIP level cost for the list of projects identified as needed to rehabilitate and improve the wastewater systems
- CIP Development – Organization of the wastewater projects into the 2-, 5-, and 20-year CIPs based on project prioritization and budget forecasting

Each section is discussed in greater detail as follows.

Cost Estimating Classification and Terminology

For the purposes of developing CIP cost estimates for the Master Plan, the following terms are defined and are specific to this cost estimating approach presented herein:

- **Construction Cost.** The cost to construct the CIP element is an estimate of the contractor's price for construction of the infrastructure in 2012 dollars including project costs (i.e., materials, equipment, installation construction labor) and contractor markups. For the purposes of the cost estimates presented in this section contractor markups are consistent for all infrastructure elements and are as follows:
  - Overhead = 10 percent
  - Profit = 5 percent
  - Mobilization/Bonds/Insurance = 5 percent

  The percentages applied to the contractor markups are based on industry standards and CH2M's experience with similar projects. Consistent with the cost estimating process, these contractor markups are added in a compounding manner following the order listed above to the project costs. After these markups are applied, a contingency of 30 percent as well as a location adjustment factor are applied. The contingency accounts for lack of detailed design definition, Gross receipts tax (GRT), cost escalation, and costs associated with unknown or unforeseen conditions at the time of implementation. The location adjustment factor adjusts the construction cost for the area where the project is located. Based on the "Historical Air Force Construction Handbook" dated February 2007 (Air Force Civil Engineer Support Agency), a location adjustment factor of 0.83 was used for Saipan**.**
- **Capital Cost.** The construction cost with additional non-construction costs (as a percentage of project costs plus contractor markups) for items that include the following:
  - Permitting = 1 percent (when applicable)
  - Engineering and Design Services = 10 percent (when applicable)
  - Services During Construction= 8.5 percent (when applicable)
  - Commissioning and Start-Up Services = 3 percent (when applicable)

  Again, the percentages applied to each of the non-construction are based on CH2M's experience.
- **Annual Operations and Maintenance (O&M) Cost.** The cost to operate and maintain the wastewater infrastructure element or system in 2013 including power, chemicals, maintenance, materials, and labor. Like the capital cost, a 20-percent contingency is included in the annual O&M Cost to account for undefined costs at this level of planning.

  O&M costs are only estimated for projects that are considered to be new additions to the wastewater infrastructure. For projects identified as replacement or upgrades to existing infrastructure annual O&M cost estimates were not included, as it was assumed that those costs are already included in CUC's annual operating budget. Furthermore, the total O&M costs presented in this section do not take into account a potential reduction in current O&M costs. Many of the projects identified in the Master Plan could potentially result in a reduction of labor, material, and energy costs due to increased system reliability and operation efficiency. Quantification of these savings was not completed for this report because it is difficult to calculate the magnitude of the impact that these projects will have on the overall wastewater system.

O&M costs were developed for the purpose of assisting in the development of the financial plan technical memo and were not used in the development of the CIP.

The AACE International defines the following cost estimate classifications:

- **Class 5**. This estimate is prepared based on limited information, where little more than proposed infrastructure type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of vx iability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Little time is expended in the development of this estimate. The typical expected accuracy range for this class estimate is –20 to –50 percent on the low side and +30 to +100 percent on the high side.
- **Class 4**. This estimate is prepared based on information where the preliminary engineering is from 1 to 5 percent complete. Detailed strategic planning, business development, project screening, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval are needed to proceed. Examples of estimating methods used include equipment and/or system process factors, scale-up factors, and parametric and modeling techniques. This estimate requires more time expended in its development. The typical expected accuracy range for this class estimate is –15 to –30 percent on the low side and +20 to +50 percent on the high side.

- **Class 3.** This estimate is prepared to form the basis for the project authorization and/or funding. Typically, engineering is from 10 to 40 percent complete and comprises process flow diagrams, preliminary piping runs for major processes, facility layout drawings, and complete process and facility equipment lists. This estimate becomes the project control or project budget estimate until more detailed estimates are completed. Examples of estimating methods used include a high degree of detailed unit cost and quantity takeoffs for major processes. Factoring and/or scale-up factors can be used for less significant or support areas of the project. This estimate requires a great deal of time to prepare, where actual equipment and processes have been designed. The typical expected accuracy range for this class estimate is –10 to –20 percent on the low side and +10 to +30 percent on the high side.
- **Class 2.** This estimate is prepared to form a detailed control baseline for the project. Typically, engineering is from 30 to 70 percent complete and comprises process flow diagrams, piping and instrument runs for all processes, final facility layout drawings, complete process and facility equipment lists, single-line diagrams for electrical and major electrical components, and schedules. This estimate becomes the detailed project control estimate. Examples of estimating methods used include a high degree of deterministic estimating and detailed quantity takeoffs for all of the facility processes and/or systems, with little factoring and/or scale-up factors used, except for minor support areas of the project. This estimate usually becomes the final estimate and requires significant line-item information, which takes time to prepare. The typical expected accuracy ranges for this class estimate are –5 to –15 percent on the low side and +5 to +20 percent on the high side.

- **Class 1.** This estimate is prepared to confirm the control baseline for the project. Typically, engineering is from 80 to 100 percent complete, which comprises virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. This estimate becomes the final control baseline of the project. Examples of methods used are the highest degree of deterministic estimating, with very detailed quantity takeoffs for all of the facility processes and/or systems of the project. This type of estimate usually becomes the bid-check estimate and requires the most effort to create. The typical expected accuracy ranges for this class estimate are –3 to -10 percent on the low side and +3 to +15 percent on the high side.

The Class 5 estimate is the estimate type usually used to evaluate project alternatives at the planning-level stage and is the class of estimate supported for the development of CUC's CIPs presented in this section of the Master Plan.

The Class 5 estimates presented in this section and any resulting conclusions on project financial or economic feasibility or funding requirements are prepared for guidance in project evaluation and implementation, and use the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimates developed using the information described in this section and presented in this Master Plan. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed, prior to making specific financial decisions or establishing project budgets, to help ensure proper project evaluation and adequate funding.

Cost Estimating Assumptions

The following assumptions were made for the purposes of this cost analysis:

- Land purchase was excluded from capital cost estimates for new facilities
- No market adjustment factor was applied
- When housing was required, it was assumed unit processes were housed in concrete masonry buildings

O&M costs were estimated based on a percentage of the capital cost. The percentage of O&M took into account the life expectancy of the infrastructure. Infrastructure life expectancy presented in this report ranges from 20 to 50 years depending on the infrastructure type; see the cost appendices for specific details on the individual projects. As a result, the O&M percentage ranges from 2 to 5 percent of the construction cost depending on the project.

The following O&M items were considered, but not explicitly estimated:

- Equipment power
- Building electrical (applicable to housed facilities only)
- Chemicals

Cost estimates were developed using the CH2M Parametric Estimating System (CPES) and includes construction costs, non-construction costs, and operations and maintenance costs. The construction cost assumptions are presented in Table 4.3.2-1. The cost estimates developed for the Master Plan are classified as an AACE Class 5 Estimate (+100 percent/-50 percent). Consequently, the actual construction costs could vary significantly from what is presented in Appendix V, which provides the cost estimate details for the wastewater system. Deviations from any of the above assumptions can significantly affect the costs.

Table 4.3.2-1. **Capital and O&M Cost Assumption Summary**

Construction Cost Estimate Assumptions	
Project Location	Saipan, CNMI
Local Adjustment Factor	0.83
Contractor Markups)	
Overhead Markup	10%
Profit	5%
Mob/Bond/Insurance	5%
Contingency	30%
Non Construction Additional Costs (when applicable)	
Permitting	1%
Engineering and Design	10%
Services During Construction	8.5%
Commissioning & Startup	3%
O&M Cost Assumption	
O&M costs	2% to 5% of Capital Costs
Contingency	20%

Project Identification and Costs

Section 4.4.1 provides details on how wastewater projects were identified and prioritized for inclusion in the Master Plan. Projects were ranked based on a methodical scoring process; after which the top ranking projects were prioritized for inclusion in the cost estimates. The full project descriptions can be found in Appendix T. Capital and operation and maintenance costs were estimated for each of these projects utilizing the methodology and assumptions discussed previously.

4.3.3 Prioritized Wastewater System Modifications/Improvements Program

This section presents the methodology and results of the 2-year, 5-year, and 20-year CIP development process, which meets the requirements set forth in the Stipulated Order. In order to assist with the development of a financial model and the CIPs, a project sequencing plan was created based on project cost, priority, phasing and available budget for capital projects. O&M costs were not a consideration when developing the CIP and therefore are not presented in this section.

The available budget was developed and is described in detail in the Financial Plan. A summary of the assumed funding for the first 5-year period for the wastewater system is presented in Table 4.3.3-1.

Table 4.3.3-1**. Assumed Available Budget for Capital Improvement Projects**[a]

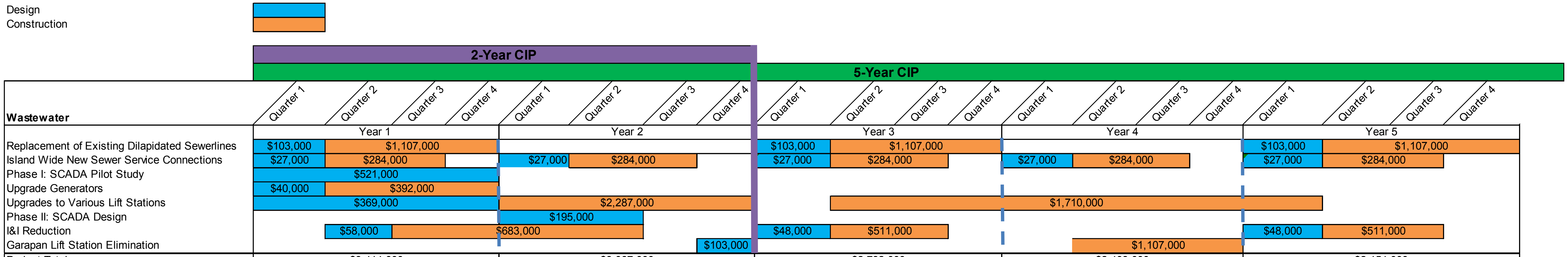
	FY2016	**FY2017**	**FY2018**	**FY2019**	**FY2020**
Wastewater Grant Funding	$ 3,550,000	$ 3,180,000	$ 2,840,000	$ 2,540,000	$ 2,260,000

[a] Budgets were rounded to 3 significant figures. Actual budget estimates can be found in the Financial Plan and Capability section of this Master Plan.

2- and 5-Year CIP Development

Based on priority, projects for wastewater were chosen for the 2- and 5-year plans and each project was divided ito two or three phases (permitting, design, and construction). Each phase was assigned an estimated time to completion and projects were then sequenced starting with the highest priority first and were added until the available budget for all five years was depleted. Several wastewater projects that were identified as being top priorities have already been included in the 2012 fiscal year (FY) budget and subsequently removed from the CIP schedules. Figure 4.3.3-1 presents the project sequencing for wastewater in which only eight of the top projects were included in the 5-year plan due to budgeting constraints. For the wastewater CIP project sequencing, a discretionary fund was included for each year to be used for emergency projects not included in the CIP project list. The discretionary amount varies each year for wastewater and includes $100,000 every year. Any remaining funds not utilized by the CIP prioritized projects were added to the base discretionary fund. It should be noted that if the projects bid out for less than the conceptual placeholder costs presented herein, additional projects from the project identification list should be added to the project sequencing plan, and should be done according to the projects' relative prioritization. The complete prioritized projects are provided in Figures 4.3.1-1, 4.3.1-2, and 4.3.1-3. Those projects in bold font are specific to Saipan.

Figure 4.3.3-1. **Implementation Schedule for First 5-Year CIP**



	Year 1	Year 2	Year 3	Year 4	Year 5
Project Total	$3,414,000	$3,067,000	$2,732,000	$2,403,000	$2,154,000
Discretionary	$136,000	$113,000	$108,000	$137,000	$106,000
Yearly Totals	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000
Estimated Wastewater Budget	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000

20-Year CIP Development

For the 20-year CIP, it was assumed that the available funding assumed for the fiscal year 2020 would remain constant through the 20-year period of the Wastewater Master Plan. The 20-year CIP for wastewater is presented in Table 4.3.3-2; projects specific to the island of Saipan are presented in bold in the table.

Table 4.3.3-2. **20-Year Wastewater CIP Capital Costs**[b]

Project Location	Project #	Project Description[a]	1st 5-Year CIP (FY2016-2020)	2nd 5-Year CIP (FY2021-2025)	3rd 5-Year CIP (FY2026-2030)	4th 5-Year CIP(FY2031-2035)
Saipan	**1**	**Replacement of Existing Dilapidated Sewerlines**	**$ 3,630,000**			
Saipan	**2**	**Island-wide New Sewer Service Connections**	**$ 1,555,000**			
Saipan	**3**	**SCADA Phase I: Pilot Study**	**$ 521,000**			
Saipan	**4**	**Upgrade Generators**	**$ 432,000**			
Saipan	**5**	**Upgrades of Various Lift Stations**	**$ 4,366,000**			
Saipan	**6**	**SCADA Phase II: Design**	**$ 195,000**			
Saipan	**7**	**I&I Reduction**	**$ 1,859,000**			
Saipan	**8**	**Garapan Lift Station Elimination**	**$ 1,210,000**			
		5-Year Total	**$13,768,000**			
Saipan	**9**	**FOG Phase II: FOG Disposal Facility Design & Construction**		**$ 3,260,000**		
Saipan	**10**	**As Terlaje Sewerline Replacement & Lift Station Elimination**		**$ 3,461,000**		
Saipan	**11**	**S-3 Force Main Replacement**		**$ 378,000**		
Saipan	**12**	**Sadog Tasi Hygiene Facility**		**$ 303,000**		
Saipan	**13**	**Lower Sadog Tasi Sewer Collection System**		**$ 863,000**		
Saipan	**14**	**Inventory Upgrades**		**$ 550,000**		
Saipan	**16**	**Lower Base Phase IIb: Southern Tanapag and Chalan Pale Arnold Sewer Collection System**		**$ 1,344,000**		
Rota	R1	Phase I: Wastewater System Needs Analysis - Song Song		$ 60,000		
Rota	R2	Phase I: Wastewater System Needs Analysis - Sinapalo		$ 60,000		
		5-Year Total		**$10,279,000**		

Table 4.3.3-2. **20-Year Wastewater CIP Capital Costs**[b]

Project Location	Project #	Project Description[a]	1st 5-Year CIP (FY2016-2020)	2nd 5-Year CIP (FY2021-2025)	3rd 5-Year CIP (FY2026-2030)	4th 5-Year CIP(FY2031-2035)
Saipan	**15**	**Isa Drive Sewer Realignment**			**$ 3,318,000**	
Saipan	**17**	**Afetna Sewer Collection System Upgrades & Expansion**			**$ 2,102,000**	
Saipan	**19**	**Wireless Road Phase I: Gravity Sewer System**			**$ 2,076,000**	
Saipan	**20**	**As Perdido Road Sewer Collection System**			**$ 441,000**	
Saipan	**21**	**Saipan Wastewater Equipment Maintenance Facility**			**$ 2,340,000**	
Tinian	T1	Phase I: Wastewater System Needs Analysis			$ 60,000	
		5-Year Total			**$10,337,000**	
Saipan	**18**	**Sludge Composting**				**$10,550,000**
		5-Year Total				**$10,550,000**
		Discretionary Project Funds	$ 602,000	$ 1,021,000	$ 963,000	$ 750,000
		Total Project Costs	$14,370,000	$11,300,000	$11,300,000	$11,300,000
		Available Budget	$14,370,000	$11,300,000	$11,300,000	$11,300,000

[a] Complete project descriptions can be found in Appendix S.

[b] All costs have been rounded to the nearest thousand. Actual cost estimates can be found in Appendix V.

4.4 Wastewater System Operations and Maintenance Improvement Recommendations

Throughout the course of developing the Wastewater Master Plan for Saipan, a number of non-capital improvement recommendations were made that fall under general operation and maintenance activities. The project team recommends the operation and maintenance activities listed below.

4.4.1 Lift Stations

General Recommendations

- Provide for standardized pumps and controls at all lift stations.
- Provide proper signage, such as site ID and warning: high voltage signs, at all lift stations.
- Increase the redundancy and reliability at each pump station.
- Relocate existing check valves to new valve pits at lift stations.
- Upgrade riser pipe from cast iron to stainless steel as needed (noted in Lift Stations S-4, S-5, and W-4).
- Maximize collection system runs to reduce the need for new lift stations.

Area-Specific Recommendations

- Repair the manholes in the Tanapag area collection system. This system is known to have I/I problems, and the manholes are severely deteriorated.
- Conduct routine maintenance of the Capitol Hill collection system to address root intrusion.
- Frequently clean the collection system in the Garapan area. Accumulated oil and grease is resulting in backwater effects and odor problems.
- Reinspect the Chalan Kanoa area of the collection line in 5 years.
- Reinspect the San Antonio along Middle Road area of the collection line in 5 years.
- Install a variable frequency drive (VFD) as an interim upgrade to the T-1 Pump Station until the force main size can be increased to 10 inches.

Electrical System

- Properly provide high leg marking in accordance with the NEC.
- Where a generator backup system is provided, ensure the high-leg phase between the utility and the generator system match.
- Perform a complete assessment of the facility grounding system and correct deficiencies as required.
- Ensure compliance with code-required working clearances for all electrical equipment.
- Provide explosion-proof seals in accordance with NEC requirements.
- Utilize watertight splice kits for all splices located in handholes.
- Install all wiring/cabling in conduit.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.
- Seal all handhole conduit openings.
- Clean all electrical handholes of dirt, debris, and foreign materials.

- Maintain a stock of spare parts for electrical equipment.
- Train personnel at every opportunity in all aspects of theory, principles of operations, installation practices, maintenance, and troubleshooting.
- Consider installing Transient Voltage Surge Suppressors (TVSS) at the service entrance equipment.
- Install fuses on all fusible disconnect switches. Consider utilizing non-fusible disconnect switches where possible. Where protection is required, consider providing enclosed circuit breakers.
- Consider installing provisions for connection of a portable generator system where a backup generator system is not necessarily required.
- Replace all lighting with an energy-efficient lighting system.
- Provide an automatic control system with manual override for exterior lighting.
- Install generators on concrete pads and provide vibration isolators.

Force Mains

- Collect field information for Lift Stations W-3 and W-10 as there is limited to no information available.
- Pressure test the old ACP force main at the A-1 Lift Station to verify its integrity. Until this test is done and depending on the results, further use of this old ACP force main is not recommended.
- Embark on a customer connection program to aggressively connect those customers who are most accessible to the southern area of the Sadog Tasi system (S-10, S-11, and S-12 Lift Stations) where there is carrying capacity available.
- Pressure-test the force main at the S-3 Lift station.

4.4.2 Wastewater Treatment Plants

General Recommendations

- Document plant data by logging key operational information and process parameters to aid future operators in terms of understanding and operating the system.
- Develop a training program for plant operators and implement changes to the personnel system to recognize and reward staff who reach specified education and certification milestones.
- Improve the inventory and tracking system for tools and equipment, and build a stock of required tools to facilitate regular and efficient maintenance work.
- Ensure nameplates for equipment are correctly labeled.
- Monitor and control the brine discharge into the sewage system.
- Continue using aerobic digestion as the stabilization process for both WWTPs.

NPDES Permits

Sadog Tasi WWTP

- Conduct quarterly water column monitoring.
- Widen the existing range of pH limit values (7.4 to 8.6) to be more consistent with that for Agingan WWTP, which has an allowable range of 6 to 9.
- Consider the use of a higher dilution factor to address *Enterococci* values.

- Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.
- Review the permit requirement to achieve 85 percent or more reduction in influent BOD and TSS concentrations.

Agingan WWTP

- Propose the use of *Hyalella azteca* as the only species for WET testing as *Daphnia magna* is a freshwater species not suitable for a saline environment.
- Consider the use of a higher dilution factor to address *Enterococci* values.
- Consider inclusion of a mixing zone dilution factor for metals and other toxic pollutants at the outfall mixing zone to increase the permit limit, thus allowing the toxic metal values to meet the permit requirements.
- Review the permit requirement to achieve 85 percent or more reduction in influent BOD and TSS concentrations.

Sadog Tasi WWTP

- Allocate resources to collect and review operational data such as DO measurements, mixed liquor suspended solids (MLSS) concentrations, sludge recycle and wasting rates, and sludge solids content.
- Maintain a DO of 1 mg/L in the last basin before the clarifier so that denitrification does not occur in the clarifier, causing a rising sludge blanket.
- Configure sludge transfer from the aerobic digester to the BFP. Continue thickening the digested sludge as long as the operational issues with sludge pumping can be overcome (e.g., by drilling more holes into the suction pipe).
- Add a disinfection step to achieve the *Enterococci* limits in the permit based on the current plant treatment processes alone. Alternatively, a revision of the NPDES permit for Sadog Tasi that accounted for dilution at the outfall would allow for consistency with standard EPA guidance and place the plant into compliance.

Agingan WWTP

- Install a flow meter within the plant to record total plant flow.
- Operate with one aeration basin under current conditions.

Saipan Harbor Outfall

- Perform maintenance on the outfall and diffuser section, which should include replacing the broken clamping strap and the corroded anchor cable on the diffuser section, and clearing all marine growth and other debris from the diffuser risers.
- Fit all six riser ports with Tideflex check valves.
- Install a seventh port fitted with a Tideflex check valve on the diffuser endgate to provide additional flow capacity as well as prevent buildup of sediment in the diffuser section.

Future Loading

Reevaluate future wastewater flows in 5 years to determine whether bottleneck conditions continue to exist.

4.4.3 Unsewered Areas

- Regularly sample drinking water wells, especially wells where there has been a lack of monitoring, to document nitrate concentrations.
- Focus sampling in areas within a specified radius of drinking water wells considered “hot.”
- Study septic discharge from homestead areas.
- Conduct a Groundwater Under Direct Influence (GWUDI) study in unsewered areas.
- Study projected future impacts of increased homesteading with and without the benefit of a sewer system.
- Identify effluent sources by utilizing chloroform DNA polymerase chain reaction (PCR) chromatography methodology and specific genetic markers for human, bovine, avian, or other DNA.
- Conduct a comprehensive study of the potential impacts of septic systems on drinking water quality and stormwater discharge and impacts on the reef and other near-shore marine life.

Recommendations to address the nitrate concentrations in the Isley wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.
- Conduct a detailed groundwater study of the Isley Wellfield.
- Based on the results of the groundwater study, consider elevating the priority for installation of a gravity collection system within the Dan Dan Homestead.
- Connect homes and businesses along Tun Herman Pan Road (Dagu area) that are not presently connected to the sewer system.
- Once feasible, reduce production within the Isley wellfield, particularly from the northern and eastern rim wells that have the highest levels of nitrate.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.
- Consider additional treatment to continue use of the well field if the blended water supply starts to reach the MCL level for nitrate.

Recommendations to address the nitrate concentrations in the Obyan wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.
- Conduct more research into potential sources of nitrates in the area; identify whether there is potential contamination from agricultural use in the area or some other unknown activity.

Recommendation to address the nitrate concentrations in the Koblerville wells are as follows:

- Continue sampling at all wells and the blended water supply, and increase the sampling frequency for wells of concern.

Recommendations for all wells where nitrate monitoring is occurring:

- Review nitrate concentrations at each well as the samples are analyzed to determine whether nitrate concentrations are increasing over time.

- Evaluate unsewered areas in order of priority to determine the source of water contamination. The order of priority for these areas is as follows:
  1. Isley
  2. Kagman
  3. Obyan
  4. Koblerville
  5. San Vicente/As Lito/Dan Dan
  6. Central Well Fields
  7. Northern Well Fields
- Implement the recommendations from the APEC report (2011):
  - Conduct a 12-month spatial sampling program of agricultural and drinking water wells, especially for wells where there is a lack of data.
  - Continue to sample quarterly at wells of concern and seasonally for all other wells in the same area where there are wells of concern until the 12-month sampling plan is developed and implemented. No additional nitrate sampling is necessary in the central and northern well fields no additional nitrate sampling is necessary.
  - Conduct additional focused sampling for twelve months in areas within a certain radius of wells considered hot based on the 12-month spatial sampling program.
- Recommend that DEQ consider developing and adopting a comprehensive onsite wastewater disposal management approach that oversees the full range of issues related to the widespread use of septic systems: planning, siting, design, installation, operations, monitoring, and maintenance.

4.4.4 GIS Use and Operation

- Update the GIS when major or significant system components are replaced or added.
- Survey, map, and document by title or written declaration CUC ownership of all easements, right-of-way corridors, and real estate (land parcels) on public lands containing CUC water system assets. The following process is recommended for documenting CUC's real property interests utilizing the GIS program where appropriate:
  - Meet with the Department Public Lands (DPL) to discuss CUC's real estate ownership goals, intention to seek titles to real properties containing CUC water (and wastewater) system assets, and the process to achieve these requirements.
  - Establish a prioritized list of CUC water system assets by island that need real estate ownership documentation, keeping DPL in the information loop.
  - Determine the general real estate requirements for each prioritized asset, such as parcel size and easement/right of way width.
  - Using the GIS program/database, generate a conceptual layout of the real estate requirements of each water system asset (in order of priority for documentation).

  - Submit partial requests (demands) to DPL for survey, mapping, and grant of title to the real property or declaration of easement/right of way containing each CUC water system asset. CUC requests should be made in manageable increments in consultation with DPL and in the predetermined order of priority for real property ownership documentation.
  - Provide for the orderly filing of real property information at CUC and for the input and maintenance of the real estate information in the GIS program database.

4.4.5 Risk Assessment

- Continue to ensure that critical system knowledge is recorded and stored such that any new employee can easily access and understand the information.
- Update the asset hierarchy at the same time new information is obtained or as assets are improved upon or removed from the system.
- Review and revise as necessary the asset hierarchy every year; review likelihood of failure (LOF) scores annually as well.
- Review consequence of failure (COF) scores every 3 to 5 years to ensure levels of service have not drastically changed.

4.4.6 Organizational Structure

- Continue to refine the Engineering function under the direction (and office) of the Chief Engineer.
- Integrate the Water Task Force into the water and wastewater engineering support groups under the Chief Engineer while maintaining 24-hour water for all customers as a key mission and goal.
- Place the GIS and modeling functions under the direct supervision of the Chief Engineer and managed by one staff member trained in GIS and systems modeling.
- Assign an engineer whose dedicated, primary duty is to provide engineering support to water and wastewater systems operations.

4.4.7 Resident Professional and Technical Workforce Development and Training

- Identify current CUC employees who have demonstrated a high potential for advancement to professional, technical, or high-level operational positions required for the management and operation of CUC's water and wastewater systems; develop and implement a program customized for each candidate to pursue a targeted, high-level position.
- Identify and contact professionals and technicians who were former CNMI residents and recruit those who indicate a desire to relocate back to the CNMI.
- Track local islanders who are pursuing higher education on the U.S. mainland or elsewhere and target them for incentivized recruitment efforts.
- Offer internships to CNMI students seeking higher education abroad and who wish to spend summers in the CNMI in CUC Engineering and Operations.
- Visit local high schools during "Career Day" to promote employment at CUC as a career opportunity under various professional, technical, and operations positions.

- Approach Northern Marianas College to develop a technical curriculum for current and prospective CUC employees.
- Conduct periodic training workshops for all CUC engineers and engineering technicians on the capabilities and features of the GIS and system modeling programs.

4.4.8 Dealing with Absenteeism

- Educate and support middle and lower level supervisors regarding attendance policies and enforcement.
- Discontinue “sick leave” accruals and adopt the more common Paid Time Off or Personal Leave concept.
- Revise the Reduction in Force (RIF) approach to favor/give preference to retaining employees based on merit rather than seniority.
- Conduct “all hands” meetings to address common issues.

4.4.9 Elevating the Standard of Level of Care of CUC Facilities

- Develop and post written guidelines and performance standards defining the minimum level of care required at CUC facilities.

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