Draft Final

Drinking Water and Wastewater Master Plan – Tinian, Commonwealth of the Northern Mariana Islands

Prepared for

Commonwealth Utilities Corporation

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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 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 Tinian water system were:

- Large water losses associated with failing infrastructure, theft, and poor meter reading
- Failure to comply with Safe Drinking Water Act water quality requirements

The most significant problems with the Tinian wastewater system were:

- Lack of central sewer systems in major homestead areas

The Tinian Drinking Water and Wastewater Master Plan is the first step toward compliance with Stipulated Order No. 1. Development of the Master Plan resulted in a roadmap that identified new capital projects, replaced and repaired existing facilities, modified operational procedures, and assessed current staffing levels and related policies.

The development process, listed below, identified 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 operation of CUC's water and 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 are 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.

Goals for the Tinian Drinking Water and Wastewater Master Plan

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

- Reduction of non-revenue water to the industry-level best practice (less than 10 percent)
- Improved water quality with regard to primary standards

CUC's desired outcomes for the Tinian wastewater system include the following:

- Develop needs assessment for the wastewater systems in major homestead areas
- Design and construct, if required, wastewater systems in major homestead areas

The Tinian Drinking Water and Wastewater Master Plan addresses these outcomes as described in the following sections.

Reduce Non-revenue Water to the industry-Level Best Practice (Less than 10 Percent)

The non-revenue water for Tinian has been estimated to be in excess of 70 percent. The root causes are a combination of theft, leaky pipes, overflows from the distribution system reservoirs, and metering errors. The 20-year CIP does not include any projects to address this problem. It is possible with the military expansion on Tinian that funding may be available to include key projects like SCADA and relocation of the QMT. These two projects have been identified to improve water management and reduce water loss.

Compliance with Safe Drinking Water Act Regulations

The Groundwater Under the Direct Influence (GWUDI) Study was conducted on the Maui II well during the wet seasons in July through December 2012 and 2013. Prior to the start of the GWUDI study, the CUC team modified the existing chlorination station so that it did not inject chlorine into the pump wet well, but rather into the discharge pipeline. This was required because the GWUDI sample location for the Maui II well was in the wet well and was required to be non-chlorinated. The determination by EPA and DEQ, based on the 2-year study, agrees with CUC that the Maui II Well is borderline GWUDI. CUC needs to install a permanent bypass system that will send the water back to the marsh during periods of elevated turbidity excursions. Tinian CIP Project number 1 (Improvements to Maui II) has been included in the second 5-year Drinking Water CIP Program for design and implementation.

Central Sewer Systems for Large Homestead Areas

CUC does not operate a sewer system on Tinian, so concerns have been raised about the potential impacts on the underlying groundwater and coastal areas adjacent to the large homestead areas. To begin to address these concerns, a Wastewater Treatment and Collection System Needs Assessment Project has been incorporated into the third 5-year Wastewater CIP Program.

Recommended Capital Improvement Plan and Operations and Maintenance Projects

Based on Stipulated Order requirements, goals that CUC has set for its water and wastewater systems on Tinian, and information collected as part to the Master Plan development, recommended CIP and O&M projects, listed below, were identified.

Water and Wastewater Capital Improvement Projects

The Tinian Drinking Water and Wastewater Master Plan project evaluated and ranked 16 water improvement projects for the drinking water system and two for the wastewater system. After the initial ranking was completed, water storage tanks were evaluated against a second set of criteria based on additional management asset information received for the tanks at the highest risk of failure. Using the additional information, some tanks were moved up on the priority list, which could have a very significant impact on the public health and safety of the community and CUC staff.

During the development of the drinking water and wastewater master plan, a number of operation and maintenance (O&M) enhancements were identified that have been included in this document. Table ES-1 provides a high-level summary of the capital improvement projects evaluated and operational improvements that have been documented.

Table ES-1. **Projects Identified by the Master Plan**

System	Total Number of Capital Improvement Projects Evaluated	Number of Capital Improvement Projects in 20-year Plan	Capital Improvement Costs over 20 Years	Number of O&M Recommendations
Water	16	3	$611,000	41
Wastewater	2	1	$60,000	0

Water Capital Improvement Projects

Based on the projected funding available from EPA State Revolving Fund (SRF) grants, the plan will be to implement one project for the Tinian water system during the first 5-year CIP period (2016 through 2020) as shown in Table ES-2.

Table ES-2. **20-Year Water CIP Projects and Associated Costs**

Project Location	Project #[d]	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	West Project	$ 667,000			
Saipan	2	Island-wide Pressure Zone Isolation Project	$ 1,054,000			
Saipan	3	Remove and Replace San Vicente 1.0-MG Tank	$ 2,634,000			
Saipan	4	Annual Leak Detection and Repair	$ 2,500,000			
Saipan	27	Upgrade Isley Tank – Old (CCB)	$ 1,564,000			
Saipan	29	Replace Dan Dan Tank 0.5-MG Tank	$ 2,876,000			
Saipan	32	Upgrade As Matuis (Marpi) 1.0-MG Tank	$ 1,398,000			
Rota	1	Rota Water System Reconfiguration Phase I	$ 877,000			
Tinian	**4**	**Upgrade HMT (0.5-MG)**	**$ 388,000**			
		5-Year Total	**$ 13,958,000**			

Table ES-2. **20-Year Water CIP Projects and Associated Costs**

Project Location	Project #[d]	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	5	Fina-Sisu Waterline Replacement		$ 1,722,000		
Saipan	6	New Meter Installation (24-hr and non-24-hr zones)		$ 1,525,000		
Saipan	7	Chinatown/Sugar King Waterline Replacement		$ 1,485,000		
Saipan	8	Replace Talofofo Waterline		$ 220,000		
Saipan	9	Airport-owned Tank Modification		$ 8,000		
Saipan	10	Isley II Booster System-Upgrades		$ 980,000		
Saipan	14	Interim Agag Vacuum Controls		$ 29,000		
Saipan	18	Install Air Relief and Vacuum Valves		$ 33,000		
Saipan	20	Generator Upgrades		$ 378,000		
Saipan	32	Upgrade As Matuis (Marpi) 1.0-MG Tank		$ 1,478,000		
Rota	1	Rota Water System Reconfiguration Phase I		$ 309,000		
Rota	2	Rota Water System Reconfiguration Phase II		$ 2,521,000		
Tinian	**1**	**Improvements to Maui II Well**		**$ 60,000**		
Tinian	**2**	**Upgrade QMT Tank (0.25-MG)**		**$ 163,000**		
		5-Year Total		**$ 10,911,000**		
Saipan	7	Chinatown/Sugar King Waterline Replacement			$ 2,969,000	
Saipan	8	Replace Talofofo Waterline			$ 1,982,000	
Saipan	11	Wireless Ridge Waterline Replacement			$ 1,755,000	
Saipan	16	System Wide SCADA Project			$ 800,000	
Rota	2	Rota Water System Reconfiguration Phase II			$ 2,522,000	
Rota	3	Rota Water System Reconfiguration Phase III			$ 572,000	
Rota	4	Rota Water System Reconfiguration Phase IV			$ 141,000	
Rota	5	Main Cave Enclosure			$ 69,000	
Rota	6	Replacement of Old Valves on Distribution Lines			$ 89,000	
		5-Year Total			**$10,899,000**	

Table ES-2. **20-Year Water CIP Projects and Associated Costs**

Project Location	Project #[d]	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	12	Isley to As-Perdido Transmission Line Replacement				$ 7,545,000
Saipan	13	As Lito Distribution Project[c]				$ 392,000
Saipan	15	Well Upgrades				$ 2,208,000
Saipan	16	System Wide SCADA Project				$ 578,000
Saipan	25	Emergency Backup Power for Water Supply Systems				$ 130, 000
Rota	7	Well Facility Upgrade				$43,000
		5-Year Total				**$10,896,000**
	Discretionary Project Funds		$ 412,000	$ 389,000	$ 401,000	$ 404,000
	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 for the drinking water CIP projects can be found in Appendix S.

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

[c] Only engineering costs were included in the 20-year CIP.

[d] The project numbers correspond to the project prioritization rankings developed in Section 4.3.1. Projects were added to the 20-year CIP in order of highest priority to lowest priority (1 being the highest priority) when possible. Some projects with high capital costs were excluded from the CIP to include more projects, some of which had a lower project priority ranking. The high risk tanks were incorporated into the 20 year CIP regardless of the tank project priority ranking to ensure that these tank projects are included in the first two 5-year phases of the CIP.

Project Implementation Approach

Figure ES-1 provides an implementation schedule for the first of four 5-year CIP periods developed for the Tinian Drinking Water Master Plan.

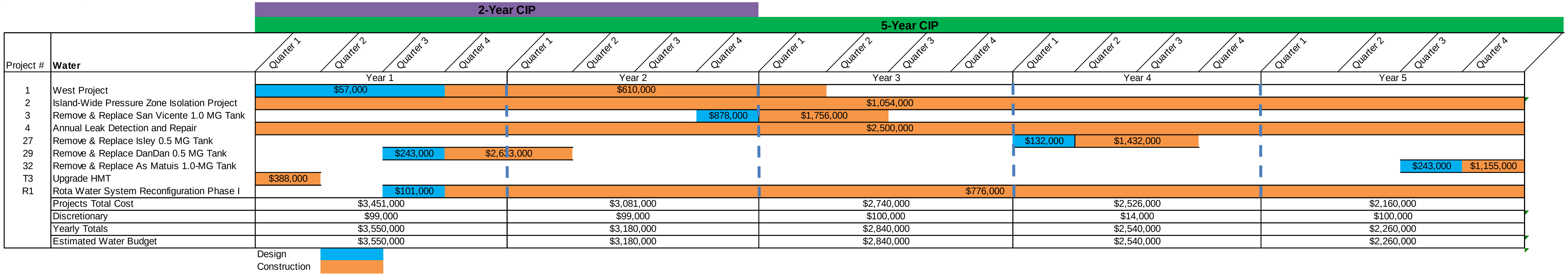
Operation and Maintenance List

Throughout the course of developing the Drinking Water Master Plan for Rota, a number of non-capital improvement recommendations were identified that fall under general operation and maintenance (O&M) activities. The combined CUC/DCA Master Plan Team identified 41 drinking water system O&M activities described below.

Chlorination Facilities

- Continue to use the newly installed chlorine injection and pump system.
- Provide proper signage, such as high voltage and chlorine, at each of the sites as applicable.
- Install or relocate existing chlorine alarms to be audible and/or visible outside the booster pump stations.
- Relocate mechanical vent switches to outside of the chlorine building so buildings do not need to be entered to turn on the mechanical vent.

Figure ES-1. **Implementation Schedule for First 5-Year CIP (FY2016-FY2020)**



Project #	**Water**	Year 1	Year 2	Year 3	Year 4	Year 5
1	West Project	$57,000	$610,000			
2	Island-Wide Pressure Zone Isolation Project			$1,054,000		
3	Remove & Replace San Vicente 1.0 MG Tank		$878,000	$1,756,000		
4	Annual Leak Detection and Repair			$2,500,000		
27	Remove & Replace Isley 0.5 MG Tank				$132,000 $1,432,000	
29	Remove & Replace DanDan 0.5 MG Tank	$243,000 $2,6[illegible]3,000				
32	Remove & Replace As Matuis 1.0-MG Tank					$243,000 $1,155,000
T3	Upgrade HMT	$388,000				
R1	Rota Water System Reconfiguration Phase I	$101,000		$776,000		
	Projects Total Cost	$3,451,000	$3,081,000	$2,740,000	$2,526,000	$2,160,000
	Discretionary	$99,000	$99,000	$100,000	$14,000	$100,000
	Yearly Totals	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000
	Estimated Water Budget	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000

Design 🟦
Construction 🟧

- Install automatic chlorine tank switchovers.
- Install amperometric chlorine analyzers at the entry point into the distribution system.

Chlorine Storage Facilities

- Install a permanent chain system to secure the full and empty cylinders.

Booster Pump Stations

- Install a level control (combination pressure reducing/sustaining) valve to the site piping at the dormant Maui I well site. Upgrade the piping as its condition is considered poor.
- Keep at least two redundant pumps online at the Maui II site at all times.
- Decommission the piping to and within the Maui I station after CUC completes installation of a control valve in the piping along the main road leading to the station.
- Inspect the Maui II slow actuating check valves to ensure proper operation.

Booster Pump Stations Electrical System Recommendations

- Consider installing Transient Voltage Surge Suppressors (TVSSs) at the service entrance equipment.
- Perform a complete assessment of the facility grounding system and correct deficiencies as required.
- 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 (corrosive environment, wet location rated, damp location rated, etc.)
- Ensure compliance with code-required working clearances for all electrical equipment.
- Where applicable, determine the cause of water intrusion into electrical/generator rooms and permanently rectify the condition.
- Remove all electrical equipment no longer in use rather than abandoning in place.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.
- 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.

Distribution System

- Replace fiberglass PVC lines.
- Provide air relief valves at high points and blow-off valves at low points. Manual valves are recommended.
- Properly abandon or replace the existing network of older, smaller water lines that makes up approximately 28 percent of the Tinian water system.
- Install individual household pressure regulators where high pressures cannot be avoided.
- Wherever feasible, serve CUC water customers using a distribution line connected to a storage tank.
- Install pressure-reducing valves (PRVs) to reduce high pressures to preferred service pressures.

- Some of the smaller and isolated areas within the CUC system cannot be included in a tank service area. These areas currently use a booster pump system to provide the needed pressure (head). For such systems, the following are recommended:
    - Size pump systems and pneumatic tanks according to the 10 States Standards.
    - Locate air relief valves (ARVs) at the upper portion of the areas served by the booster pump.
    - Pay careful attention to conditions on the suction side of the pump system so that the pump does not cause a drop in system pressure below the recommended pressure listed.

PRVs

- Specify aluminum or stainless steel pilot piping for reapers, upgrades, and replacements.
- Conduct additional training on the maintenance and operation of PSVs.

Water Meters

- Purchase and evaluate both the Sensus accuSTREAM and the Badger Disc Meter while continuing to test the Sensus iPerl meter, then select a system-wide meter based on actual performance.

Tanks

- Compare the 20-year lifecycle cost of steel and concrete in the context of available funding to determine the tank material of choice on a project-by-project basis. Given the current poor condition of the majority of CUC steel tanks and the corrosive effects of the local environment, the use of concrete is recommended.
- Install a flow control valve, which will be operated by the pressure grade in the QMT TSA, as a short-term correction to the constant overflow from the QMT.

Cross Connection Control and Protection

- Install a level control valve to correct the siphoning at Maui I.

Asset Hierarchy and Risk Assessment

- If more accurate risk scores are desired:
    - Perform condition assessments for booster stations. After condition data are collected in the field, update the asset hierarchy with revised LOF scores.
    - Reconcile the asset hierarchy with regard to identification of transmission and distribution system pipes (i.e., document the pipe age and material in individual service areas and neighborhoods, and update COF and LOF scores).
    - Ensure that critical system knowledge is written down, recorded, and stored such that any new employee can easily access and understand the information.

  It is recommended that the asset hierarchy be updated as 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 require updating as frequently, but every 3 to 5 years the COF scoring matrix should be reviewed to ensure levels of service have not drastically changed.

Leak Detection

- Valve installation should continue on Tinian with a level control valve placed between the tanks
- The development of a leak detection program in Tinian is recommended; the program should be modeled after the ongoing leak detection program in Saipan.

GWUDI Investigations

- Because of the concerns with the rain event related water quality changes at Maui II and the lack of a rain event MPA analysis, it is recommended that additional data be collected during another complete rainy season.

Land Ownership

- 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 WW) 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.

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.

Wastewater Capital Improvement Projects

Based on the projected funding available from EPA State Revolving Fund (SRF) grants, the plan will be to implement one project for the Tinian wastewater system during the third 5-year CIP period (2026 through 2030) as shown in Table ES-3.

Table ES-3. **20-Year Wastewater CIP Projects and Associated 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		

Table ES-3. **20-Year Wastewater CIP Projects and Associated 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	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**		
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 for Tinian wastewater CIP projects can be found in Appendix W.

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

Summary

The Tinian Drinking Water and Wastewater Master Plan provides a comprehensive evaluation of the condition of existing assets, discusses EPA regulatory compliance with the GWUDI Rule, creates a 20-year capital improvement plan with an implementation schedule, and identifies a number of recommended operational practices for CUC to consider incorporating into its drinking water and wastewater programs. The CIP assumes that only EPA State Revolving Fund (SRF) funding will be available and will decrease over time. This assumption was based on the 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 for the overall economies of the three islands.

The EPA SRF grants for drinking water and wastewater 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 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 Drinking Water and Wastewater Master Plan is to provide a cost-effective and implementable roadmap to reduce water loss, maintain regulatory compliance, 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 and wastewater systems from design to operations and maintenance, so with adequate funding and local political support the future of the drinking water and wastewater systems in Tinian is very bright.

Structure of the Master Plan

This Drinking Water and Wastewater Master Plan for Tinian 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 drinking water system Stipulated Order requirements, the planning and design criteria, and ultimate recommendations that address the requirements and criteria.
- Section 5 describes the Master Plan itself, summarizing the wastewater system Stipulated Order requirements, the planning and design criteria, and ultimate recommendations that address the requirements and criteria.

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Acronyms and Abbreviations

°C	Degrees Celsius
ACM	Asbestos Cement Pipe
ADCP	Acoustic Doppler Current Profiler
AMWA	Association of Metropolitan Water Agencies
AOR	Actual Oxygenation Rate
API	American Petroleum Institute
ARV	Air relief valve
AST	Aboveground storage tank
ATS	Automatic transfer switch
BFP	Belt Filter Press
BOD_5	5-Day Biochemical Oxygen Demand
BPS	Booster pump station
CCTV	Closed-circuit television
CDP	Census Designated Place
CFU	Colony-Forming Units
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
CUC	Commonwealth Utility Corporation
CW	CNMI-Only Transitional Worker
DCA	Dueñas Camacho & Associates, Inc.
DEQ	Department of Environmental Quality
DIA	Diameter
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	Horse Power
HRT	Hydraulic Retention Time
I/I	Inflow and infiltration
in	Inch
IPS	Influent Pump Station
IWA	International Water Association
lb	Pound
LOF	Likelihood of Failure
LOS	Level(s) of service
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
Pro2D	Professional Process Design

PRV	Pressure reducing valve
PVC	Polyvinyl chloride
RAS	Recycled Return Activated Sludge
SCADA	Supervisory control and data acquisition
SDW	Safe Drinking Water
SOP	Standard Operating Procedure
SOPAC	Pacific Islands Applied Geoscience Commission
SOR	Standard Oxygenation Required
SOTE	Standard Oxygen Transfer Efficiency
sq. ft.	Square Feet
SRF	State Revolving Fund
SRT	Solids Retention Time
SS	Stainless steel
SSF	Slow sand filter
SVI	Sludge Volume Index
TDH	Total dynamic head
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TNTC	Too numerous to count
TSS	Total Suspended Solids
TVSS	Transient voltage surge suppressors
USCIS	U.S. Citizenship and Immigration Services
V	Volt
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

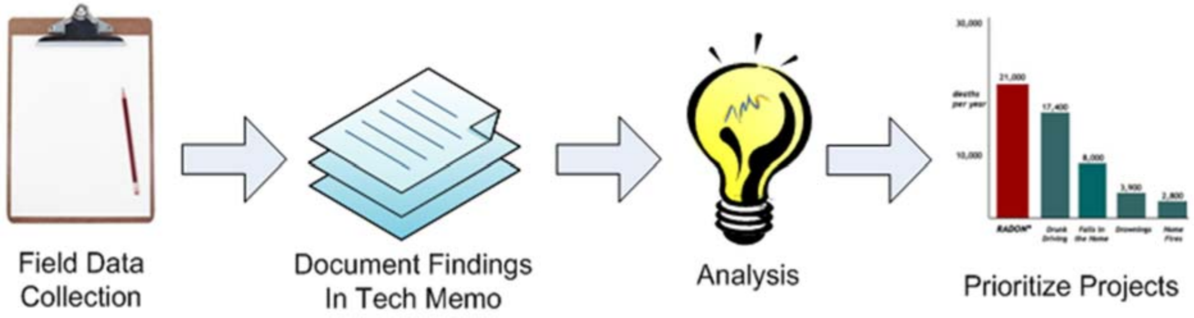
1.1 Background

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. In 2008, the U.S. Environmental Protection Agency (EPA) and CUC entered into a Stipulated Order Number One for Preliminary Injunctive Relief (Civil Case No. CV 08-0051) that 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 plan for CUC drinking water and wastewater systems improvements for the three major islands of CNMI: Saipan, Rota, and Tinian.

1.2 Introduction

This document is submitted to fulfill one of the requirements for Stipulated Order Number One. This Master Plan focuses on findings and recommendations for the Island of Tinian. (Findings and recommendations for Saipan and Rota have been submitted as separate Master Plans.) The individual technical memoranda (TMs) that were compiled to form this Master Plan were part of an overall process that initiated with the gathering of raw data from field assessments, information requests, and knowledge transfer from CUC. After the initial data collection phase, the next step was the processing of the raw data into organized information in TM format. The information was in turn analyzed through a variety of techniques, such as hydraulic modeling. The output from the analytical process was assembled into a consolidated list of potential capital improvement projects that were scored against an array of criteria to conform project prioritization to U.S. Environmental Protection Agency (EPA) 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:

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  2.2.2 Condition Assessment of Existing Water Facilities 2-6
  2.2.3 Water Distribution Hydraulic Model 2-66
  2.2.4 Water System Infrastructure Geographic Information System 2-77
  2.2.5 Asset Risk Assessment 2-84
2.3 Wastewater Infrastructure System Condition Assessment 2-99

2.1 Chartering Meeting

On August 22, 2011 a chartering meeting was held at CUC's Dan Dan office to kick off the Drinking Water and Wastewater Master Plans project. Those in attendance at the chartering meeting from CUC included 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, Inc. (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 assistance from CUC engineering and operations staff members. Initial results from the field findings, particularly with regard to lift station, drinking water well, and booster station inspections on Saipan, were also presented during this chartering meeting.

The agenda for the meeting including the following items:

- Team Introductions/Attendance Roster
- Scope of Work
- Project Schedule and Milestones
- First 90-Day Activities
- Saipan Well Inspections – 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.
- 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 is not duplicative of 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 EPA.

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.
- Existing water base maps will be updated and a new wastewater base map 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 Drinking Water Infrastructure System Condition Assessment

The project team performed field condition assessments of the existing drinking water infrastructure in September 2011 in Tinian. The purpose of the condition assessments was to identify defective or deteriorated system components in need of repair, rehabilitation, or replacement. The water infrastructure condition assessment included the following elements:

- Wellhead and Protective Structures
- Treatment (Chlorination) Facilities
- Booster Pump Station (Pump and Pump Stations) and Associated Above-Ground Piping
- Pipelines
- Pressure-Reducing and Pressure-Sustaining Valves
- Water Storage Tanks

This section of the master plan also includes discussions on leak detection, cross connections, and water meters.

2.2.1 Literature Review

Table 2.2.1-1 lists the documents reviewed for the Tinian Master Plan.

Table 2.2.1-1. **Documents Reviewed for the Tinian Master Plan**

Document	Prepared by	Year
CUC-RFP-11-007	CUC	2010
Sanitary Survey - PWS ID# MP0000002 CUC Tinian	CNMI Division of Environmental Quality	2011
Executive Summary for the Water Infrastructure Development Plan for the Islands of Saipan, Tinian and Rota	Winzler & Kelly & Belt Collins	2003
Feasibility Study: Privatisation of Various Utilities of the Commonwealth of the Northern Mariana Islands	CH2M	1997
Management Audit of the CUC	Metzler	1994
Stipulated Order No.1	Environmental Protection Agency	2008
Stipulated Order No.2	Environmental Protection Agency	2008
Electric, Water and Wastewater Rate Study	Economist.com	2007
Drinking Water Regulations	Commonwealth Utility Corporation	2004
Northern Mariana Islands Administrative Code (NMIAC) - CUC	Commonwealth Utility Corporation	2004
2011 DWINS – Drinking Water Infrastructure Needs Survey and Assessment for Saipan, Rota, and Tinian (a.k.a., SRF Priority Projects)	CUC	2011
CNMI Safe Drinking Water Infrastructure Grant Program	CNMI Division of Environmental Quality (DEQ)	2000
Historical Air Force Construction Handbook	Air Force Civil Engineer Support Agency	2007
DRAFT Cross Connection Control and Backflow Prevention Program	CUC	2011
Cross-Connection Control Manual	Environmental Protection Agency	2003
Source Book Guide to Water Industry Products and Services	American Water Works Association	2012

Table 2.2.1-1. **Documents Reviewed for the Tinian Master Plan**

Document	Prepared by	Year
Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)	Environmental Protection Agency	1992
Determining Groundwater Under the Direct Influence of Surface Water	AWWARF	
AWWA Standards	AWWA	Various
AWWA Manual M22	AWWA	2004

Information-Gathering Meetings

In addition to the literature review, a great amount of information on the history of CUC's infrastructure and details on how CUC's systems are currently maintained and operated was obtained through regular communications with CUC, 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 gather this type of information; Table 2.2.1-2 summarizes these information gathering meetings.

2.2.2 Condition Assessment of Existing Water Facilities

As part of the development of the Drinking Water and Wastewater Master Plan for Tinian for CUC, a comprehensive physical inventory and assessment of the public drinking water and wastewater systems facilities/components on each island was conducted.

The project team performed field condition assessments of the existing drinking water infrastructure in late 2011. The purpose of the condition assessments was to identify defective or deteriorated system components in need of repair, rehabilitation, or replacement. The water infrastructure condition assessment included the following elements from Stipulated Order Section B1, Assessments for Master Plan; Part 55, Condition Assessment of Drinking Water Systems:

a. Wellheads

b. Wellhead Protective Structures

c. Treatment Systems

d. Storage Tanks

e. Pump and Pump Stations

f. Transmission Lines and Distribution System Lines

g. Drinking Water Meters

The findings from these field condition assessments are qualitative in nature. 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 when developing the overall numeric risk scores for each asset. The assignment of quantitative scores for the physical condition, likelihood of failure, and overall risk of failure for all drinking system assets was accomplished during the risk assessment workshops (see Section 2.2.5).

The information collected as part of the condition assessments was also incorporated into the geographic information system (GIS) asset database. The GIS database will provide both location information as well as recent information collected during the field assessments.

This section includes a description of the site assessment methodology, results, and recommendations for each type of water infrastructure asset inspected on Tinian. This section also includes an analysis of cross connections, leak detection, water supply/sources, hydraulic modeling, and the development of the Tinian water system GIS.

Table 2.2.1-2. **List of Information-Gathering Meetings**

Meeting Subject	Topic(s) Covered	Parties Involved	Date
Site Visits	Condition assessment inspections of lift treatment facilities, booster stations, tanks	CUC, Project Team	Late 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
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
GWUDI Site Visits	Installation and startup of all GWUDI sites (Rota, Tinian, and Saipan)	CUC, Ken Thompson (CH2M), s::can	7/9/12 – 7/19/12
GWUDI Webinars	Review of GWUDI data collection	Project Team, CUC, DEQ, EPA	9/18/12, 11/8/12, 1/29/13
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

Wellhead and Protective Structures Inspection and Condition Assessment

There are no active wells within the Tinian CUC water system. The primary and only active source for water production is the Maui II well, which is discussed in the booster pump section of this Master Plan. In the past CUC has operated deep well pumps on Tinian. These deep well pumps have since been abandoned and are no longer usable. Private wells were observed to be in use at residences in Tinian. These private wells commonly serve agricultural uses and are not under the control of CUC; therefore, they are not included in any part of the Master Plan.

Treatment (Chlorination) Facilities Inspection and Condition Assessment

The single drinking water treatment (i.e., chlorination) facility in Tinian is located at the Maui II well, which was inspected by the project team to assess its existing physical condition and develop recommendations for improvements. This section describes the methodologies used, data assessed, and results from the condition assessment inspection.

Data Gathering

The condition of the drinking water distribution system was determined through a literature review, discussions with CUC Operations and Engineering staff, and site visits for the treatment (chlorination) facility located at Maui II. Access into the treatment (chlorination) facilities was provided by CUC personnel.

Assessment Methodology

The project team used the Booster Station Inspection Forms presented in Appendix A to record data collected during the site inspections. The booster station inspection forms also contained sections to record the condition assessment information for the treatment (chlorination) facilities broken out into the following categories:

- Chlorine Injection Pump and Motor
- Chlorinator
- Chlorine Tanks and Manifold
- Chlorine Analyzers
- Chlorine Alarms
- Operation and Maintenance Comments

The inspection team consisted of two consulting personnel (both civil engineers) assisted by CUC Operations and Engineering personnel. CUC personnel provided access to the treatment (chlorination) system. The project team completed the assessment form and took photographs. Interviews with CUC personnel were conducted on site to derive equipment information (when not visible) and collect critical operation and maintenance information on the facility being inspected.

Treatment (Chlorination) System Design Criteria

The minimum contact time for chlorine to meet the groundwater treatment rule is based on pH and temperature. Based on then historical CUC laboratory data, the pH of the groundwater in Tinian ranges between 6 and 9, so the CT values for typical water temperatures are as follows:

- 20 degrees Centigrade: 3 mg-min/L
- 25 degrees Centigrade: 2 mg-min/L

Entry points into the distribution system are required to achieve the required CT prior to delivery to the first customer. The Maui II pump station is considered the entry point into the distribution system.

CUC Operations staff have a DEQ approved Standard Operating Procedure (SOP – Revised October 2010) for the operations and maintenance for all treatment (chlorination) systems that can be found in Appendix B. The purpose of the SOP is to ensure that the drinking water treatment (chlorination) system are properly monitored and maintained to ensure the maximum protection for the end users.

Treatment (Chlorination) System Condition Assessment Findings

The project team inspected the treatment (chlorination) system at the Maui II pump station, and the condition assessment findings are discussed in this section. Disinfection is accomplished at the Maui II site with the use of gas chlorine and a rotameter and ejector. The main components of this system are discussed below.

Chlorinator and Injection Pump

The chlorinator regulates the delivery of chlorine gas that is to be mixed with the groundwater. The Maui II site is equipped with a rotameter manufactured by Regal. The control of the gas flow is accomplished by manually turning a knob located at the top of the rotameter to adjust the position of the float to the desired output, which is determined by the daily water usage. The rotameter was functional, although no chlorine ejector pump was in place at the time of the inspection. The chlorine injector pump at this site was not in place at the time of inspection is because the operators eliminated the need for this pump by discharging the chlorinated water to the wet well. This strategy is not preferred as it results in chlorinating the aquifer and running chlorinated water through the main booster pumps, reducing the life span of the booster pumps.

CUC modified the chlorination system at the Maui II site as part of the GWUDI investigation. This modification/upgrade provided a small, 2-hp injection pump. This injection pump provided the additional head needed to overcome the head of the main pumps, allowing CUC operators to stop discharging chlorinated water into the wet well of the Maui II sump. This upgrade matches the initial design of this chlorination system, and the chlorination system is currently meeting operational expectations. It is recommended that CUC continue this operation procedure. Figure 2.2.2-1 shows the new injection pump that was installed at Maui II. The new pump burned out after the first year of operation, and a replacement pump was purchased and installed.

Chlorine Tanks

A 150-lb chlorine gas cylinder is used to hold and transfer the bulk chlorine gas at the Maui II site. Chlorine is considered a hazardous gas and only experienced operators should handle it. Twelve full gas cylinders were located within a secured storage building at the Maui II site. These tanks were secured to the walls of this building by makeshift ropes and chains. This is not the preferred way of securing these tanks. It is recommended that a permanent chain system be installed to secure the full and empty cylinders.

The ventilation system in the chorine storage room was not operating at the time of the inspection. The chlorine gas alarm was also not operating at the time of the inspection, and no self-contained breathing apparatus was observed on site. These are all major deficiencies that must be addressed.

The in-use chlorine cylinders are located on a working chlorine cylinder scale.

Figure 2.2.2-1. **New Maui II Chlorine Injection Pump**

Water Quality Monitoring Equipment

No continuous online chlorine monitoring equipment was observed at the Maui II site. It is recommended that, for the primary disinfection facilities (i.e., entry points into the distribution system), amperometric chlorine meters with data recorders be installed to provide a continuous measurement of chlorine residual entering the distribution system. The data should be collected on a monthly basis and entered into a database for trending analysis and assessment of long-term chlorine storage needs. Alternatively, the data could be transferred via cellular communications and viewed real-time using the GWUDI investigation website and stored in a database maintained for the long term.

Treatment (Chlorination) System Condition Assessment Summary

The following recommendations were identified as part of the chlorination facility inspection:

- Continue using the newly installed chlorine injection pump system.
- Provide proper signage at each of the sites, such as high voltage and chlorine hazard signs, where applicable.
- Install and/or relocate chlorine alarms to be audible and/or visible outside the booster pump stations.
- Relocate mechanical vent switches outside of the chlorine building so buildings do not need to be entered to turn the mechanical vent on.
- Install an automatic chlorine tank switchover.
- Install reagent-free chlorine analyzers at the entry point into the distribution system.

Storage Tank Inspections and Condition Assessment

The two water storage tanks on the island of Tinian were inspected by the project team to assess the existing physical condition and develop recommendations for improvements to the tanks. This section describes the methodologies used, data assessed, and results from the condition assessment inspections.

Data Gathering

The tank inspection assessments were based on available data provided by CUC and field inspection by the project team. The project team reviewed available as-built data for the tank assessment. Limited data were available, thus the tank assessments relied largely on the field inspection.

Assessment Methodology

Two engineers (one civil and one structural) inspected each tank location. Personnel from CUC provided access to each of the tank sites. The assessment form identified the tank and deficiencies observed during the inspection. Noted deficiencies were based on the project team's past experiences with tank inspections of related scope. Deficiencies observed include, but are not limited to, the following:

- Vegetation within and adjacent to the tank site boundaries
- Cracking/spalling of tank foundation
- Corrosion of exterior tank shell/roof surfaces
- Severity of corrosion to anchor bolts and anchor bolt supports
- Condition of mechanical and electrical components
- Condition of interior structural members (if accessible)

The approach used during the site inspection consisted of visual findings, which were documented by photographs of each specific deficiency. Each photograph, along with the approximate location of the deficiency, has been recorded on a plan drawing for the tanks inspected.

Tank Condition Assessment Findings Summary

Table 2.2.2-1 presents a brief summary of the findings from the initial Tinian tank assessments. Detailed information collected during the tank inspections is provided in Appendix C, along with a matrix system ranking the severity of each individual tank based on its deficiencies. The results from the field investigations, in addition to the many other sources of information gathered and developed as part of this Master Plan, were used to aid in the determination of prioritized capital improvement projects (see Section 4.3.1, "Drinking Water Project Identification and Prioritization"). During the inspections, the tanks were rated on a qualitative scale as either Low, Moderate, High, or Severe condition. Recommendations, based on initial external tank condition assessment findings, are provided in Table 2.2.2-1.

Table 2.2.2-1. **Tank Assessment Summary based on 2013 External Inspections**

Asset Name	Year Built	Assessment Condition	Final Recommendation
Carolinas 0.50 MG	1983	Severe	API 653 inspection needed
Marpo 0.25 MG	1983	High	API 653 inspection needed

Follow-up API inspections were conducted at the Carolinas and Marpo tanks in 2015. Copies of the API inspections are provided in Appendix C. Findings from the API inspections are provided below, following the tank assessment discussion from February 2013.

Tank Assessment Discussion 2013

The Carolinas and Marpo tanks in Tinian have been classified as being in severe and high condition, respectively. Both tanks require an API inspection. Detailed inspection reports for these two tanks are provided in Appendix C.

The steel welded tanks are overdue for an API or American Water Works Association (AWWA) inspection. Industry standards, such as AWWA, recommend that an API inspection be scheduled in 5-year intervals. However, an API/AWWA inspection will require the tank(s) be taken out of service, which would result in disruption of drinking water service to customers and in most cases will require transmission and distribution system modifications to accommodate the tank outage.

It is understood that CUC cannot take all of its steel potable water tanks out of service concurrently and still maintain adequate service to its customers. Taking the HMT tank out of service will be a particularly major challenge. As a result, an assessment schedule must be developed and implemented to minimize disruption to customers.

Currently, a similar tank assessment program is underway on Guam. Given that Guam faces similar logistical challenges to delivering drinking water, a similar method is recommended for Tinian's tank inspection program. The recommended program is as follows:

1. Select tank to shut down, remove tank from service, and perform the assessment. Hire an approved API (or equivalent) inspector to perform the inspection.

   It may be that the assessment recommends taking the tank out of service until immediate repairs can be done. Such repairs may include complete replacement of floor bottoms, anchor bolts, installation of protective coatings, or replacement of roof rafters. CUC must be prepared to handle such occurrences or decide if it is impractical. The decision could require operating with the tank out of service until repairs can be made or placing it back on-line until a team can be assembled to perform the work as rapidly as possible and then taking the tank off-line to minimize down time.
2. Conduct any minor repairs that can be completed while the tank is out of service.
3. Disinfect tank and return to service. If a reduced operating level is suggested, CUC must be prepared to address this and others operational changes that could arise from the API inspection.
4. Proceed with next tank inspection.

Carolinas API Tank Assessment Findings 2015

The findings from the 2015 follow-up API inspection of the Carolinas tank are presented below.

Mandatory Major Repairs (Internal)

These mandatory major repairs address items that affect the overall operability and integrity of the tank and must be performed in the immediate near future:

1. Repair by welding the two areas of external shell plate corrosion at and near the tank corner (Chime) weld. The repairs can be made by overlay puddle welding the existing areas until full thickness of the shell plate is achieved. Welding must be performed by a welder certified to ASME Section IX. Welding electrodes must be low hydrogen, E-7108, or equal. Care should be exercised so as to not overheat the localized repair area, which may cause cracking of the parent metal.

2. Repair by welding the three areas of shell plate corrosion noted in the additional mechanical lift aided inspection noted above. The repairs can be made by overlay puddle welding the existing areas until full thickness of the shell plate is achieved. Welding must be performed by a welder certified to ASME Section IX. Welding electrodes must be low hydrogen, E-7108, or equal. Care should be exercised so as to not overheat the localized repair area, which may cause cracking of the parent metal.
3. Perform overlay “puddle” welding and lap patch weld repairs to the areas of severe corrosion and pitting on the tank floor. Any areas identified as having a pit depth greater than 0.125-inch should be repaired by welding or covered by the use of a 0.375-inch circular or rounded corner lap patch. Welding of lap patches is required to have a two-pass minimum and a full fillet weld height of 0.375 inches.

Future Major Repairs

These repairs address items that adversely affect the overall operability or integrity of the tank, but the repairs can be performed in the near future, i.e., within 5 years of the date of this plan:

1. Perform abrasive blasting of entire tank internally and externally; re-coat with a two-part epoxy coating with a clear, UV-resistant top coat.
2. Perform roof plate lap weld repair and lap patch weld repair to the areas of severe corrosion on the tank roof.
3. Replace the 12-inch tank inlet/outlet nozzle flange and bolting.
4. Repair or replace the roof manway.
5. Replace the tank 8-inch overflow expansion joint and bolting at the soil interface.
6. Repair by replacement the tank center vent with an approved “mushroom” or “cone” capped vent cover.
7. Repair by welding and replace as necessary sections of the corroded roof handrail system.
8. Repair by welding and replacement all components necessary to the exterior and interior roof access ladders and mid-point platforms.
9. Repair the tank retaining wall on the east side of the tank.

Marpo Tank API Assessment Findings 2015

The findings from the 2015 follow-up API inspection of the Marpo tank are presented below.

Mandatory Major Repairs (Internal)

These mandatory major repairs address items that affect the overall operability and integrity of the tank and must be performed in the immediate near future:

1. Remove the antenna from the tank. The antenna is attached in such a manner that any type of weld failure due to the current attachment points or failure due to the severe corrosion of the support structure could cause catastrophic failure of the tank.
2. Repair by the use of lap welded plate patches the four through-holes in the roof. Since the current through-holes are located at the edges of lap plate patches for the antenna anchor points, the current patches should be removed and replaced by larger plate patches.
3. Repair by welding the three areas of external shell plate corrosion at the water sample nozzle and overflow nozzle. The repairs can be made by overlay puddle welding the existing areas until full thickness of the shell plate is achieved. Welding must be performed by a welder certified to ASME Section IX. Welding electrodes must be low hydrogen, E-7108, or equal. Care should be exercised so as to not overheat the localized repair area, which may cause cracking of the parent metal.

4. Repair by welding the area of chime corrosion noted on the tank south side. The repairs can be made by overlay puddle welding the existing areas until full thickness of the shell plate is achieved. Welding must be performed by a welder certified to ASME Section IX. Welding electrodes must be low hydrogen, E-7108, or equal. Care should be exercised so as to not overheat the localized repair area, which may cause cracking of the parent metal.

Future Major Repairs

These repairs address items that adversely affect the overall operability or integrity of the tank, but the repairs can be performed in the near future, i.e., within 5 years of the date of this plan:

1. Perform abrasive blasting of entire tank; internal/external to re-coat with a two-part epoxy coating with a clear, UV-resistant top coat.
2. Repair or replace the roof manway.
3. Repair or replace the 24-inch round manway cover, with severe pitting and metal loss on and around the handle.
4. Repair by replacement the tank center vent with an approved “mushroom” or “cone” capped vent cover.
5. Repair by welding and replace as necessary sections of the corroded roof handrail system.
6. Repair by replacement the deteriorated grout around the tank circumference.
7. Repair by replacement the severely deteriorated tank anchor studs. Replacement may require relocating the entire anchor chair so that a new core hole can be located for stud replacement.
8. Repair by replacement or the use of a lap welded plate patch, the through-hole in the tank overflow piping. Since the overflow piping does not form a continuous fluid boundary, repair by the use of a lap welded plate patch formed to the outside radius of the pipe is acceptable.

Booster Pump Stations Inspection and Condition Assessment

There are two booster pump station facilities in Tinian, located at the active Maui II site and at the inactive Maui I site. Both booster pump stations were inspected by the project team to assess the existing physical condition and develop recommendations for improvements. This section describes the methodologies used, data assessed, and results from the condition assessment inspection. The abandoned Maui I Booster Pump Station could potentially be used in the future to provide water for the Marine Expansion project.

Data Gathering

The condition of the drinking water distribution system was determined through a literature review, discussions with CUC operations and engineering staff, and a site visit of the booster pump stations. Access into the booster pump stations was provided by CUC personnel.

Assessment Methodology

The project team used the site inspection form and photos presented in Appendix A to record data collected during the booster pump station site inspections. The Booster Pump Station inspection form is broken out into the following categories:

- Civil (e.g., security, vegetation, site condition)
- Structural/Architectural (e.g., building)
- Mechanical
- Electrical (e.g., lighting, generator, control panel)
- Operation and Maintenance Comments

The project team consisted of two consulting civil engineers, assisted by one to two CUC operations and engineering personnel. CUC personnel provided access to the Maui I and Maui II booster pump stations. The project team completed the assessment forms and took photographs. Interviews with CUC personnel were conducted on-site in order to derive equipment information (when not visible) and collect critical operation and maintenance information on the facility being inspected.

In some cases the make and model of the check valves, isolation valves, and pumps were not readily visible to the project team. In nearly all cases, these equipment details were painted over, corroded, and/or the tags were removed. Information on the size and make of each valve was ascertained by project team based on the configurations and orientations of the valves. Information on the pumps was derived from CUC records.

Condition Assessment Findings Summary

The project team inspected the Maui booster pump stations as part of the Master Planning Project, which including the dormant Maui I and the active Maui II booster pump stations. Both were inspected during the September 2011 site visit.

The findings at each booster pump station are presented in the following subsections. Site-specific information is presented in the field assessment form presented in Appendix A.

Civil

Both of the sites were fenced by a standard 4-inch mesh, 6-foot high chain-link fence with some form of padlock for security. The grounds at both of the sites were well maintained.

Structural and Architectural

The Maui I site is no longer in use and all of the mechanical components have been either removed or left as dormant. This system is no longer functional and was allowed to deteriorate. The Maui I site is used as a transition point between the quarter million gallon tank (QMT) and the half million gallon tank (HMT). This transition occurs through a choked valve.

The structural and architectural condition of the Maui II site is very good. The site is well maintained. There were no structural or architectural deficiencies identified at the Maui II site. Figure 2.2.2-2 provides a photo of the Maui II facility.

Figure 2.2.2-2. **Maui II Booster Pumps**

Pump System

There are four booster pumps located at the Maui II site. These 75 hp pumps are used to deliver the only source of water in Tinian. Each pump is rated at 350 gpm. One pump is adequate to deliver the average daily demand; typically a second pump runs as needed for peak demands. This allows for two redundant pumps at the facility. At the time of the inspection the motor for pump #3 was in service. The condition of these pumps and motors was good.

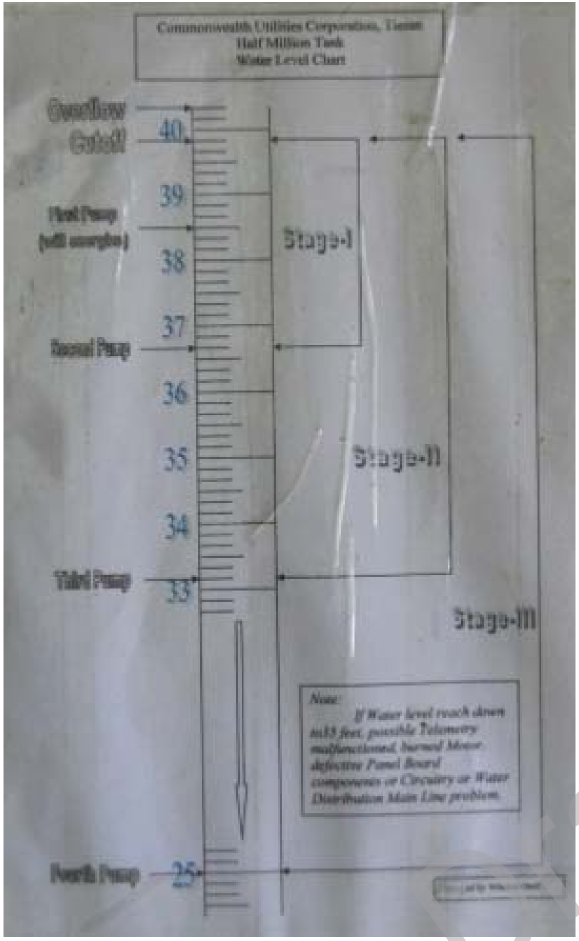
It is important to note that the logistics for replacing these pumps and motors does not allow for a quick (i.e., one day) turn around. In the event a failure occurs and more than two pumps are out of service, continuous water supply to the island will be in jeopardy. It is critical that pumping redundancy be maintained at this site. It is recommended that at all times at least two redundant pumps be kept on line.

Control System

The Maui II pump is a constant speed pump and is operated through a float control system. Figure 2.2.2-3 presents the level setting for this system. The control system appears to be in good working order and no operational failures were reported to the project team by CUC operations staff.

There is a higher level of control which relays based on the level of the HMT. This system calls for the Maui II system to activate when the level in the HMT drops. The Maui II system is shut off when the level in the HMT is high. The CUC operator demonstrated that this system operates as intended. A noted deficiency with this system is that the QMT and HMT are interconnected, resulting in a continuous overflow of the QMT. This results in the HMT never reaching its full capacity. Further discussion on this is provided in the hydraulic modeling section of this master plan.

Figure 2.2.2-3. **Maui II Pump Level Settings**



Piping

The piping at the Maui II pump station is ductile iron pipe. All piping appeared in good condition. The site piping at the Maui I site was in poor condition. Although this station is not active, water is transferred from the HMT to the QMT at this site. This transfer point experiences high pressure and high velocities. Figure 2.2.2-4 shows a photo of the existing Maui II site piping. The CUC operator noted two recent failures of piping at this site. A repair sleeve can be seen in the background behind the choked gate valve. Upgrades to this configuration are recommended and a new level control valve is recommended between these two zones. CUC is currently preparing plans to install a control valve in the piping along the main road leading to the Maui I station. Once construction is complete, the piping to and within the Maui I station may be decommissioned.

It is recommended that the new control valve be a combination pressure reducing/sustaining valve that sustains the high pressure within the HMT and reduces the pressure to the QMT zone. The pressure-reducing function should be set to the pressure established when the QMT is just below high level.

Figure 2.2.2-4. **Maui II Piping**

Valves

The isolation valves at the booster Maui II site were in good condition. The pump control/check valves appeared in fair condition. It was not clear if the slow actuating check valves operated as designed. It is recommended that CUC maintenance personnel inspect these valves to ensure proper operation.

Electrical System

The electrical system at Maui II Pump Station was assessed based on general visual observations. The overall condition of the electrical systems at the booster pump stations was found to be good condition. Inspection of the electrical system included the main electrical service to the site, the generator, general lighting, and power.

Electrical Service

The Maui II pump station is provided with three phase electrical service at 480V. A step down transformer is provided to obtain 120V power for lighting and general receptacle loads. The overall condition of the electrical service is good, though the grounding system needs to be reviewed carefully to ensure compliance with the latest NEC regulations. These regulations include, but are not limited to, proper neutral-to-ground bonding and equipment grounding.

Generator

The backup power at the Maui II site is provided by a generator. The generator was not able to be tested during the inspection of the facility. Based on discussion with the operator, the generator was in working order. This generator appeared to be adequately maintained.

General Lighting and Power

The 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. The lighting was in good condition.

Summary of Booster Pump Station Assessment

The overall rating of the condition of the booster pump stations was discussed and determined during the risk assessment workshops (Section 2.2.5), and was based on the condition assessment findings in addition to CUC input. Remaining service life of the booster pump station was not evaluated. The following is a summary of existing conditions and recommended upgrades:

- The condition of site piping at the dormant Maui I well site is considered poor and must be upgraded to include a level control valve.
- The condition of the Maui II pump station is good. There are no major upgrades needed at this site.

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

- 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.
- 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 (corrosive environment, wet location rated, damp location rated, etc.).
- Ensure compliance with Code-required working clearances for all electrical equipment.
- Where applicable, determine cause of water intrusion into electrical/generator rooms and permanently rectify the condition.
- Remove all electrical equipment no longer in use rather than abandoning in place.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.
- 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.

Pipelines Condition Assessment

The water distribution system in Tinian was built in the 1980s and is considered relatively new and in good condition. The exceptions to this are listed below. In this Master Plan, the water distribution system is categorized as the pipeline network supplying chlorinated water to the customer. The transmission system is the water line network which supplies water from the source to a water storage tank with no costumers between the source and storage tank. The water tank in the transmission system is used for disinfection contact time. Based on this definition, there is no separate water transmission system in Tinian. Water from the Maui II pump station is sent directly into the distribution system. The head from the HMT set the grade for this pump station.

Table 2.2.2-2 presents a breakdown of all the waterlines 4 inches or greater in the distribution system.

Table 2.2.2-2. **Water Line Inventory (4-inch Pipes and Greater)**

	Line Size (in)					
Material	**4**	**6**	**8**	**10**	**12**	**Totals (ft)**
CIP			1,414			1,414
DIP				797		797
GP	5,426	43				5,469
PVC	2,064	66,747	59,884	12,424	27,161	168,280
Totals (ft)	**7,490**	**66,790**	**61,298**	**13,221**	**27,161**	**175,960**

Note:
CIP - cast iron pipe; DIP - ductile iron pipe, GP - galvanized pipe, PVC - polyvinyl chloride pipe

The total length of CUC distribution water is 246,720 ft. Approximately 28 percent of this length is less than 4 inches and consists of PVC and GP pipe.

There is approximately 6,000 ft of 8 inch PVC pipe installed between the Maui I pump station and the HMT. This pipe was installed in the early 1980’s. This type of PVC is reinforced with fiberglass. This pipe has had numerous failures. Figure 2.2.2-5 shows a photograph of this pipe. The failure of this pipe is longitudinal cracking. This suggests that this pipe cannot handle compression or transient flows. Replacement of this pipe is recommended.

Further discussion on water loss and leakage is included in Section 2.2.2. See “Leak Detection and Drinking Water Conservation Programs.”

Figure 2.2.2-5. **Photo of Longitudinal Cracking between Maui II Pump Station and the HMT**

Pressure-Reducing and Pressure-Sustaining Valves Condition Assessment

There are five main pressure-reducing valves (PRVs) located within Tinian water system.

The first PRV serves the San Jose Village. Appendix D presents the location of this PRV. This PRV breaks the pressure from the HMT. Without it, pressures exceeding 100psi can be seen throughout San Jose. This PRV is located in a concrete vault. Upon inspection, this vault was flooded and CUC personnel had to pump the vault out to inspect the PRV. The pilot tubing on this PRV has failed causing the vault to flood. This PRV is in poor condition.

Three PRVs serve the undeveloped southern Carolina’s homestead. Appendix D presents the location of this PRV. There are no current costumers downstream of this PRV. As a result, this system is dormant.

There is one more PRV located within the Marpo valley upstream of the San Jose PRV. This PRV was never placed into service.

Recommendations for PRVs

The following recommendations are made for the distribution and transmission PRV and PSVs:

- CUC should specify aluminum or stainless steel pilot piping for reapers, upgrades, and replacements.
- Additional training on the maintenance and operation of PSVs is recommended.
- Refurbishment of the PRV serving San Jose is recommended.

Water Meter Assessment

For many years, CUC has been inundated with defective water meters and substandard meter installation, a result of poor field documentation, contract (third-party) meter installations, failed meter performance, and slow replacement of failed meters. Replacement of failed meters and installation of new meters on unmetered and unregistered accounts has been ongoing since March 12, 2011. While significant progress has been made, more progress could have been accomplished had not numerous meters continued to fail. Meter failure rates range from 64 percent for meters installed prior to 2007 to 18 percent of meters installed in 2010, which, while improved, is higher than industry standard.

Survey of Available Metering Equipment

To assist CUC in identifying and evaluating a water meter that would be more reliable than those currently in use, which have an extraordinarily high failure rate, CUC requested assistance from DCA/CH2M. DCA/CH2M contacted the vendors in Table 2.2.2-3 for information on water meters. Many of the companies on the list were identified by surveying DCA/CH2M's network of engineers to learn which meters (and metering companies) have been successfully used in the past for similar water utilities. Others were extracted from the American Water Works Association's *Source Book Guide to Water Industry Products and Services*. One company was added after contacting a client from a region with similar water conditions.

Table 2.2.2-3. **Water Meter Company Contact Information**

Company	Corporate Office or Distributor	Contact Information
Neptune	Distributor	Jered Lindstrom Product Specialist HD Supply Waterworks Mobile: 360.600.7603 Fax: 877.487.4944 E-Mail Address: Jered.Lindstrom@hdsupply.com
Metron	Corporate Office	Steve Kielley Director of Business Development - Northwest Territory Phone: (720) 641-5256 Fax: (970) 726-9004 E-mail: skielley@metronfarnier.com
Sensus	Corporate Office	Anibal Miranda Sales & Marketing Director for Mexico, Caribbean and Central America Priv. de Sostenes Rocha 2313 Frac. Rincones de la Cima Chihuahua, Chih., 31200, Mexico T: +52 614-413-0013 C: +52 1 614-427-9797 anibal.miranda@sensus.com www.sensus.com
Mueller	Distributor	Consolidated Supply Co. 503-620-7050
Master	Corporate Office	101 Regency Parkway Mansfield, TX 76063 1-800-765-6518
Elster	Corporate Office	1100 SW 38th Avenue Ocala, FL 34474 1-866-896-8858
Badger Meter	Corporate Office	Badger Meter, Inc. Tammie Stewart Sales Support Specialist 800-876-3837 ext. 15992 phone 414-371-5992 direct phone 414-371-5752 fax

Each vendor was asked to present product information on meters that would perform under the following conditions:

- Possibly brackish water
- Warm soil
- Systems with water loss (leakage and tampering)
- An application with integrated backcheck measures
- Compatible with existing system

Based on information provided by the vendors, DCA/CH2M reviewed the following meters:

- Neptune T-10
- Metron Farnier Spectrum 30D
- Sensus iPERL
- Sensus accuSTREAM
- Mueller MVR
- Master Multi-Jet
- Elster V100
- Badger Meter Disc Meter
- Badger Meter E-Series

Water Meter Evaluation

The following section describes specific water meter products for potential integration into CUC's water system and is based on the product data provided by the manufacturers. The description of each product includes basic operation, composition materials, tamper information, and the estimated price per unit.

Neptune T-10

Meter Description: This model is a positive displacement, nutating disc meter with a tamperproof seal and lead-free main case. The meter is adaptable to ARB®V, ProRead™ (ARB VI) AutoDetect, E-Coder® (ARB VII), E-Coder) R900i ™, TRICON®/S, TRICON/E®3, encoders. The model is also available with an integrated double-check backflow device to prevent contamination.

Estimated Unit Price: $126.42

Estimated Unit Price with Backflow Device and ProRead Register: $348.57

Neptune Double Check T-10 Meter Backflow Meter

Metron Farnier Spectrum 30D

Metron Farnier Spectrum 30D Meter

Meter Description: The Spectrum Meters have been designed to replace limited range displacement and multi-jet meters. The meter is a single-element, composite (reinforced plastic) meter which utilizes the innov8 electronic register. The innov8 register uses a magnetic sensor to track the impeller rotation and exerts no drag on the measurement. The meter is compatible almost any AMR/AMI system. It is designed to perform in adverse water conditions, such as the presence of sand or small debris particles in the water, and is uninterrupted by UV radiation and external magnetic fields. The Spectrum employs a tamper-resistant and tamper-evident register housing to prevent corruption.

Estimated Unit Price: $125.00

Sensus iPERL

Meter Description: With no moving parts, the iPERL water management system is based on electromagnetic flow measurement technology. The integrated construction of an iPERL system prevents removal of the register to obtain free water. The magnetic tamper and low field alarms both indicate any attempt to tamper with the magnetic field of the iPERL system. The measuring device comprises a polyphenylene sulfide alloy flow tube with externally-threaded spud ends. iPERL systems are compatible with the Sensus AMR/AMI systems currently used by CUC.

Estimated Unit Price: $133.20

Sensus iPERL Meter

Sensus accuSTREAM

Meter Description: This magnetic drive positive displacement meter uses an oscillating piston to measure a wide range of flows for a variety of residential applications or similar service needs. Meters and encoders are compatible with current Sensus and various competitive AMR/AMI systems. Main cases are made of composite material with externally-threaded spuds. Registers are housed in a bonnet of synthetic polymer. Measuring chambers are a corrosion-resistant thermoplastic material formulated for long-term performance and suitable for aggressive water conditions. A unique locking system prevents customer removal of the register to obtain free water.

Estimated Unit Price: $92.35

Sensus accuSTREAM Meter

Mueller MVR

Meter Description: MVR meters are magnetic drive, vertical turbine meters with a compact design and integral strainer. Water flows through the integral strainer and into the vertical turbine assembly. No straight pipe requirements apply before or after the meter. The Model MVR turbine operates more quietly than conventional disc or piston meters. The meter is equipped for straight reading through a permanently sealed magnetic drive with low-flow indicator. Remote reading units such as AMR are optional. The lowest available size for the meter is ¾-inches. The main case of the meter is composed of bronze, while the rotor assembly and strainer are thermoplastic.

Estimated Unit Price: $277.00

Mueller MVR Meter

Master Multi-Jet

Meter Description: A 360-degree advance polymer basket strainer protects the critical measuring element from damage through adverse water conditions. The meter uses a velocity-type flow measurement system. The meter's register integrates that velocity into totalized flow. The meter is available in a the choice of waterworks bronze case of 81 percent copper composition or a 86 percent copper, no lead bronze. The Master Meter Multi-jet adjusting port and register are concealed to prevent tampering and removal of the register. This design also provides a visual indication of tampering attempts. The meter can be read though a DIALOG 3G Integrated AMR Register or Direct Read/Manual systems.

Master Multi-Jet

Estimated Unit Price: Unknown, the company would need to have more information about the previous meter failure to provide an accurate quote.

Elster V100

Meter Description: The V100 meter is a positive displacement type meter that operates on the oscillating piston principle. The meter is available in an acetal co-polymer or bronze main case. It operates on a direct read system only. The measuring chamber is a bottom-in and top-out design and consists of the measuring chamber with division plate and thrust bearing insert, the piston, the chamber cover including the drive bar assembly and a cover locator pin. The sealed register is liquid filled and free from condensation and tampering.

Estimated Unit Price: $60.00

Elster V100

Badger Meter Disc Meter

Meter Description: The meter is a positive displacement, nutating disc meter. Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate.

Permanently sealed, dirt, moisture, tampering and lens fogging problems are eliminated. Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Straight reading, permanently sealed magnetic drive standard. The meter is available with the remote reading or automatic meter reading options.

Estimated Unit Price: $112.00

Badger Disc Meter

Badger Meter E-Series

Meter Description: The E-Series is an electronic meter that can provide information on water usage and other data such as rate of flow and reverse flow indication, and eliminates measurement errors due to sand, suspended particles, and pressure fluctuations. The LCD display shows total volume and alarm conditions and can toggle to display rate of flow. E-Series meters feature a stainless steel, lead-free meter housing, an engineered plastic and stainless steel metering insert, a meter-control circuit board with associated wiring, LCD, and battery. The meter is not compatible with the Versi-wand Probe or any other touch systems. A transmitter system such as the Badger ORION or Itron system is required for the meter to function.

Estimated Unit Cost: Unknown, the company would also need to know which transmitter system would be used.

Badger Meter E Series

Cost Summary

The cost summary for each of the water meters previously discussed in captured Table 2.2.2-4. Some of the meters incur an additional cost in order to be compatible with CUC's water system. In these cases, the costs for system compatibility were identified separately from the meter unit costs in the Summary Table.

Table 2.2.2-4. **Summary of Water Meters Researched by DCA/CH2M**

Company	Model	Estimated Cost	System Compatibility Cost
Neptune	T-10	$126.42	$0
Neptune	T-10 (with backflow device)	348.57	$0
Metron	MP5	$125.00	$15.00
Sensus	iPerl	$133.20	$21.60
Sensus	accuSTREAM	$92.35	$0
Mueller	MVR	$277.00	$16.00
Master	Multi-Jet	Unknown	Unknown
Elster	V100	$60.00	N/A
Badger Meter	Disc Meter	$112.00	$0
Badger Meter	E-series	Unknown	Unknown

Drinking Water Meter Evaluation Results

Based on the information collected from meter companies and DCA/CH2M's knowledge of CUC's water system, our recommendation is for CUC to purchase and evaluate both the Sensus accuSTREAM and the Badger Disc meter. Currently, CUC is testing the Sensus iPerl meter. CUC should select a system-wide meter based actual on performance one or more of the three meters in the field.

Cross-Connection Control Program Inspection and Condition Assessment

The EPA and CUC define a cross connection as any actual or potential connection between the public water supply and a source of contamination or pollution. To develop a degree-of-hazard (used for the selection of a backflow protection device), the terms contaminant, pollutant, and lethal hazard must be defined. These terms are defined as follows:

- Pollutant (Non-health Hazard) – A foreign substance that, if permitted to get into the public water system, will degrade its quality so as to constitute a moderate hazard, or impair the usefulness or quality of the water to a degree that does not create an actual hazard to the public health, but which does adversely and unreasonably affect such water for domestic use.
- Contaminant (Health Hazard) – A substance that will impair the quality of the water to a degree that it creates a serious health hazard to the public, leading to poisoning or the spread of disease.

- Lethal Hazard (Health Hazard) – Sewage and radioactive materials are considered Lethal Hazards because of the epidemic possibility associated with sewage and the tremendous dangers associated with radioactive material.

The degree of protection must be a function of the degree of hazard. CUC has established the following list of protections as they relate to the degree of hazard:

- High Hazard (Health Hazard)
  - Air gap, reduce pressure principal device, or combination thereof
- Low Hazard (Non-Health Hazard)
  - Air gap, atmospheric vacuum breaker, pressure vacuum breaker, double check valve, reduce pressure principal device, or combination thereof

Two hydraulic conditions may lead to a backflow event through a cross connection. One is back-siphonage, where a substance is introduced into the system by a sudden or gradual reduction of water pressure. A back-siphoning effect could also be generated by an increase in velocity. The second condition is backpressure, which is when the customer’s pressure is greater than the system pressure.

To control back-siphonage, the “10 States Standards” require a minimum of 20 psi at ground level in all points of the distribution system under all conditions of flow. The 10 States Standards also specify that each utility have a program conforming to the States’ requirements to detect and eliminate cross connections.

A Cross-Connection Program is required as part of the Stipulated Order, Section A5, Drinking Water Operations and Maintenance at CUC; Paragraph 38, Cross Connection Control and Backflow Prevention Program. CUC has submitted a Draft Cross Connection Control and Backflow Prevention Program document to EPA. This draft program is discussed in subsequent sections.

Past Findings

The Inspection and Sanitary Survey Report produced by DEQ (2011) called out a leaking pump gland at the Maui II pump station as a possible source of contamination though a cross connection. The Sanitary Survey required that this deficiency be corrected.

CUC Draft Cross Connection Control and Backflow Prevention Program

CUC has prepared a Draft Cross Connection Control and Backflow Prevention Program document (2011) that uses existing generic guidance developed by EPA for cross-connection programs. This draft program sets the stage for the responsibilities and administrative requirements associated with the program. The draft program also discusses hazards and the requisite protections associated with these hazards. Testing and training are also discussed.

While this draft program sets the stage for dealing with cross connections, the following program elements require revision, approval, and adoption by CUC:

- Standard backflow preventer installation details.
- Inclusion of a list of approved backflow preventer manufacturers and models. While the Foundation for Cross Connection Control and Hydraulic Research (FCCCHR) is stated as the basis for the training, annual certification and approved manufacturers for the units themselves must be discussed.

- A more detailed discussion on the specific types of hazard encountered in CNMI. For example, agricultural use of a pesticide is considered a high hazard. The level of protection should be greater than that of a check valve or double check. The type of backflow commonly associated with this activity is back-siphonage. For this condition, an atmospheric vacuum breaker, pressure vacuum breaker, or spill-resistant vacuum breaker may be used depending on the type of backflow.
- The draft program does not list the spill-resistant vacuum breaker as a recognized cross-connection device.

Additional discussion on the cross-connection program is provided in the Recommendations section below.

Findings

The following cross-connection assessment is based on visits conducted to well and booster pump sites and to various fire hydrant and water meter locations throughout the CUC Saipan water system. The areas of cross connection can be split into two categories: 1) system cross connections and 2) point-of-use cross connections. A system cross connection is one that occurs within the CUC water system; a point-of-use cross connection is one that occurs downstream of the customer water meter.

The interconnection between Maui II and the Dormant Maui I site is a possible cross connection. High velocities can result in a Venturi effect causing back siphonage.

Recommendations

This section provides both system and point-of-use operations recommendations as they relate to cross-connection control and protection.

The siphoning at Maui I can be corrected with the installation of a level control valve. This will control the flow of water though this line. Upgrade to the site piping is also recommended. Consideration to large pipes size should be done by the design engineer.

Leak Detection and Drinking Water Conservation Programs

A non-revenue water rate of 74 percent in Tinian is a major issue for CUC, and the implementation of an island-wide leak and detection program is vital to sustainable operation. The program should consist of regular leak detection activities to identify pipelines that are abandoned but still connected to the distribution system and other sources of water loss (e.g., improper connections, damaged/cracked pipe, or leaky valves). The details of the program should be developed in conjunction with CUC personnel and in consideration of CUC practices and should include a program to research and implement new leak detection approaches.

Leak Detection Assessment

On the island of Tinian groundwater is pumped from the Maui II Well, where it is disinfected before being sent to the HMT, and then to customers in the distribution system. The amount of water produced is measured using a flow meter installed at the Maui II site. This meter is manually read at various times during the month. Once the water enters the distribution system, it is categorized as either metered or non-revenue water.

Metered water is water consumed by an end user that has been measured through the use of a water meter. Metered account charges for customers are based on set rates and total consumption, and generate an income for CUC. Non-revenue water is the exact opposite, i.e., it is water that does not generate any income and is considered “lost” in the system. Lost water can mean many different things but it is normally defined as:

- Leaks – either due to damaged pipes, improper connections, or faulty appurtenances.
- Non-metered customers – customers that are legally connected to the distribution system that do not have a meter installed at the point of use but rather pay a bulk water charge. Agricultural use is a big example of legal non-revenue water use.
- Illegal connections (theft) – people illegally connect to the system at some point along the distribution system.
- Abandoned pipelines – when new pipelines are installed, connections to out-of-service pipelines are not severed.

Table 2.2.3-2 presents a summary of the production, metered, and non-revenue water for the Tinian tank service areas (TSAs). Non-revenue water represents a large percentage, nearly 75 percent, of total water consumed in Tinian.

Non-revenue water not attributed to agricultural use is categorized as “lost” due to theft (i.e., illegal connections) or leaks within the distribution system. System age, pipe materials, condition, and regularity of leak detection projects can indicate the portion that leaks represent. According to the EPA and depending on the pipe material, the average lifetime of a pipeline is anywhere from 15 to 100 years.

Table 2.2.2-5 summarizes the pipe age and material found in each of the homesteads in Tinian. The age of pipeline in Tinian is between 5 and 35 years. Over 95 percent of the waterlines 4 inches and greater are PVC. The PVC pipe is performing well in Tinian, with the exception of the fiber glass reinforced PVC pipe, which is prone to failure and is a probably source of leakage in Tinian’s drinking water system. These lines are under high pressure (i.e., over 100 psi), which will increase the rate of leakage. Replacement of the fiberglass PVC lines is recommended.

Table 2.2.2-5. **Summary of Water Distribution Pipe Material and Age in Tinian**

Homestead	Year Installed	Material
Carolina Agricultural Water	2002	PVC
San Jose	1997	PVC
Carolinas	1983	FR PVC
Carolinas	1984	PVC
Carolinas South	1984	PVC
Marpo Heights	2004	PVC

While the waterlines in the homesteads are relatively new, there is an existing network of older, smaller water lines that makes up approximately 28 percent of the Tinian water system. The installation date of these lines is unknown, but can likely be traced to the installation of the Maui I well in the 1950s. The material of this line is galvanized pipe, which is prone to heavy leakage over time. Proper abandonment or replacement of these lines is recommended.

Water Conservation Program Assessment

Water conservation programs that involve the customer base are typically implemented when there is an existing shortage of water or a concern for water shortages in the future. Neither of these situations are the case for Rota, so there has been little incentive for CUC to implement a large water conservation program. The non-revenue water that has been previously discussed is the most important issue for CUC to tackle to conserve its valuable water resources for the future. Once the non-revenue water problem has been corrected, CUC may want to consider implementing additional water conservation measures as needed, but should weigh this against the loss of potential revenue. Experiences in the western United States have been that, when conservation practices have been implemented, utilities need to increase water rates to account for lost revenue. The response has been universal outrage from a public who feels that it is being penalized for saving water. This may not be the case with CUC as the reduction of water production will equate to a large energy reduction, thus potentially lowering rates or allowing the creation of reserve accounts.

Two recognized approaches for water conservation include 1) the installation of water-saving devices in the interior and exterior of the home and 2) the use of a water conservation rate structure that encourages customers to reduce their water usage.

Water Conservation Devices

The installation of water saving devices in the home, such as low-flush toilets and low-flow water fixtures, would provide CUC with a one-time reduction to annual water use by that customer. External water savings, typically associated with landscape irrigation, can be accomplished through the use of timers that allow night-time irrigation, rain shut-off valves, and general best practices in irrigation system design.

Recommendations

Long-range planning of the leak detection program should be developed with CUC Operations, taking into account previous leak detection projects and activities. Based on the review of past projects and current efforts, the following recommendations should be considered for the future leak detection program:

- Valve installation should continue on Tinian with a level control valve placed between the tanks as described previously in PRV condition assessment discussion.
- The development of a leak detection program in Tinian is recommended. The focus of this program should first be to stop the overflow at the QMT, followed by replacement of the fiber glass reinforced PVC pipe. A strategic leak detection and water conservation program should then be developed; the program should be modeled after the ongoing leak detection program in Saipan.

Proposed Military Activities

The following documents prepared by the Department of the Navy in September 2014 were used for this section:

- Commonwealth of the Northern Mariana Islands Joint Military Training: Utilities Study Volume III: Potable Water
- Commonwealth of the Northern Mariana Islands Joint Military Training: Utilities Study Volume IV: Wastewater

Water

The U.S. military has proposed to use Tinian for training activities associated with the relocation of U.S. Marines from Okinawa, Japan. The estimated water demand for the proposed activities on Tinian is as follows:

- Minimum Required: 459,758 gpd
- Additional Required: 172,800 gpd
- Total Supply Required: 632,558 gpd

Based on the preferred alternative, the total supply required for the training activated will come from new water wells developed within the military's lease-back property. This action will have no direct impact on the existing CUC water infrastructure; however, it is recommended that CUC coordinate with DEQ to assure that the sustainable yield of the Tinian Aquifer is not compromised.

A projected water demand has been estimated for the existing CUC Tinian water system from the new civilian personnel who would support the training activities, construction activities (temporary), and additional port activities. The estimated water demand for the proposed Tinian activities is as follows:

- Average Demand: 121,971 gpd
- Maximum Demand: 274,434 gpd

This additional demand would result in a 17-percent increase to existing projections from the Maui II Well. The average production from the Maui II well, according to referenced documents, is 1.2 MGD (833 gpm). The estimated production used in this Master Plan is 648 gpm or 0.9 MGD. Both of these production values are much higher than the meter demand of 0.2 MGD. Theoretically, the existing CUC system may accommodate this 17-percent increase.

It is recommended that the CIP projects listed in this Master Plan be undertaken prior to the proposed development. Controlling and correcting the high value of water loss must also be done prior to the military development and associated activities.

As a future recommendation, with the development of the Military's new water system, interconnectivity should be considered. Each system could become a viable, redundant back-up for the other. Items such as chlorination supply and system hydraulics should be evaluated to allow for possible interconnection in the event of an emergency.

Wastewater

The preferred alternative for wastewater generated by the proposed military activity is a package treatment system. This system will collect wastewater from the military activities, treat it, and dispose of the effluent through a leaching field system. Under this preferred alternative there will be no direct impact to the CUC water system. There is currently no CUC wastewater collection and treatment system on Tinian.

Water Source/Supply Investigations and Assessments

The GWUDI investigation and assessment were conducted to determine whether the groundwater supplies used by CUC for its drinking water system are under the direct influence of surface water. Well selection and evaluation criteria were based on EPA and DEQ guidelines for GWUDI determination.

Groundwater Under the Direct Influence is defined by EPA as water that (1) shows significant and relatively rapid shifts in water characteristics such as turbidity, conductivity, pH, or temperature (which also change in groundwater but at a much slower rate) that closely correlate to climatological or surface water conditions, or (2) the presence of insects or other macroorganisms, algae, organic debris, or large-diameter pathogens such as *Giardia lamblia.*

Well Selection and Evaluation

CNMI DEQ, in consultation with EPA Region 9 staff, identified the Maui II Well for evaluation as part of the GWUDI Investigation.

Maui II Shaft

The Maui II well provides 100 percent of the water for Tinian's water system and is located on the Southeast side of the island adjacent to the Marpo marsh. This is a relatively new and shallow lateral infiltration gallery that was constructed by CUC in May 2001. Water flows through horizontal shafts into the well. There is no information recorded from the prior EPA or DEQ Sanitary Surveys for the Maui II well. One problem that the team noted was the opening inside the room that went directly into the wetwell to the collection sump. This is a potential source of contamination and should be sealed.

GWUDI Criteria

To determine CNMI's groundwater supplies that are under the direct influence of surface water, criteria were developed based on the EPA's general guidance for the Surface Water Treatment Rule, specifically the "Consensus Method for Determining Groundwaters under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)" (1992). The criteria developed specifically for the determination of groundwater supplies on Saipan, Rota, and Tinian also relied on additional information contained in the AWWARF report "Determining Groundwater under the Direct Influence of Surface Water," as well as input from CNMI DEQ. Additionally, the criteria were considered against the specific hydrologic conditions of CNMI.

Overview

The final judgment of whether the Main Cave spring is GWUDI will be made by DEQ in consultation with EPA based on the following five criteria developed from EPA guidance documentation:

- Historical Records of Waterborne Disease Outbreaks
- Turbidity Excursions
- Microscopic Particulate Analysis (MPA)
- Storm-Related Water Quality Excursions
- Well Construction

These criteria have been reviewed by the drinking water scientific community and substantial weight was placed upon the MPA as an indicator of surface water intrusion. Guidelines for the risks associated with MPA data are to be used in the final GWUDI determination. The following is the scoring system for GWUDI determination based on the risk associated with the MPA findings:

- **High Risk MPA.** The groundwater source is considered GWUDI if the MPA shows high risk and at least one other indicator (criteria) is consistent with GWUDI.

- **Medium Risk MPA.** The groundwater source is considered GWUDI if at least three other indicators (criteria) are consistent with GWUDI. If only one or two indicators (criteria) show positive results, then the MPA must be repeated. If the repeat MPA results in a medium to low risk then the groundwater source is considered not GWUDI but is subject to continued evaluation.
- **Low Risk MPA.** The groundwater source is not considered GWUDI. However, if three other indicators (criteria) show positive results for GWUDI, the MPA must be repeated after a rainfall event. If the result of that MPA again shows low risk, the groundwater source is not GWUDI; if the risk is medium to high, then the groundwater source will be considered GWUDI.

The GWUDI criteria based upon EPA guidance and developed specifically for this study are described below.

GWUDI Criteria No.1 – Historical Records of Waterborne Disease Outbreaks

A history of known or suspected waterborne disease outbreaks from organisms associated with surface water (e.g., *Giardia*, *Cryptosporidium*, coccidia) attributed to the source is considered evidence of GWUDI. It is believed that there are no historical records that such outbreaks have occurred on Rota. A consultation with the appropriate public health officials on CNMI should be conducted to confirm whether there is information of any historical outbreaks caused by *Giardia*, *Cryptosporidium,* or other protozoan parasite.

Comment: The GWUDI Investigation Team contacted CNMI DEQ and confirmed that there has not been any recorded instance of waterborne disease outbreaks on Tinian.

GWUDI Criteria No. 2 – Turbidity Excursions

True groundwater has low turbidity even following storm events. This is due to hydrogeological settings that provide adequate filtration to physically remove particulate matter. Confining layers, when present, can prevent downward flow of surface water containing particulates. Therefore a history of elevated turbidities associated with a source is considered evidence of GWUDI.

The following are general rules for turbidity in groundwater:

- True groundwater typically shows a turbidity level of 0.3 NTU.
- A turbidity level ranging from 0.3 to 1.0 NTU is an indicator of possible GWUDI; however, this must be considered with additional information, such as the nature of the materials causing the turbidity.
- A turbidity level greater than 1.0 NTU is an indicator of GWUDI. Again, final determination must be considered with additional information.

Continuous turbidity data for six months at significantly low levels of resolution (0.1 NTU) and accuracy (+/- 0.05 NTU), was obtained as part of the GWUDI study and is presented in the “GWUDI Phase I Water Quality and Weather Data Analysis” section below.

GWUDI Criteria No.3 – Microscopic Particulate Analysis

True groundwater is characterized by a lack of microbial pathogens, especially larger pathogens such as *Giardia* and *Cryptosporidium*. Hydrogeological settings can provide filtration to physically remove these organisms and other materials of similar size. Confining layers, when present, can prevent downward flow of surface water containing particulate matter. For these reasons, true groundwater should not have materials or organisms found in surface water or at the soil surface. These include microalgae (containing diatoms), insect parts, pollen, rotifers, *Giardia* cysts, *Cryptosporidium* cysts, coccidia, and other, larger (> 5 to 10 micron) microorganisms. Identification of these and like materials in groundwater samples using MPA to determine the presence or absence of these materials will be evident of GWUDI.

Comment: An MPA sample was collected and analyzed using EPA-approved methodology. The results are discussed in the "GWUDI Phase I Water Quality and Weather Data Analysis" section.

GWUDI Criteria No. 4 – Storm-Related Water Quality Excursions

Demonstration of water quality changes in groundwater temporarily associated with storm events or other events at the surface (sewage or chemical spills) could be evidence of GWUDI. Storm event (meteorological/rain) data will be compared with turbidity and other water quality data to assess temporal associations or correlations.

For microbiological contaminants, detection of indicator organisms following an event in wells that were negative prior to the event is indicative of GWUDI. Turbidity fluctuations of greater than 0.5 to 1.0 NTU over the course of a year or associated with a storm or spill event, temperature changes greater than 1 to 2 degrees associated with a storm event, or water chemistry changes greater than +/- 50 percent of typical ranges may also be indicative of surface water influence.

GWUDI Criteria No.5 – Well Construction

An improperly constructed well without casing or surface seal can allow surface contamination to flow or fall down the borehole. The system files should be reviewed for well construction and results of the sanitary survey and these should be consulted for the Maui II well. Evidence of defects in the surface seal or in the casing, or other surface fractures, indicate the potential for GWUDI. While properly cased and sealed wells will minimize opportunities for direct surface water contamination, the prevailing hydrogeological structure of fractured limestone in CNMI does not guarantee that proper construction alone provides adequate protection.

Comment: DEQ and EPA Sanitary Survey information and on-site inspections were used to conduct this assessment.

GWUDI Study Phases

The GWUDI Study for the Tinian Maui II well site was conducted in two phases:

- Phase I – July 2012 through January 2013
- Phase II – September 2013 – through January 2014.

The start of the study for phase I was driven by the modification of the chlorine injection system from the wet well to the pump discharge line.

GWUDI Phase I Investigation Methodology

The phase I GWUDI study was conducted during the period of September 2012 through January, 2013. The study started late due to the requirement to relocate the chlorine injection from the wet well to the pump discharge line. The study ended in January, 2013 which signifies the end of the rainy season when GWUDI is most prevalent.

Laboratory Analysis

Laboratory analysis was performed by CUC both weekly (turbidity, pH, conductivity, and temperature) and monthly (total coliform, *E. coli*). Samples were taken from the Maui II well prior to disinfection and processed at the CUC lab located in Saipan.

Data from the laboratory analysis were used as quality assurance/quality control (QA/QC) measures for the online water quality monitoring (OWQM) program. The OWQM sensors were calibrated on and checked against the QA/QC measurements to determine the validity of the data received from the online water quality monitoring equipment. The data were used to perform instrument calibrations monthly or in some cases more frequently.

OWQM Instrument Quality Control Analysis

Data from the laboratory analysis was used as QA/QC for the OWQM program. The OWQM sensors are calibrated based on, and monitoring data checked against, the QA/QC measurements to determine the validity of the data received from the online water quality monitoring equipment. The laboratory data was used to perform instrument calibrations monthly, or in some cases more frequently.

Weekly Sampling

CUC conducted weekly samples on the Maui II well and the following water quality parameters were analyzed:

- Turbidity
- Conductivity
- pH
- Temperature
- Total Coliform
- *E. coli*

Monthly Sampling

Monthly sampling and analysis for the following water quality parameters occurred during the study:

- Hardness (analyzed by CUC)
- Chloride (analyzed by CUC)
- Alkalinity (analyzed by CUC)
- Calcium (analyzed by CUC)
- Nitrate (analyzed by DEQ)

Microscopic Particulate Analysis

One sample was collected from the Maui II well and sent to Biover Laboratories for MPA testing. The sample was taken to establish a baseline for each well. During the study a second sample collection that would have been based on the 2-in/24-hour criteria in the QAPP, which states that samples must be taken after at least 2 inches of rainfall within a 24-hour time period, was not able to be taken. This was due to the delay in starting up the Maui II well GWUDI investigation. Once the sample was processed, a risk level was assigned based on the results. The risk level (for GWUDI) associated with the Maui II well is based on the microparticulate counts. The types of microparticulates, the total count of each, and the risk determination data sheet for the Maui II well is located in the QAPP. The sample was collected on the date listed in Table 2.2.2-6.

Table 2.2.2-6. **MPA Maui II Well Sampling Date**

Site ID	1st MPA Sample Date	2nd MPA Sample Date
Maui II well	November 6, 2012	None Collected

A risks level for surface water contamination was assigned to the Maui II well based on the MPA results and using the EPA guidance document Consensus Method for Determining Groundwaters under the Direct Influence of Surface Water Using MPA (EPA 910/9-92-029).

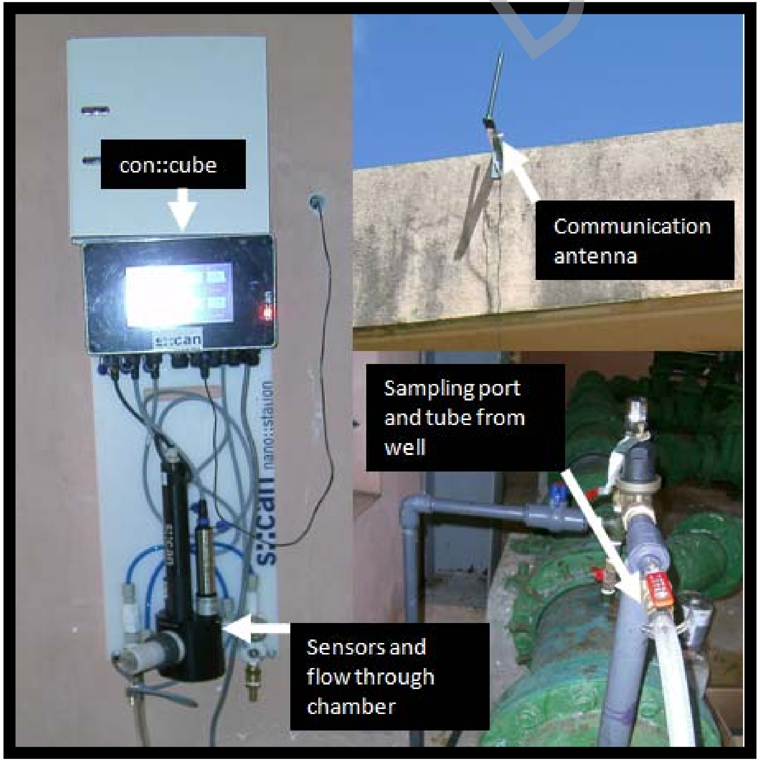
Online Water Quality Monitoring (OWQM) Stations

The Maui II well site was equipped with an s::can suite of sensors, including the following:

- Conductivity (Required)
- pH (Required)
- Temperature (Required)
- i::scan
  - TOC (Optional)
  - UV254 (Optional)
  - EPA Turbidity (Required)
  - ISO Turbidity (Optional)
  - Color (Optional)

The sensors are placed in a sampling compartment to which a ½” braided PVC feed line is attached to bring source water to the sampling unit at a flow rate of 2 L/min. The discharge from the sampling unit is directed through a ½” PVC line that is placed outside of the building into the grassy area to allow the water to percolate back into the groundwater. The sensors were connected through a cable into the controller unit known as the con::cube. The con::cube communicates wirelessly through a digital cellular communication system and data can be retrieved from the web-enabled dashboard that allows real-time OWQM trend analysis and sensor health evaluation. A photo of the station labeled with its various parts is shown in Figure 2.2.2-6.

Figure 2.2.2-6. **Online Water Quality Monitoring Station**



Instrument Selection

The GWUDI Investigation Team evaluated a number of potential technologies that could be used for the GWUDI analysis. The evaluation included incorporating the knowledge that the team has obtained in working with EPA Water Security Division for the past 6 years on the $70-million Water Security initiative to design, implement, and evaluate contamination warning systems. Online water quality monitoring was a significant part of that effort, which included sensor performance evaluation. The two instrument suites that were considered for the final evaluation were the Hach/YSI and s::can suites of instruments. The result of the evaluation was to select the suite of s::can instruments based on past instrument performance, vendor support, and ability to use the instruments for distribution system monitoring at the Maui II well entry point after the GWUDI Investigation was completed. In addition, the sensors were reagent free, which allowed the waste stream to be drained onto the ground.

Instrument Maintenance

Maintenance activities such as sensor cleaning and calibration, software upgrades, and infrastructure upgrades and repair were tracked and logged in spreadsheet format throughout the study. Important maintenance activities and the corresponding dates they were performed are presented in maintenance log tables below.

Biofilm accumulation on the i::scan sensor resulted in a slight upward drift of the turbidity data for the Maui II well. Weekly maintenance was performed to remove the biofilm from the sensor lenses with a mild acidic solution but the biofouling persisted. Stiffer autobrushes were also installed to discourage biofilm formation in between cleanings and while this helped, the upward drift was still detectable. Figure 2.2.2-7 shows the biofilm accumulation on the i::scan sensor; notice the circle where the brush has cleaned. The 90-degree detection lens is in the shadow at the top portion of the ring.

Figure 2.2.2-7. **i::scan Sensor and Biofilm Accumulation**

More detail is given below in the maintenance log tables regarding the effect biofilm accumulation had on the Maui II turbidity data.

Instrument Failures

Throughout the course of the study, there were a few instances of instrument failure. During the startup period it was detected that the initial pH sensor had a glue joint problem and was replaced when it failed. Any other issues with the sensors and sensor cables, brushes, or communications were noted in the maintenance log and are presented in the maintenance log tables below.

Chlorination System

The start-up of the GWUDI investigation for the Maui II location was delayed because treatment (chlorination) was occurring in the infiltration gallery sump. The GWUDI Investigation Team worked with the CUC Operations and Engineering team to purchase and install a new pump and chlorine injector. The point of chlorination was moved to a location in the pump station discharge line downstream of the GWUDI OWQM station.

Weather Stations

Previous to the study, there was no reliable weather station data available on Tinian. A weather station was installed at the OWQM site to continuously monitor rain and temperature associated with the Maui II Well site.

Instrument Selection

The GWUDI Investigation Team identified a low cost weather station made by HOBO that would provide continuous and reliable rainfall and temperature data. The team was sensitive to the cost of the stations because it is highly unlikely that CUC will continue to use the weather station after the conclusion of the GWUDI Investigation.

Instrument Maintenance

Little maintenance was required for the weather station other than the regular removal of leaves and debris from the rain buckets that would occasionally clog. The weather stations were equipped with data loggers that stored the collected rain and temperature data until it was manually retrieved. The data then had to be converted using the HOBOware Pro software and analyzed using Microsoft Excel.

Instrument Failures

There were a few instances where data from the weather stations was either not retrieved properly or the data logger malfunctioned and the data was lost. The weather station at the Maui II site was the only available source of data on the island, so if the station failed a data gap occurred.

GWUDI Phase I Water Quality and Weather Data Analysis

Results for the MPA, OWQM, and QA/QC laboratory data analysis for the Maui II site are presented in the following sections. OWQM instruments collected measurements every minute throughout the duration of the investigation. The collection of such a large amount of data allowed for an accurate and detailed description of the water quality of the groundwater supplies and the effect, if any, that any rainfall event had on that water quality. Rainfall and ambient temperature data were also collected continuously; the average temperature and total daily rainfall for the Maui II well are presented in the following sections. When presenting all of the collected data in graph form, it is difficult to discern whether a rainfall event had an effect on the water quality. Therefore the graphs are presented as follows:

- **Microparticulate Analysis Data.** The data collected from the MPA sample are shown to illustrate the baseline biological indicators present in the source water.
- **OWQM and Rainfall Data.** The four graphs present the conductivity, turbidity, pH, temperature, and the QA/QC data for each parameter for the Maui II well. These graphs present general trends in the water quality for the Maui II Well and also identify where any issues or problems occurred with equipment.

- **Rainfall Events.** For the Maui II well, the two largest rainfall events, which occurred on August 27 and October 10, 2012, were selected for analysis. The graphs present the turbidity observed at the well for one week after the rainfall event, along with the rainfall that occurred during that time, as this information is most relevant to the EPA GWUDI criteria.
- **Laboratory Data.** The two graphs present the calcium, chloride, hardness, alkalinity, *E. coli*, and total coliform at the Maui II well site. One graph presents the effect that the rain events had on the presence of *E. coli* and total coliform.
- **Maintenance Log.** Because turbidity is a major criterion for GWUDI determination, this graph was created to show where any maintenance (e.g., instrument cleaning, replacement, or operational problems) occurred over the course of the study and the effect that maintenance had on the turbidity measurements.

The graphs for Maui II are presented in the following sections along with a brief discussion of the data.

Maui II

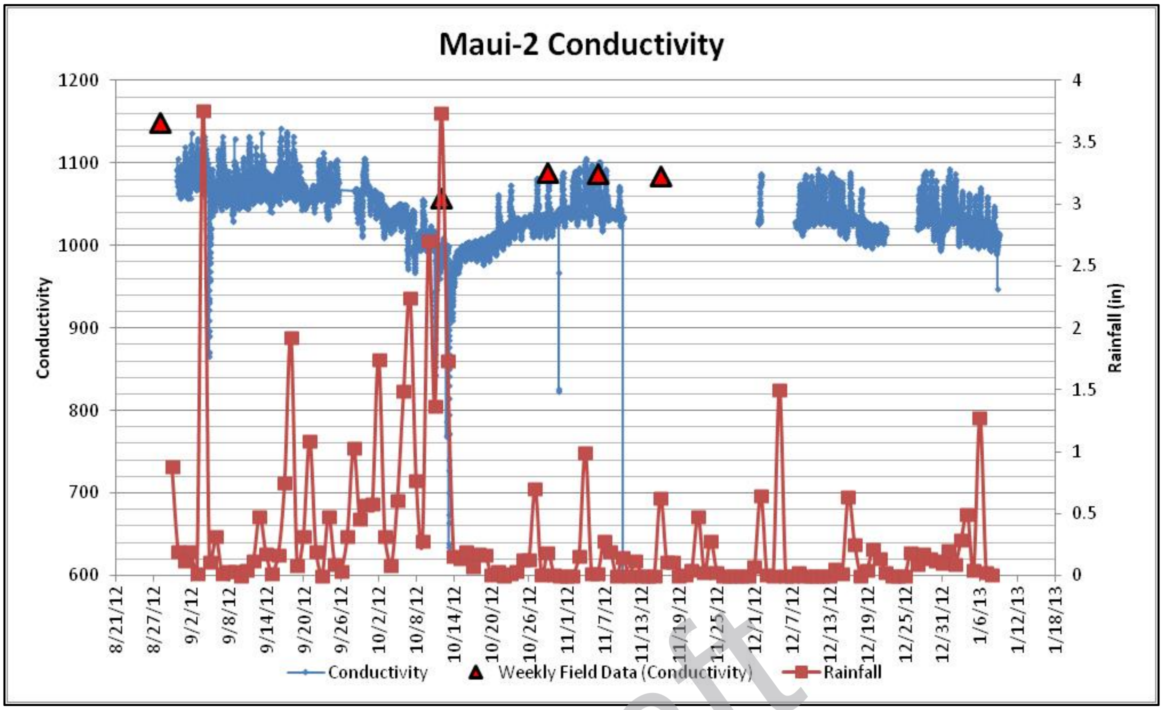
MPA Analysis. An MPA baseline sample was collected for the Maui II site. The data from the baseline sample collected does not indicate the presence of surface-related microparticulates. Table 2.2.2-7 presents the MPA results, which shows that the tests were negative for the presence of microparticulates.

Table 2.2.2-7. **Maui II Baseline Microparticulate Analysis**

Sample Date	11/4/2012				
Sample Site	Maui II				
Sample Size	3487L				
Primary Bio-indicators					
Giardia	0	in 3487 L	*Cryptosporidium*	0	in 3487 L
Coccidia	0	/100 gal	Diatoms	0	/100 gal
Other Algae	0	/100 gal	Insect/Larvae	0	/100 gal
Rotifers	0	/100 gal	Plant Debris	0	/100 gal
Secondary Indicators					
Amorphous Debris	TNTC	/100 gal	Minerals	0	/100 gal
Plant Pollen	0	/100 gal	Nematodes	0	/100 gal
Crustacea	0	/100 gal	Amoeba	0	/100 gal
Cilliates/Flagellates	0	/100 gal	Other Organisms	0	/100 gal

OWQM and Rainfall Data. The data presented in Figure 2.2.2-8 graphs suggest that the source may be GWUDI but it is difficult to determine and more data should be collected before classification.

Figure 2.2.2-8. **Overall OWQM Data for Maui II**



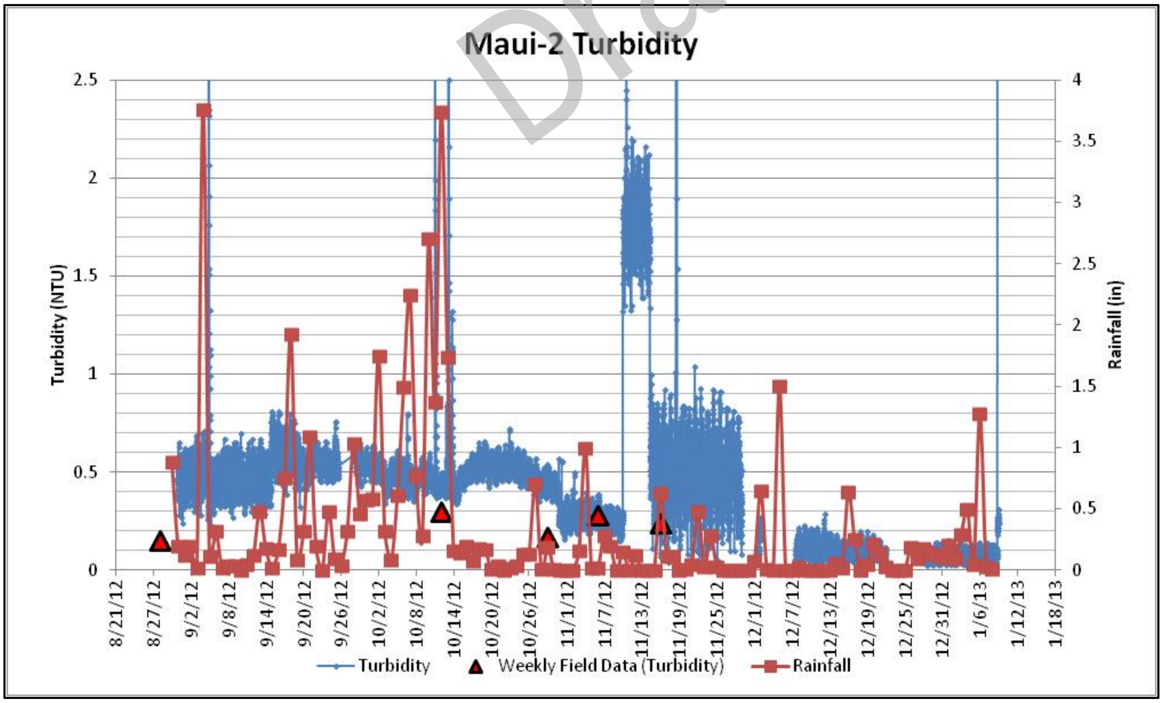
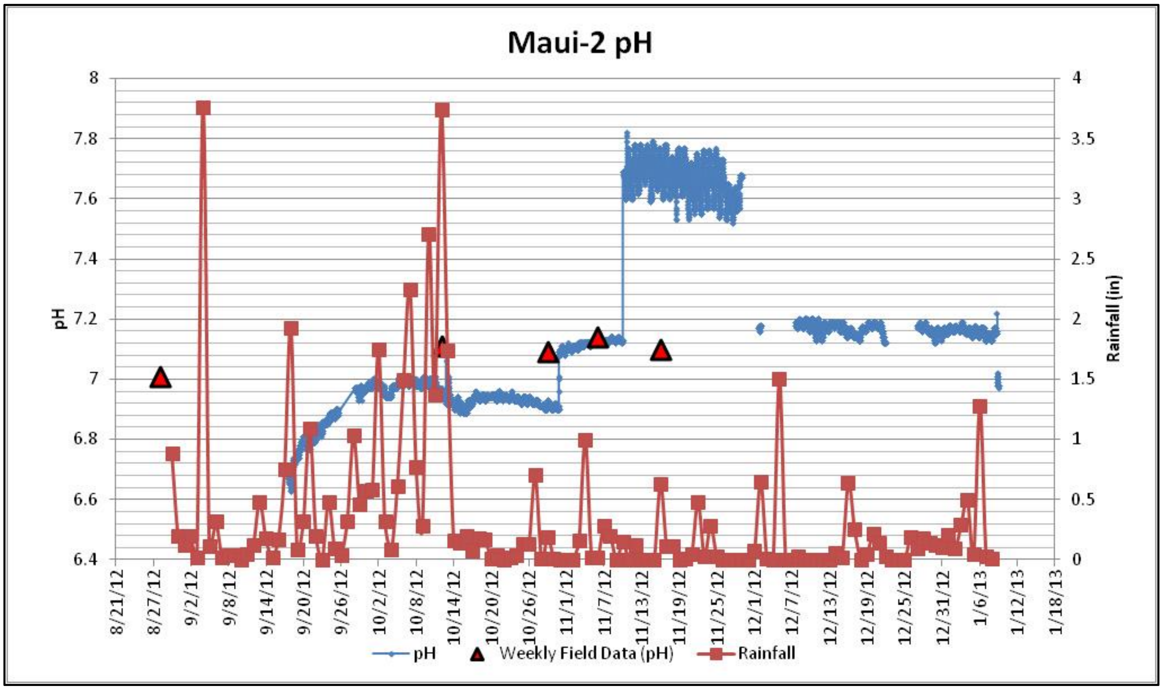
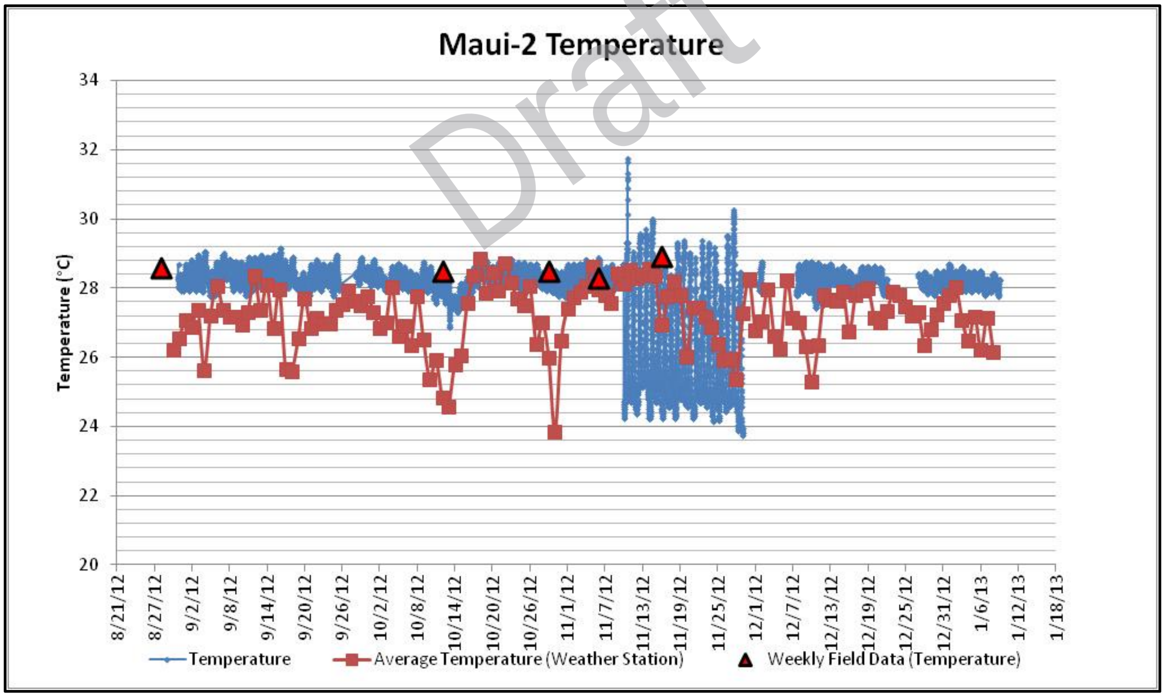


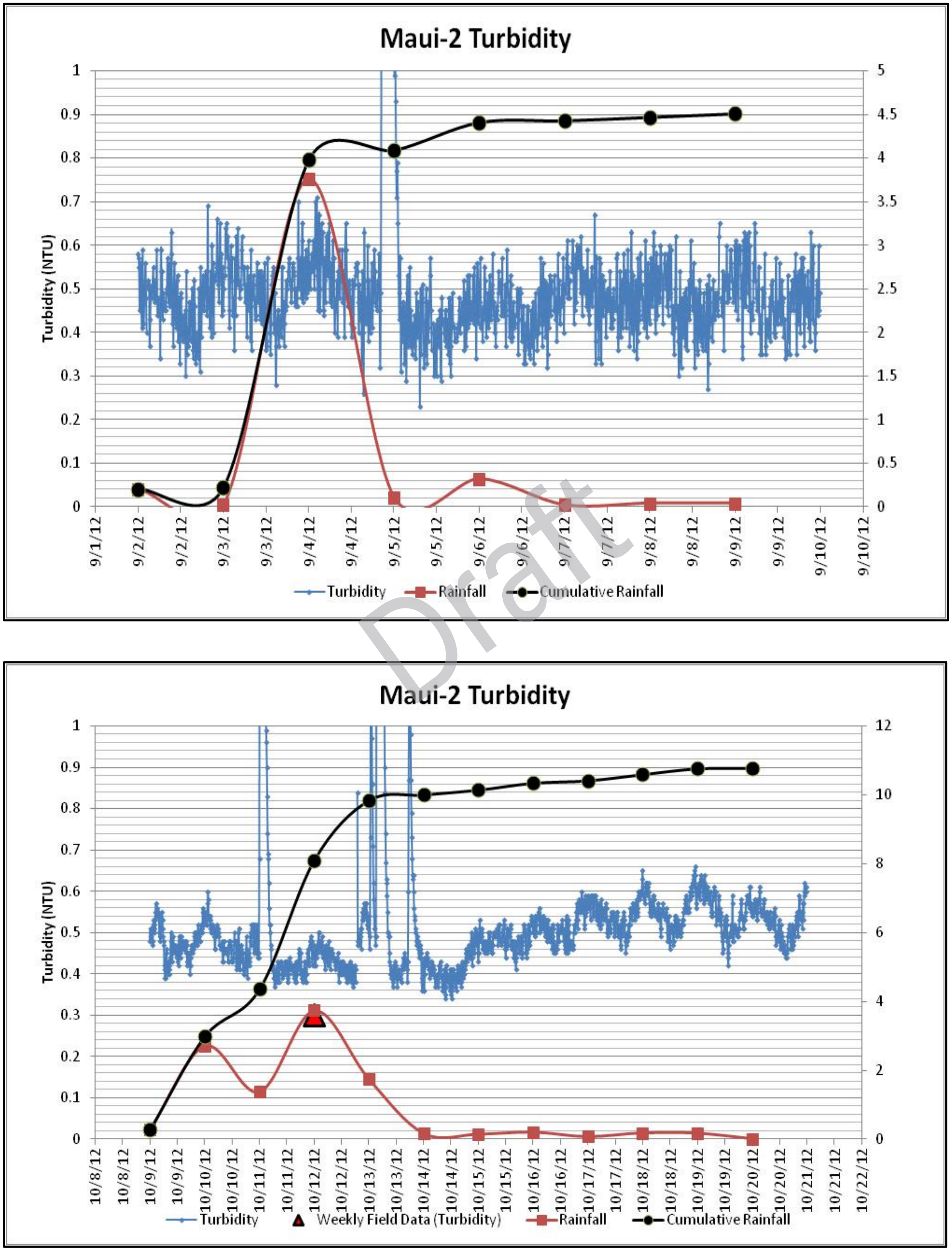
Figure 2.2.2-8. **Overall OWQM Data for Maui II**





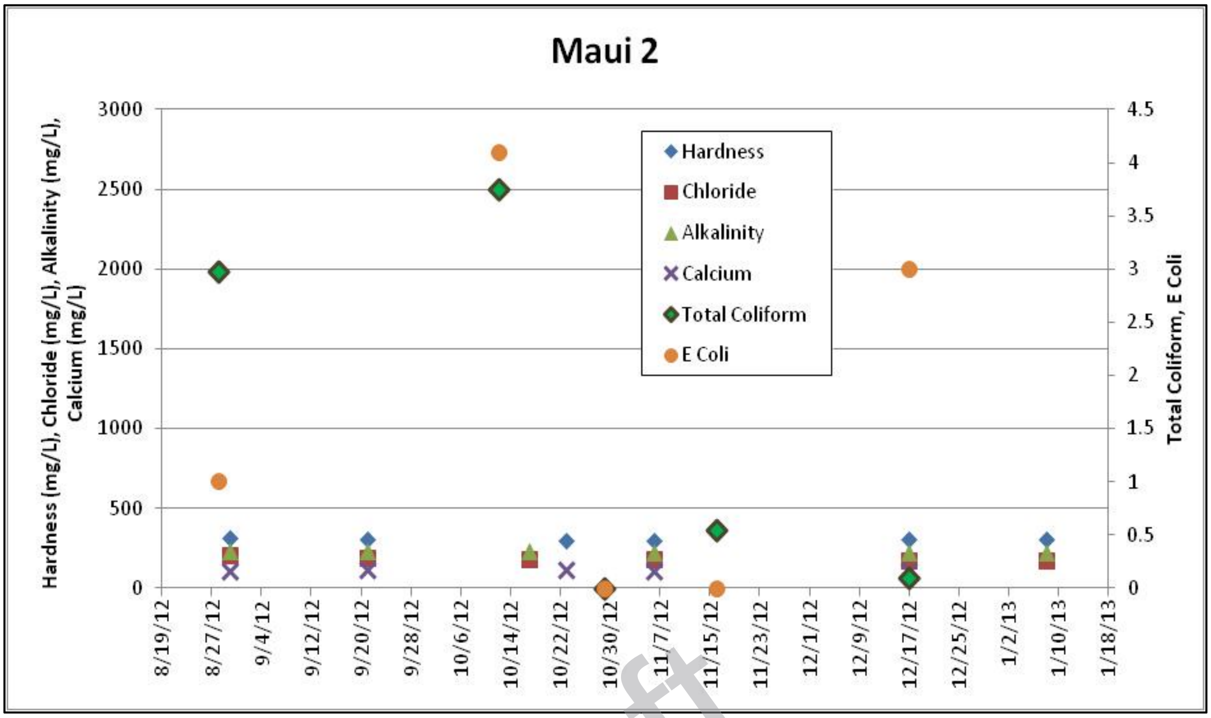
Rainfall Events: The two rainfall events presented in the Figure 2.2.2-9 graphs show a brief spike in turbidity after the rainfall events; however, the turbidity spikes occurred nearly 1 day after the rainfall and both spikes occurred about a day after maintenance was completed on the sensors (see Figure 2.2.2-11). Figure 2.2.2-10 shows that there is a presence of microbes (total coliform and *E. coli*, both of which spiked during the rain event on October 12), but the same spike was not seen during subsequent rain events. Because of the continued presence of these microbes, it is recommended that this groundwater be disinfected before it is sent to the distribution system.

Figure 2.2.2-9. **Rainfall Events at Maui II**



Laboratory Data

Figure 2.2.2-10. **Laboratory Data for Maui II**



Maintenance Log

Figure 2.2.2-11. **Maintenance Log and Corresponding Turbidity and Rainfall Data for Maui II**

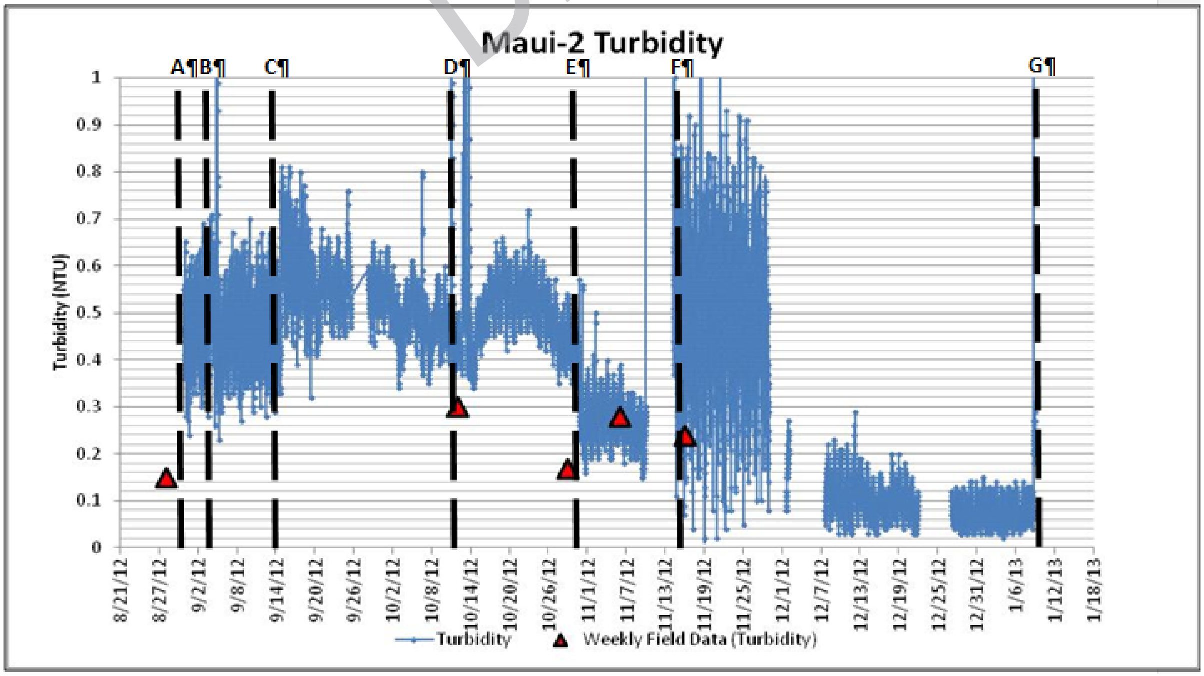


Table 2.2.2-8. **Maintenance Log Dates and Descriptions (corresponds to Figure 2.2.2-11)**

	Date	Maintenance Performed	Issue Resolved
A	8/30/2012	Updated software, cleaned and calibrated sensors	Reduced biofilm, recalibrated sensors
B	9/3/2012	Removed chlorine injection from wetwell	
C	9/14/2012	Cleaned and calibrated sensors, replaced pH sensor	Reduced biofilm, recalibrated sensors
D	10/12/2012	Cleaned and calibrated sensors	Reduced biofilm, recalibrated sensors
E	10/29/2012	Cleaned and calibrated sensors	Reduced biofilm, recalibrated sensors
F	11/16/2012	Cleaned and calibrated sensors	Reduced biofilm, recalibrated sensors
G	1/8/2013	Cleaned and calibrated sensors	Reduced biofilm, recalibrated sensors

GWUDI Phase I Investigation Summary

A plan was developed based on criteria set forth by the EPA to determine if the Maui II well on Tinian is considered groundwater under the direct influence of surface water, which would require higher levels of treatment. Heavy weight was placed on the baseline and post-rainfall event micro particulate analysis (MPA) to determine the overall risk level. Online water quality monitoring equipment was installed at the Maui II site to continuously gather data for conductivity, turbidity, pH, and temperature and trends were observed over the course of the six month study. A major indication of surface water influence is a 0.5 to 1.0 NTU change in turbidity or a +/- 50 percent change in the other water quality parameters following a rainfall event.

MPA results for the Maui II well indicate that it is at low risk of surface water interference and based on the EPA GWUDI criteria, three of the other indicators had to be positive in order for the groundwater source to be labeled as GWUDI. During the two rain events that were evaluated, a spike in turbidity and drop in conductivity was noted. The investigation of the Maui II well GWUDI investigation began late due to the requirement of relocating the chlorine feed from the pump sump and into the pump station discharge pipeline. Because of the concerns with the rain event related water quality changes and the lack of a rain event MPA analysis, the GWUDI Investigation Team recommended that additional data be collected during another complete rainy season.

Sensor Precision

The GWUDI Determination Study Program stipulates that continuous turbidity data must be obtained at low levels of resolution (0.1 NTU) and accuracy (+/- 0.05 NTU) for six months to a year. The figures presented in the previous sections provide the long-term turbidity data for the Maui II well site; Figures 2.2.2-12 through 2.2.2-15 below present the frequency of turbidity values and precisions between sensor readings during rainfall events. The increase in the precision of the sensors between readings increased over time due to software upgrades, increased cleaning efficiency and maintenance, and regular calibrations. This is demonstrated in the figures below by comparing the data from the separate rainfall events.

Figure 2.2.2-12. **Maui II Turbidity Histogram for 9/2 Rainfall Event**

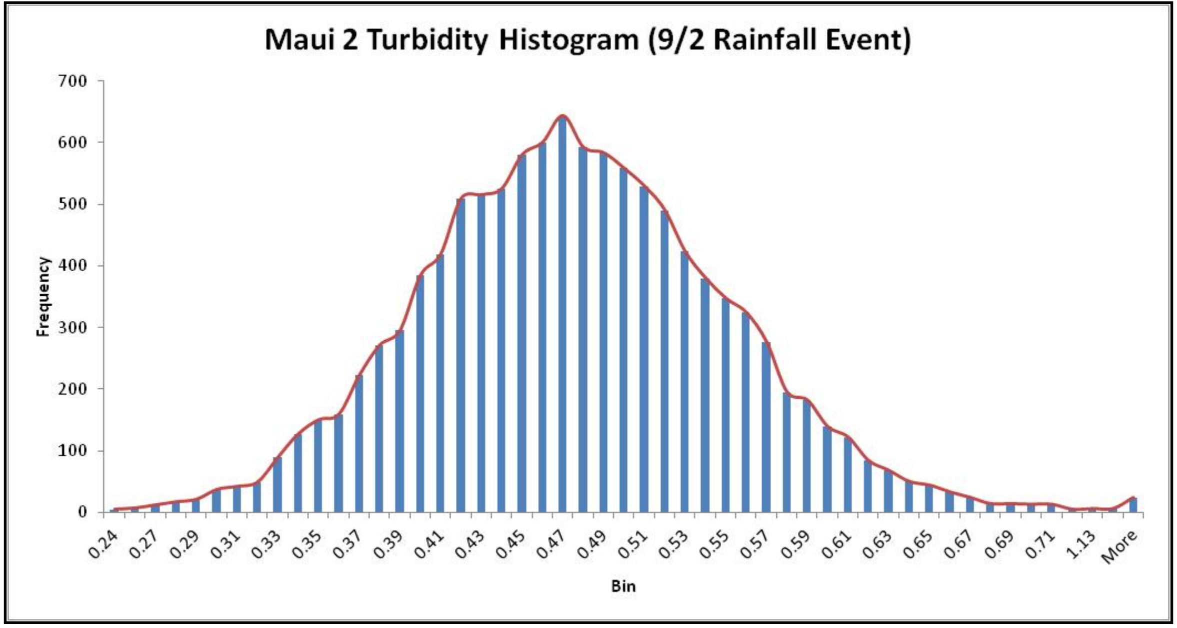


Figure 2.2.2-13. **Maui II Turbidity: Precision Histogram for 9/2 Rainfall Event**

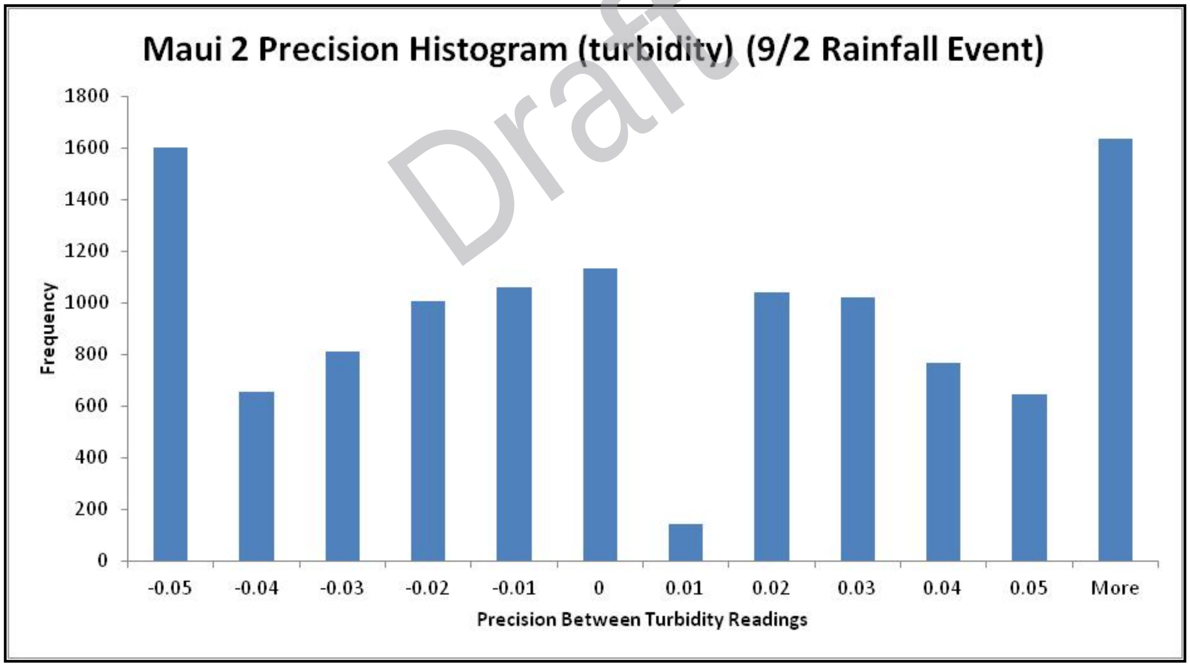


Figure 2.2.2-14. **Maui II Turbidity Histogram for 10/9 Rainfall Event**

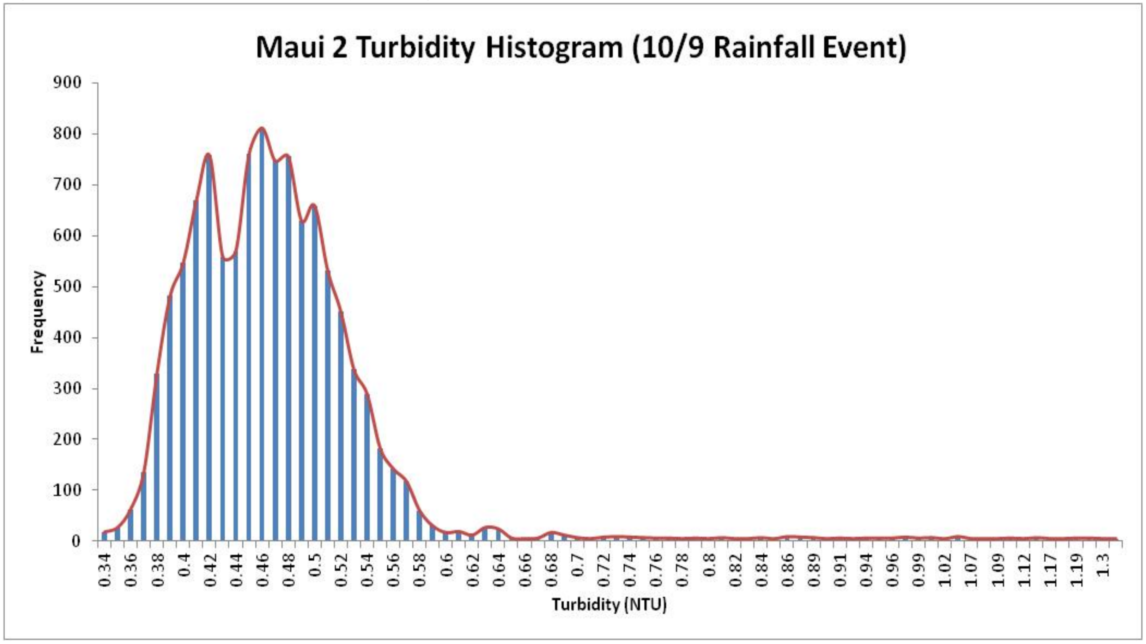
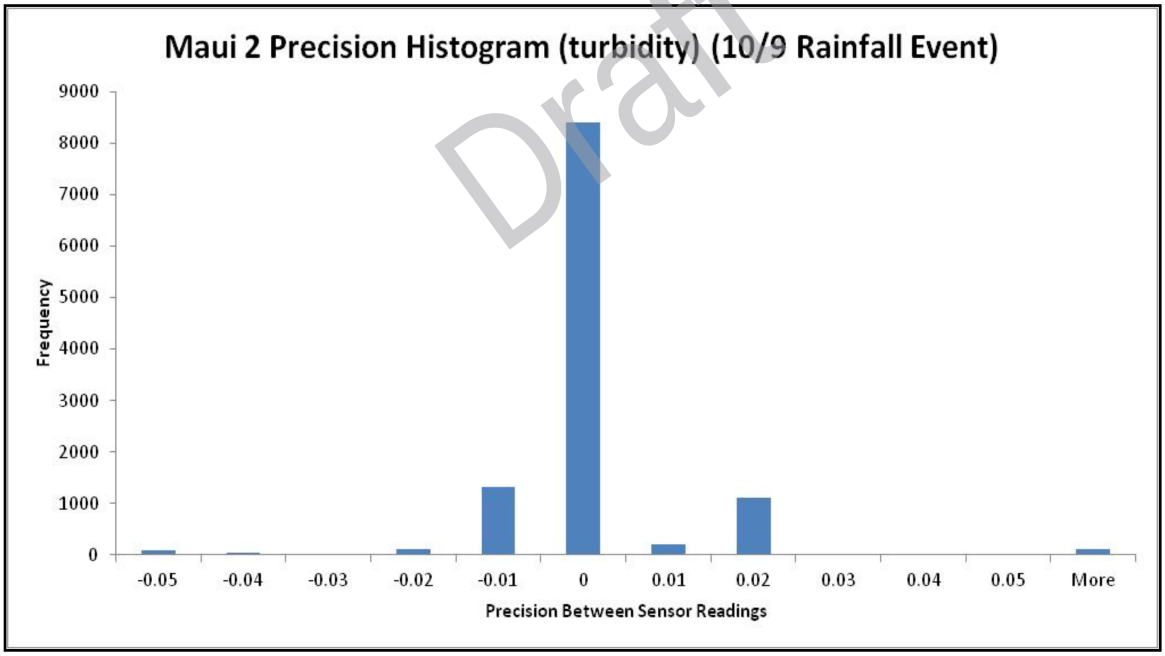


Figure 2.2.2-15. **Maui II Turbidity: Precision Histogram for 10/9 Rainfall Event**



GWUDI Phase I Final Determination

After reviewing the results from the Phase I GWUDi study for the Maui II well, the decision was that insufficient information had been collected to make a final determination. Due to the delay associated with the chlorine injection point relocation, the study lasted for 3 months instead of the proposed 6 months. Secondly, the collection of the required number of MPA samples was not accomplished. The recommendation was to continue the study throughout the 2013 rainy season.

GWUDI Phase II Investigation Methodology

Based on the inconclusive results from the GWUDI Phase I Investigation, U.S. Environmental Protection Agency Region IX and the CNMI DEQ requested that CUC perform additional work on the Maui II site that was previously evaluated.

Sampling Program

The sampling program for the GWUDI Phase II Investigation was conducted in accordance with the revised Quality Assurance Project Plan (QAPP). A summary of the sampling program is provided below.

Online Water Quality Monitoring

Continuous OWQM sampling for turbidity, conductivity, pH, and temperature was conducted throughout the GWUDI Phase II investigation. Sampling equipment specifications are located in the QAPP. Data were collected every 2 minutes for each water quality parameter and transferred using cellular communications to a central database. The central database was hosted in the CH2M Denver Data Processing Center, and information on water quality trends was available to all stakeholders using a web-based, encrypted dashboard.

Weather Station

Continuous data for rainfall and external temperature were collected at each of the stations. The data were manually collected monthly, processed, and presented during study update presentations with all key stakeholders.

Laboratory Data

The CUC Water Quality Laboratory conducted weekly total coliform and *E. coli* analysis for the Maui II well as part of the GWUDI Phase II investigation. The samples were collected either by the Efrain F. Camacho Engineers and Architects (EFC) GWUDI Field Team or the CUC laboratory staff. All sample collectors were trained on proper techniques by the CUC Laboratory Director.

Field Calibration Data

The frequency of field calibration data collection, described below, was in accordance with the QAPP.

Turbidity

- High drift (>0.3 NTU/week): Quality control (QC) readings were taken twice weekly (typically Tuesday and Friday) for the Maui II site. The Tuesday sample was used for instrument calibration.
- Stable (<0.3 NTU/week): QC readings were taken once weekly and used for instrument calibration.
- Very stable (<0.3 NTU/2 weeks): QC readings were taken every two weeks and used for instrument calibration.

pH

pH readings were taken either weekly or bi-weekly based on the turbidity testing program. The data were used for instrument calibration.

Conductivity

Conductivity readings were taken either weekly or bi-weekly based on the turbidity testing program. The data were used for instrument calibration.

Temperature

Temperature readings were taken either weekly or bi-weekly based on the turbidity testing program. The data were used for instrument calibration.

GWUDI Phase II Data Gathering Analysis

Data collection was conducted based on the approved QAPP during the GWUDI Phase II Investigation. During the GWUDI Phase I Investigation, the data collected from the MAUI II well were determined to be inconclusive and required an additional rainy season of study. In preparation for the Phase II GWUDI Study, the sensors were upgraded and a panel was installed. The improved OWQM system was started up on June 27, 2013. The station optimization and debugging was completed by mid-July.

Power Outages

The CUC Power Division did not record any power outages at Maui II during the GWUDI Phase II Investigation.

Maintenance Activities

The GWUDI Field Team maintained detailed records of any on-site or remote changes that were made at the station during the course of the investigation. This information is very important during the analysis of the data as it can often capture water quality v such as:

- Short-term water quality changes during maintenance operations
- Baseline water quality shift associated with cleaning and recalibration of the instruments
- Non-instrument related problems, such as unusual site conditions (i.e., unusual pump noises, flow reversals)

Table 2.2.2-9 provides detailed notes associated with all maintenance activities and site visits.

Table 2.2.2-9. **Maui II Maintenance Activities – GWUDI Phase II Investigation**

Date	Equipment Affected	Who	What	Why
6/27/13 9:40 a.m.	Software and Sensors	Ken Thompson/ CH2M, Brittany Baker/s::can, Efrain Camacho/EFC and Nicolette Villagomez/ EFC	Changed electron on pH probe, changed autobrush, changed i::scan, updated software to version 2.0, cleaned conductivity probe, cleaned filter, installed new Sim card, installed new software license, and calibrated all sensors. Downloaded rainfall data.	Phase II GWUDI Investigation Startup
7/5/13 8:15 a.m.	Software and Sensors	Efrain Camacho/EFC	Routine check.	Weekly Routine
7/10/13 7:34 a.m.	Software and Sensors	Efrain Camacho/EFC and Nicolette Villagomez/EFC	Downloaded rainfall data and cleaned i::scan, condu::lyser, and ise::lyser. Calibrated both pH and turbidity. Conductivity was well within the tolerance range. Connectivity displayed only two bars. Collected bacteriological sample at 8:51 a.m.	Weekly Routine

Table 2.2.2-9. **Maui II Maintenance Activities – GWUDI Phase II Investigation**

Date	Equipment Affected	Who	What	Why
7/16/13 8:44 a.m.	Software and Sensors	Efrain Camacho/EFC and Nicolette Villagomez/EFC	Downloaded rainfall data and cleaned all sensors. Added pH temperature to the values screen. Calibrated pH temperature, pH, and turbidity. Conductivity was within tolerance range. Connectivity displayed only two bars with VPN disconnected. Collected bacteriological sample at 9:14 a.m. NOTE: Temperature for QA/QC readings will from now on reflect pH temperature.	Weekly Routine
7/23/13 7:23 a.m.	Software and Sensors	Efrain Camacho/EFC and Nicolette Villagomez/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity displayed only two bars with VPN disconnected. Collected bacteriological sample at 8:16 am.	Weekly Routine
7/30/13 8:00 a.m.	Software and Sensors	Efrain Camacho/EFC and Nicolette Villagomez/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity displayed only two bars with VPN disconnected. Collected bacteriological sample at 8:16 a.m. NOTE: Noticed that cleaning device settings were changed from 60 seconds to 120 seconds for interval and from 10 seconds to 5 seconds for duration. We do not know whether we are saving it properly or it is being modified by another user.	Weekly Routine
8/6/13 8:04 a.m.	Software and Sensors	Efrain Camacho/EFC and Nicolette Villagomez/EFC	Downloaded rainfall data and cleaned all sensors. Connectivity displayed 2 bars with VPN connected. Calibrated all parameters. Collected bacteriological sample at 8:30 a.m.	Weekly Routine
8/13/13 8:20 a.m.	Software and Sensors	Nicolette Villagomez/EFC and Jordan Scott/EFC	Downloaded rainfall data and cleaned all sensors, including the empty cell. Connectivity displayed 2 bars with VPN connected. Calibrated all parameters. Collected bacteriological sample 8:45 a.m.	Weekly Routine
8/20/13 8:09 a.m.	Software and Sensors	Nicolette Villagomez/EFC and Jordan Scott/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity displayed 2 bars with VPN connected. Collected bacteriological sample at 8:33 a.m.	Weekly Routine
8/27/13 8:00 a.m.	Software and Sensors	Nicolette Villagomez/EFC and Jordan Scott/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. No connectivity. Collected bacteriological sample at 8:40 a.m.	Weekly Routine
9/4/13 7:45 a.m.	Software and Sensors	Nicolette Villagomez/EFC and Jordan Scott/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity was at two bars with VPN connected. Collected bacteriological sample at 8:05 a.m.	Weekly Routine

Table 2.2.2-9. **Maui II Maintenance Activities – GWUDI Phase II Investigation**

Date	Equipment Affected	Who	What	Why
9/10/13 8:00 a.m.	Software and Sensors	Jordan Scott/EFC and Vince Castro/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity was at two bars with VPN connected. Collected bacteriological sample at 8:20 a.m.	Weekly Routine
9/17/13 8:01 a.m.	Software and Sensors	Jordan Scott/EFC and Vince Castro/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity was at two bars with VPN connected. Collected bacteriological sample at 8:24 a.m.	Weekly Routine
9/24/13 8:10 a.m.	Software and Sensors	Jordan Scott/EFC and Vince Castro/EFC	Downloaded rainfall data and cleaned all sensors. Calibrated all parameters. Connectivity was at two bars with VPN connected. Collected bacteriological sample at 8:31 a.m. NOTE: Installed surge protector.	Weekly Routine
10/8/13 7:40 a.m.	Software and Sensors	Jordan Scott/EFC and Vince Castro/EFC	Calibrated pH. Connectivity displayed 3 bars with VPN connected. Collected bacteriological sample at 7:50 a.m.	Weekly Routine
10/15/13 9:57 a.m.	Software and Sensors	Jordan Scott/EFC	No calibration needed. Connectivity displayed three bars with VPN connected. Collected bacteriological sample at 7:50 a.m.	Weekly Routine
10/29/13 8:01 a.m.	Software and Sensors	Jordan Scott/EFC	No calibration needed. Connectivity displayed three bars with VPN connected. Collected bacteriological sample at 8:30 a.m.	Weekly Routine
11/13/13 9:16 a.m.	Software and Sensors	Jordan Scott/EFC	Calibrate pH. Connectivity displayed three bars with VPN connected. Collected bacteriological sample at 9:30 a.m. NOTE: There was a mechanical failure with one of the pumps that disturbed the water, causing high turbidity. Both the QA/QC and con::cube readings were fluctuating together, and turbidity was not calibrated as a result.	Weekly Routine
11/27/13 10:15 a.m.	Software and Sensors	Jordan Scott/EFC	No calibration needed. Connectivity displayed three bars with VPN connected. Collected bacteriological sample at 10:38 a.m. NOTE: Brush failure resulted in unusual readings. Brush was replaced and readings returned to normal.	Weekly Routine

Table 2.2.2-9. **Maui II Maintenance Activities – GWUDI Phase II Investigation**

Date	Equipment Affected	Who	What	Why
12/12/13 9:53 a.m.	Software and Sensors	Jordan Scott/EFC	Unable to calibrate on site due to the con::cube being unresponsive. Connectivity displayed three bars with VPN connected. Collected bacteriological sample at 10:13 a.m. NOTE: The new brush was not aligning properly causing the high turbidity. The brush is now working. Also, the con::cube was reacting very slowly and then not at all. The screen freezes and prompts the user to either "go back" or "restart the browser." It froze many times and unplugging it and plugging it back in was the only thing to get it to work. It was taking readings before departing the site. The dashboard of MAUI2 is just as unresponsive and very slow to load but it made it through to the calibration and pH was calibrated.	Weekly Routine
12/24/13 7:43 a.m.	Software and Sensors	Jordan Scott/EFC	No calibration needed. Connectivity displayed three bars with VPN connected. No sample taken. NOTE: Upon arrival the turbidity was reading normal ranges and the brush was working. Replaced the bristles with "P" bristles and replaced the desiccant pad.	Weekly Routine

Significant maintenance activities during the GWUDI Phase II Investigation included:

- Increase in i::scan cleaning frequency (July 30)
- Pump mechanical failure (November 13)
- Autobrush failure (November 27)
- Autobrush issues (December 12)
- “P” bristles installation (December 24)

Online Water Quality Monitoring and Weather Data

Continuous OWQM data were collected for turbidity, pH, conductivity, and temperature throughout the period of investigation. The station was considered to be collecting stable data after July 27, 2013 following installation, start-up, and minor optimization. The data were corrected for drift (turbidity), maintenance activities, and power outages. The most important parameters collected for determining GWUDI or treatment for microbes were turbidity and conductivity. The data for pH and temperature is available, but not included below in Figures 2.2.2-16 and 2.2.2-17, which displays several graphs of OWQM data.

Weather station data were collected continuously for rainfall and temperature throughout the GWUDI Phase II Investigation. Data were collected every minute at the station and rolled up to provide daily information for total rainfall and average temperature. The data are provided in biweekly graphs shown below in Figures 2.2.2-16 and 2.2.2-17.

Figure 2.2.2-16. Maui II Conductivity Data

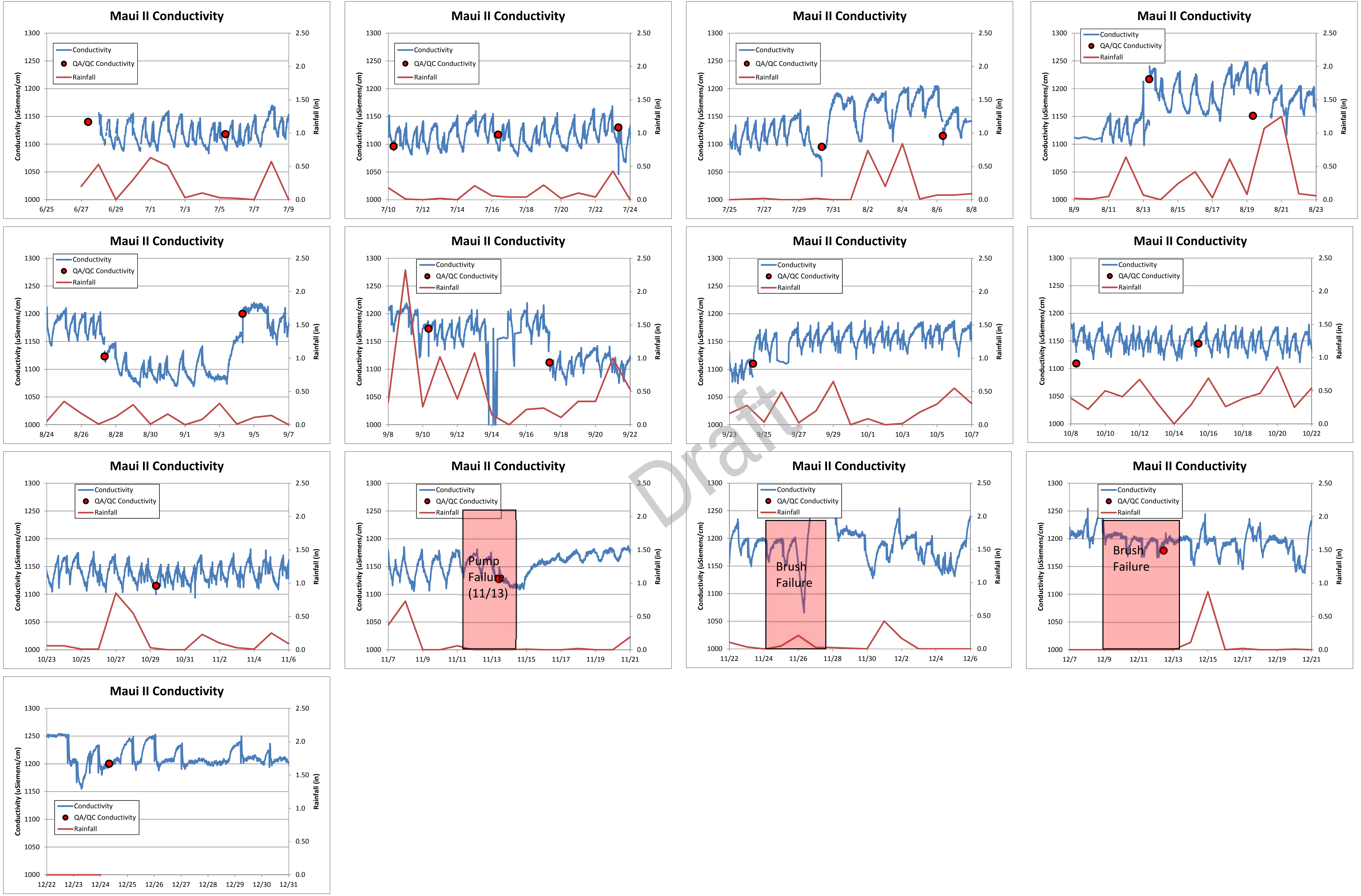
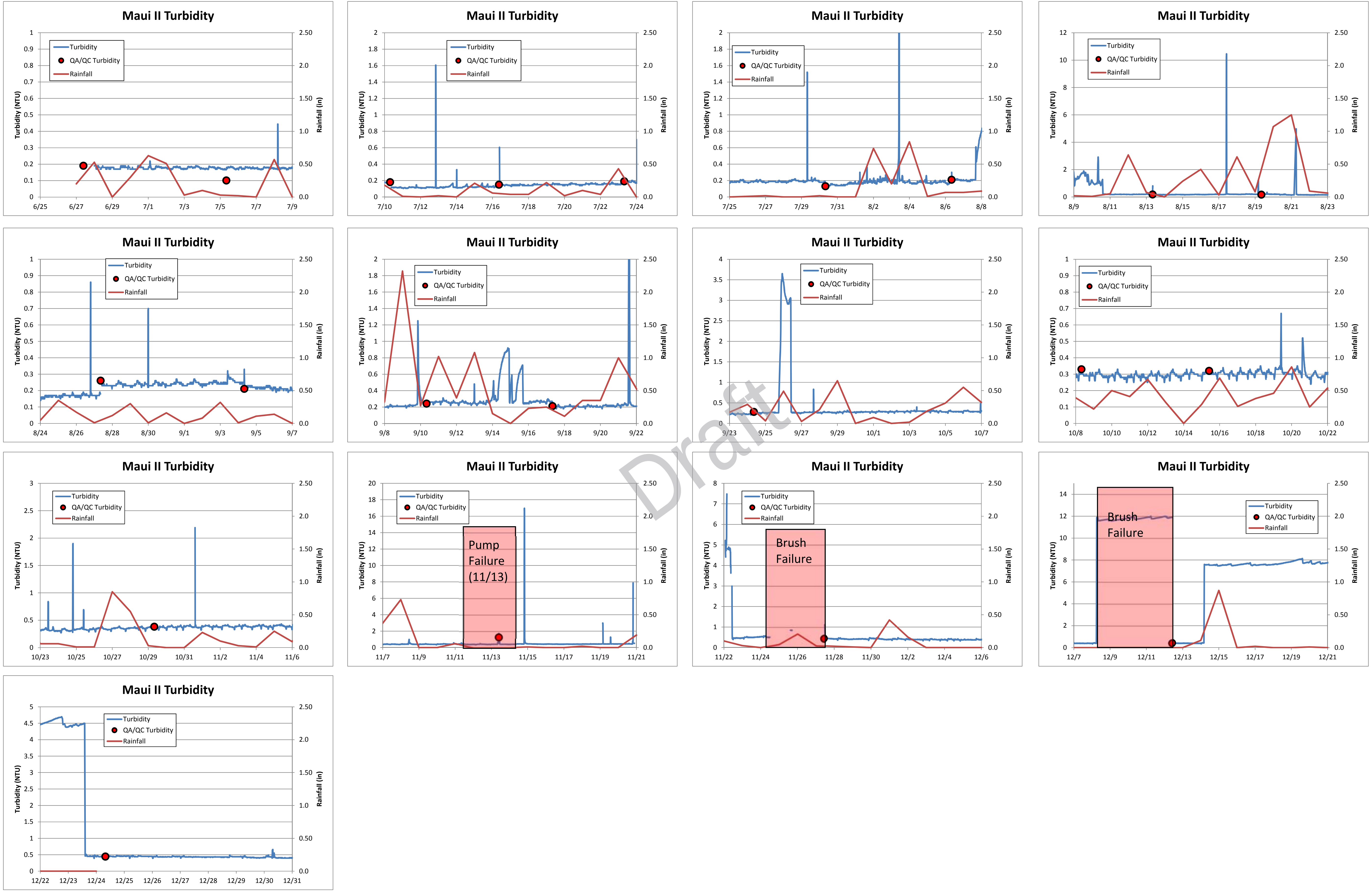


Figure 2.2.2-17. Maui II Turbidity Data



OWQM and Rainfall Data Discussion

Conductivity

Conductivity has a daily fluctuation of approximately 40 microSiemens, which is more than likely associated with temperature inside the building. Some slight drops were associated with rainfall events, but they were less than 10 percent of the reading, which is not significant.

Turbidity

The baseline turbidity for the Maui II well ranged between 0.1 to 0.3 NTU. During the largest storm on September 8, 2013 the turbidity spiked to 1.2 NTU. The turbidity also spiked to 0.9 NTU following three consecutive storms between September 8 and September 13. The turbidity remained above 0.5 NTU off and on for about 1½ days. This was the only extended spike during the 6-month study period other than a few associated with either a pump failure or brush failures that partially blocked the i::scan measuring pathway.

Rainfall

There was only one significant rainfall event over 2-inches during a 24-hour period, which occurred on September 8, 2013. Events that occurred over multiple days that were associated with a single storm approaching the 2-inch threshold were on July 1-2, August 2-4, September 11-13, and October 27-28.

Calibration Results

The frequency of calibration of the OWQM station at the Maui II site was conducted based on the requirements of the revised QAPP. During the period of the investigation the frequency was once weekly. Table 2.2.2-10 provides the calibration data collected for the station.

Table 2.2.2-10. **Maui II Calibration Data**

Date	Time	Sample Type	Conductivity (µS)	Turbidity (ntu)	Temperature (°C)	pH
6/27/2013	9:40 a.m.	QA/QC	1140	0.19	28.9	7.05
	10:11 a.m.	Post-calibration	1130	0.2	28.5	7.05
7/5/2013	8:10 a.m.	Pre-calibration	1088	0.189	28.3	6.93
	8:15 a.m.	QA/QC	1118	0.1	28.5	7.37
		Post-calibration	Did not calibrate, parameters within tolerance			
7/10/2013	7:34 a.m.	Pre-calibration	1096	0.18	28.5	6.91
	8:01 a.m.	QA/QC	1102	0.12	28.7	7.04
	8:45 a.m.	Post-calibration	1106	0.14	28.4	7.03
7/16/2013	4:34 a.m.	Pre-calibration	1103	0.111	28.6	7.06
	8:44 a.m.	QA/QC	1117	0.15	29	7.07
	9:26 a.m.	Post-calibration	1093	0.152	29	7.06
7/23/2013	7:46 a.m.	Pre-calibration	1123	0.168	29	7.06
	7:52 a.m.	QA/QC	1130	0.19	28.6	7.00
	8:17 a.m.	Post-calibration	1117	0.177	28.6	7.00
8/13/2013	8:15 a.m.	Pre-calibration	1146	0.193	29	7.13
	8:24 a.m.	QA/QC	1217	0.18	28.8	7.07
	8:50 a.m.	Post-calibration	1240	0.178	28.8	7.05
9/4/2013	7:51 a.m.	Pre-calibration	1161	0.244	28.3	7.06
	8:04 a.m.	QA/QC	1200	0.21	27.8	6.99

Table 2.2.2-10. **Maui II Calibration Data**

Date	Time	Sample Type	Conductivity (μS)	Turbidity (ntu)	Temperature (°C)	pH
	8:21 a.m.	Post-calibration	1189	0.22	27.8	6.99
9/10/2013	8:00 a.m.	Pre-calibration	1171	0.237	27.7	7.00
	8:14 a.m.	QA/QC	1173	0.24	28.2	7.02
	8:29 a.m.	Post-calibration	1168	0.243	28.2	7.01
10/8/2013	7:40 a.m.	Pre-calibration	1129	0.32	29.2	6.99
	7:46 a.m.	QA/QC	1109	0.33	28.1	7.07
	7:58 a.m.	Post-calibration	1151	0.31	28.2	7.07
10/15/2013	9:57 a.m.	Pre-calibration	1151	0.301	28.2	7.06
	10:05 a.m.	QA/QC	1145	0.32	28.4	7.09
	10:13 a.m.	Post-calibration	1142	0.295	28.2	7.06
10/29/2013	8:01 a.m.	Pre-calibration	1103	0.392	28.2	7.05
	8:12 a.m.	QA/QC	1115	0.38	28.3	7.1
	8:43 a.m.	Post-calibration	1118	0.372	28.2	7.05
11/13/2013	9:16 a.m.	Pre-calibration	1130	1.307	28.4	7.06
	9:27 a.m.	QA/QC	1128	1.28	28.3	6.99
	9:41 a.m.	Post-calibration	1150	0.95	28.3	6.99
11/27/2013	10:15 a.m.	Pre-calibration	1269	NA	28.3	6.95
	10:25 a.m.	QA/QC	1270	0.44	26.7	6.97
	11:33 a.m.	Post-calibration	1261	0.46	28.3	6.94
12/12/2013	9:53 a.m.	Pre-calibration	1195	11.93	28.2	6.95
	10:08 a.m.	QA/QC	1179	0.42	28.2	7.05
	10:36 a.m.	Post-calibration	1185	0.41	28.2	7.05
12/24/2013	7:43 a.m.	Pre-calibration	1192	0.439	28.2	7.05
	7:53 a.m.	QA/QC	1200	0.44	28.4	7.05
	8:08 a.m.	Post-calibration	1213	0.452	28.1	7.05

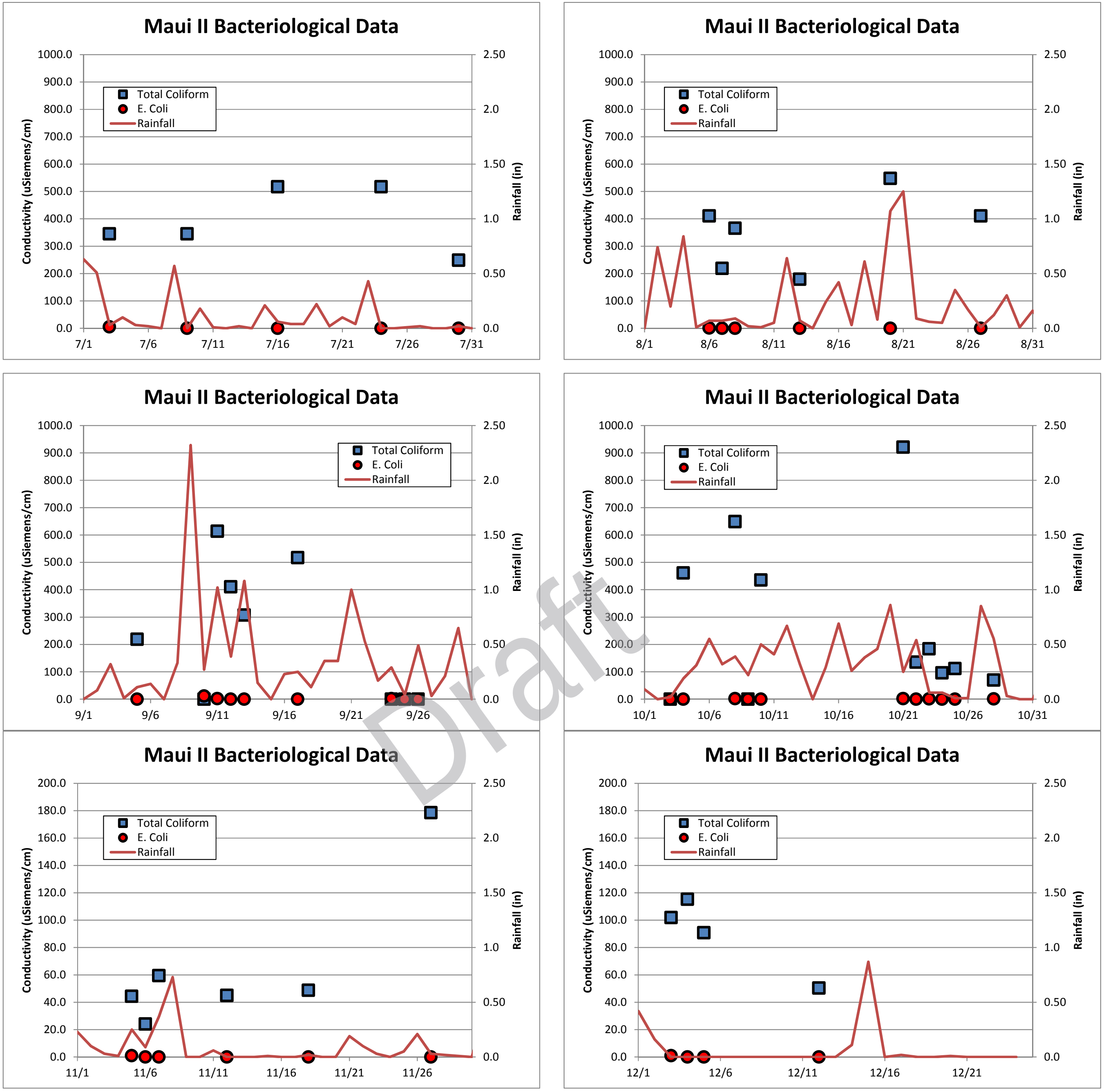
Bacteriological Results

Weekly bacteriological samples were taken for total coliform and *E. coli* during the course of the GWUDI Phase II Investigation. Table 2.2.2-11 and Figure 2.2.2-18 illustrate the results of the sampling.

Table 2.2.2-11. **Maui II Bacteriological Results**

Date	Total Coliform (colonies)	Date	E. Coli (colonies)	Date	Total Coliform (colonies)	Date	E-Coli (colonies)
7-24-13	517	7-24-13	<1	10-9-13	>2413.6	10-9-13	<1
7-31-13	248.9	7-31-13	<1	10-10-13	435.2	10-10-13	<1
8-6-13	410.6	8-6-13	**1**	10-21-13	920.8	10-21-13	**2**
8-7-13	218.7	8-7-13	<1	10-22-13	136.4	10-22-13	<1
8-8-13	365.4	8-8-13	<1	10-23-13	184.2	10-23-13	1
8-13-13	178.9	8-13-13	<1	10-24-13	95.9	10-24-13	<1
8-20-13	547.5	8-20-13	<1	10-25-13	111.9	10-25-13	<1
8-27-13	410.6	8-27-13	<1	10-28-13	69.7	10-28-13	**1**
9-3-13	218.7	9-3-13	<1	10-29-13	129.6	10-29-13	<1
9-10-13	>2419.6	9-10-13	**11**	10-30-13	46.4	10-30-13	<1
9-11-13	613.1	9-11-13	**2**	11-5-13	44.3	11-5-13	**1**
9-12-13	410.6	9-12-13	<1	11-6-13	24.1	11-6-13	<1
9-13-13	307.6	9-13-13	<1	11-7-13	59.4	11-7-13	<1
9-17-13	517.2	9-17-13	<1	11-12-13	45	11-12-13	<1
9-24-13	>2419.6	9-24-13	**2**	11-18-13	48.8	11-18-13	<1
9-25-13	>2419.6	9-25-13	<1	11-27-13	178.5	11-27-13	<1
9-26-13	>2419.6	9-26-13	<1	12-3-13	101.9	12-3-13	**1**
10-3-13	>2419.6	10-3-13	<1	12-4-13	115.3	12-4-13	<1
10-4-13	461.1	10-4-13	<1	12-5-13	90.8	12-5-13	<1
10-8-13	648.8	10-8-13	**2**	12-12-13	50.4	12-12-13	<1

Figure 2.2.2-18. Maui II Bacteriological Data



Bacteriological Data Discussion

Total Coliform

Forty samples for total coliform were collected during the Phase II GWUDI Study with values ranging from 45 to more than 2419.6 colonies.

Fecal Coliform

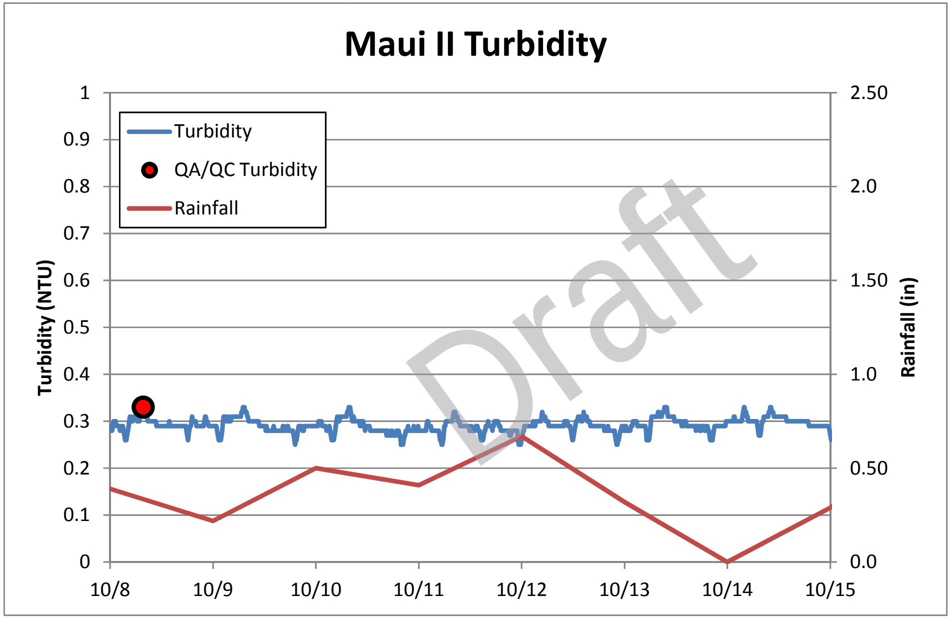
Forty samples for *E. coli* were collected during the Phase II GWUDI Study with eight positive samples. The positive samples included seven samples with counts between one to two colonies and one sample with a maximum value of 11 colonies. The highest *E. coli* value was associated with the largest rain event recorded during the season on September 8, 2013.

MPA Results

October 12, 2013 MPA Results

The graph of the turbidity and rainfall data associated with the MPA sampling period is shown in Figure 2.2.2-19.

Figure 2.2.2-19. **Maui II Turbidity and Rainfall Data**



The results of the MPA test for October 13, 2013 are provided in Table 2.2.2.-12.

Table 2.2.2-12. **Maui II MPA Primary and Secondary Bioindicators**

Type	Value	Type	Value
Primary Bioindicators			
Giardia	0 in 1624 L	Cryptosporidium	0 in 1624 L
Coccidia	0 / 100 gal	Diatoms	0 / 100 gal
Other Algae	0 / 100 gal	Insect/Larvae	0 / 100 gal
Rotifers	0 / 100 gal	Plant Debris	0 / 100 gal
Secondary Bioindicators			
Amorphous Debris	TNTC / 100 gal	Minerals	0 / 100 gal
Plant Pollen	0 / 100 gal	Nematodes	0 / 100 gal
Crustacea	1 / 100 gal	Amoeba	0 / 100 gal
Ciliates/Flagellates	0 / 100 gal	Other Organisms	0 / 100 gal

Based on the MPA test results the overall risk of surface water contamination was low, which is the primary criterion for whether a groundwater is under the direct influence of surface water.

GWUDI Phase II Investigation Summary

Some general observations that the team observed as part of the GDUWI Phase II investigation for all three islands were as follows:

Power Outages

Impacts

Backflow associated with power outages results in two types of water quality issues: turbidity excursions and elevated bacteriological levels.

Considerations

Evaluate and replace as necessary all check valves to ensure proper operations to protect the groundwater source from potential short-term contamination.

Chlorination Stations

Impact

Loss of continuous chlorination can have a negative impact on public health.

Consideration

Add continuous chlorine monitoring equipment with data and alerts sent back to the operations center. The GWUDI OWQM stations, with the addition of a chlorine sensor, can provide these data along with additional water quality parameters that are useful for operations.

Microbiological Sample Collection

Impact

Collecting samples from a tap that has been contaminated will cause extra work for operations and laboratory staff due to false positives.

Consideration

Either flame or disinfect the sample tap (based on sample tap material) before starting the sampling process.

MPA Results

The MPA results for the sample taken for the Maui II water source during the GWUDI Phase II Study demonstrated low risk for potential contamination associated with surface water. The MPA results are given the highest weight in the EPA criteria for the determination of whether groundwater is under the influence of surface water. With this understanding, it is also acknowledged that other concerns associated with turbidity excursions and elevated bacterial levels may require additional treatment or mitigation for some of the specific surface waters evaluated as part of the Phase II GWUDI Investigation on Tinian. These specific areas of concern are discussed below for the Maui II groundwater supply.

Category of Groundwater Sources

Evaluation of the results from the GWUDI Phase II investigation revealed three types of categories into which the twelve Saipan, Tinian, and Rota groundwater sources fit:

- **Category 1 – Non-GWUDI:** The majority of the groundwater wells, with the exception of Puerto Rico 164, fell into this category based on the results from the MPA analyses, OWQM sampling for turbidity and conductivity, and bacteriological analyses.
- **Category 2 – GWUDI:** Two of the groundwater sources fit into this category based on the direct relationship established between turbidity excursions and significant rain events. This is a borderline consideration because no MPA analysis showed any surface water indicator organisms and thus were considered to be low risk.
- **Category 3 – Non-GWUDI with Elevated Bacteriological Samples:** Three of the groundwater supplies fit this category and will require that reliable disinfection be in place and potentially a diversion scheme or automated shut down be implemented in the event of elevated turbidity excursions.

Maui II Category Type: Borderline GWUDI

Data Discussion

Maui II has a relatively high background of total coliform that is more than likely associated with the wildlife that inhabits the adjacent wetlands. Eight samples collected contained *E. coli* with seven of those samples having values between 1 and 2 colony-forming units. The one sample that has counts of 11 *E. coli* colony-forming units was associated with the largest storm event of the season, and the count dropped to 2 colonies within 24 hours and <1 colony within 48 hours, demonstrating the short-term effect of the storm. During the same storm event, the turbidity spiked to slightly over 1.2 NTU within 24 hours following the storm, and this level lasted for a couple of hours.

Considerations

Two possible options for the Maui II well to mitigate the elevated *E. coli* and short-term turbidity spikes include the following:

Treatment

Treatment is the most costly approach; an alternative analysis was conducted as part of Change Order 5 for the Master Plan. Based on the infrequent instances of elevated turbidity, this appears to be an expensive approach that will only provide value for a day or two for the entire year.

Operations Adjustment

The second option would be to install an operations protocol that would bypass the well into the wetlands when the turbidity exceeds 0.5 NTU (or another value agreed-upon with CNMI DEQ) and place the well back into the system when the turbidity drops below 0.5 NTU. This would require CUC to rehabilitate one or more of the deeper wells to supply water during these off periods.

GWUDI Phase II Final Determination

- EPA Region IX and DEQ staff provided their determination for the Maui II Well in a letter dated October 20l, 2014. The letter was titled, "Saipan GWUDI Determinations; Stipulated Order One; Paragraph 43 Additional GWUDI sampling on Saipan, Rota, and Tinian. Preliminary Injunctive relief (Civil Case No. CV 08-0051).
- The letter states, EPA and DEQ agree with CUC's assessment that Maui II ls borderline GWUDI based on the results from the MPA analysis, on-line water quality monitoring for turbidity and conductivity, and bacteriological analysis. Maui II has demonstrated low risk for potential contamination associated with surface water, although there was some evidence of total coliform likely associated with the wildlife that inhabits the adjacent wetlands during storm events.
- EPA and DEQ agree with CUC's proposal to mitigate the elevated *E.coli* and short term turbidity spikes by installing an operations protocol to bypass the well when the turbidity exceeds a certain threshold. CUC proposes that when turbidity exceeds 0.5 NTU, the well will bypass into the wetlands, and the well water will return into the system when the turbidity drops below 0.5 NTU. EPA agrees with this approach, however EPA believes that a level of 1.0 NTU may be more appropriate to avoid false positives. EPA also recommends CUC to switch to a Hach turbidimeter for this purpose. Additionally, for this operations protocol to function properly, it is essential that the calibration of the turbidity equipment be maintained. EPA suggests that CUC and DEQ develop additional protocols and reporting to ensure the turbidity meter is properly functioning at all times.

2.2.3 Water Distribution Hydraulic Model

Section 57 of the stipulated order requires a hydraulic capacity assessment of the CUC distribution system including sources, transmission lines, storage, pumps and booster pump stations, and distribution system lines. The model must be run at current conditions and with future population projections forecasted out 20 years with ensuring adequate quantity and pressure for 24-hour drinking water. Per the stipulated order the model must provide extended time (multiple-day) analyses of the drinking water systems' hydraulics.

This section of the Master Plan presents the water hydraulic model development, existing flow metering based on customer meters and well production flow meters, results of the water pressure metering, model calibration, existing water distribution system capacity analysis, booster pump station capacity review, and recommendations to improve the hydraulics, operations, pressure and capacity of the water distribution system. Information on the condition of the water assets may be found in Section 2.2.2, "Condition Assessment of Existing Water Facilities."

Discussion and analysis on the ability of CUC to provide 24-hour water is presented in this Section. The overall cost for the recommended improvements is presented in Section 4.3.2 of this Master Plan.

Modeling Software

The new hydraulic modeling platform that was selected for use with Tinian's water system was WaterCAD since CUC already had the software platform in-house. Prior to the Master Plan project there was no hydraulic model developed for the Tinian water system.

Base Map/Model Development

An existing water system base map prepared and maintained by CUC engineering was available for use during the modeling. A comprehensive GIS database was built using the CUC base map. The entire island of Tinian was modeled as one system (e.g. the model was not broken into smaller basins). Prior to model development a hydraulic profile was developed. A copy of this profile is provided in Appendix E. The model inputs are provided in Appendix F. The model input summary provides the following:

- Number of junctions
- Pipe sizes and lengths
- Number of tanks, pumps, and PRVs

Distribution System

Water pumped from the primary and only water supply, the Maui II Well, is transmitted to the Half Million Gallon Tank (HMT) located in the Carolina Homestead. The water line between the pump station and HMT serves customers and therefore is considered a distribution line. These customers are labeled as direct feed customers. The model developed for Tinian is therefore both a transmission and distribution system model.

Asset Inventory

The project team conducted an asset inventory of all water booster stations, water storage tanks, and PRVs (August to December 2011). Data collected as part of this asset inventory was used to assess the condition. Information collected during the asset inventory was also used in the model development. Prior to model development, the project team got a debrief of the water system through the asset inventory workshops conducted with CUC. Information on active and inactive tanks, PRV settings, pump station operations, as well as control operations was collected and discussed and is reflected in this Master Plan

Tank Service Areas

For the distribution system model, Tinian's water system was divided into “tank service areas” similar to the “sewersheds” characterized in the wastewater collection system hydraulic model. There are two Tank Service Areas (TSAs) located within Tinian, though hydraulically they are operate as one. Appendix G includes a map with the TSAs within the Tinian water distribution area. Table 2.2.3-1 presents a list of the TSAs located within Tinian.

Table 2.2.3-1. **Tank Service Areas, Tank Size, and Finished Elevations**

Service Area	Tank Material and Size	Tank Finished Elevation (ft)
Carolinas and San Jose TSA (HMT)	Steel 0.5 MG	404
Marpo TSA (QMT)	Steel 0.25 MG	338

Carolina's and San Jose TSA

The Carolina's and San Jose Tank Service Area provides water to the Carolinas Homestead, San Jose village, Tinian Dynasty and the southern end of the island. This TSA has one 0.5MG storage tank. Water is supplied to this TSA through the Maui II well. There are two PRVs that set the hydraulic grade in this TSA.

Marpo TSA

The Marpo tank service area provides water to the Marpo Homestead and to the Tinian airport. This TSA has one 0.25MG storage tank. Water is supplied to this TSA through the Maui II well.

Hydraulic Profiles

The project team conducted several meetings with CUC operations and engineers during the development of this profile. Feedback from DEQ personnel was also received. The profiles show the following:

- Hydraulic grade of the storage tanks
- Elevation of major demand areas
- Wells within TSA
- Simple schematic of the Transmission and Distribution Lines
- Major PRV, PSV and isolation valves
- Major Pump Stations
- Chlorine Injection Points

This profile used to build the new system water model. Appendix E includes the hydraulic profile for both TSAs.

Water Meter and Well Production Data

The project team collected and reviewed water meter and production data for October through December of 2011 through March 2012.

CUC uses a system of meter reading routes for customer billing and these sources of data were used to reflect system demands.

CUC collects production data from the well supply monthly. These data are tabulated monthly and used to reflect system production. The project team reviewed these data for September, October and November 2011. The Maui II well production data varied from month to month based on system demands. Table 2.2.3-2 presents a summary of the water meter and well flow data.

Table 2.2.3-2. **CUC Production and Meter Data October 2011 through March 2012**

Month-Year	Monthly Billing Gallons	Production Gallons	Daily Billing (gal)	Daily Production (gal)	Average Billing GPM	Average Production GPM	% Un-metered
Oct-11	7,191,030	24,549,900	239,701	818,330	166	568	71%
Nov-11	7,673,927	25,211,800	255,798	840,393	178	584	70%
Dec-11	7,567,859	27,854,200	252,262	928,473	175	645	73%
Jan-12	7,380,133	29,859,600	246,004	995,320	171	691	75%
Feb-12	7,354,985	30,340,400	245,166	1,011,347	170	702	76%
Mar-12	6,910,581	30,020,300	230,353	1,000,677	160	695	77%
Average	**7,346,419**	**27,972,700**	**244,881**	**932,423**	**170**	**648**	**74%**

Additional water production and billing information was provided by CUC for November 2013 through December 2014 (Table 2.2.3-3).

Table 2.2.3-3. **CUC Production and Meter Data November 2013 through December 2014**

Month-Year	Monthly Billing Gallons	Production Gallons	Daily Billing (gal)	Daily Production (gal)	Average Billing GPM	Average Production GPM	% Un-metered
Nov-13	9,872,458	38,304,000	329,082	1,276,800	229	887	74%
Dec-13	9,803,380	44,451,200	316,238	1,433,910	220	996	78%
Jan-14	12,129,372	44,451,400	391,270	1,433,916	272	996	73%
Feb-14	10,858,085	40,143,000	387,789	1,433,679	269	996	73%
Mar-14	13,471,495	38,150,300	434,564	1,230,655	302	855	65%
Apr-14	6,650,370	43,283,300	221,679	1,442,777	154	1,002	85%
May-14	9,550,233	39,635,300	308,072	1,278,558	214	888	76%
Jun-14	9,668,230	41,731,700	322,274	1,391,057	224	966	77%
Jul-14	8,776,423	41,770,100	283,110	1,347,423	197	936	79%
Aug-14	9,483,706	39,464,500	305,926	1,273,048	212	884	76%
Sep-14	8,217,381	37,435,700	273,913	1,247,857	190	867	78%
Oct-14	7,244,897	38,361,000	233,706	1,237,452	162	859	81%
Nov-14	13,201,855	39,318,800	440,062	1,310,627	306	910	66%
Dec-14	10,965,066	38,920,300	353,712	1,255,494	246	872	72%
Average	9,992,354	40,387,186	328,671	1,328,089	228	922	75%

The water production and water-billed values did show an increase when compared to 2011. However, the ratio of water produced to water billed still averages a 75-percent loss, consistent with the findings in 2011.

Pressure Data

The project team used the Environmental Data Services (EDS) pressure loggers in the Saipan CUC water system. The pressure loggers all failed as a result of the negative pressures logged in the Saipan water system. As a result these meters were not available for use in Tinian.

Calibration

The water demand and water production used in the models were based off of existing meter data and well production data, respectively.

Water Balance

To run a meaningful EPS, the continuity principle must be satisfied. Simply put, the continuity equation stated the following:

Change in storage = [Inflow – Outflow] X Time

While this relation appears simple, it is crucial in calibrating a water model. If too much inflow is provided, the model will yield erroneous pressure results. This may be not seen if one runs the model for a short period of time (e.g. one or two days), as the storage within the system can mask the results. This can be seen with the EPS results.

Balancing the system is an iterative process, it starts with the known inflow and demands. As stated earlier there is 74 percent unaccounted-for water. This makes accurately balancing the model a difficult task. Additional demand was placed at agricultural areas and areas known to have older leaky pipes. Table 2.2.3-4 presents the daily inflow and outflow used for each TSA.

Table 2.2.3-4. **CUC Demand versus Model Inflow**

Service Area	CUC Average Production Data (gpm)	Average Model Inflow (gpm)	Percent Difference
HMT TSA[a]	648	422	34%
QMT TSA[b]	-	-	-

[a] A large amount of water is lost through the constant overflowing of the QMT. This loss is estimated to be between 100 and 150 gpm.

[b] Water consumed in this TSA is supplied via the HMT. Demand and production were all lumped into the HMT TSA.

Once the model results indicate a smooth diurnal pattern and the amount of inflow and outflow are balanced with the data provided, the model is considered calibrated with respect to flow.

Pressure Balance

In the absence of field pressure logging data, a theoretical model was run. This is the approach used for modeling a new undeveloped project. Engineering judgment and discussions with CUC operations was done to validate the model results.

Model Assumptions

The following assumptions were made in the development of the water model:

- The models were developed using CUC water system base map and a review of CUC as-builts.
- The models were calibrated using 2011-2012 Maui II well production data and CUC customer meter data. It is assumed that the 2011-2012 data is representative of ‘existing conditions’ for Tinian's water service area so there have not been any significant leak prevention programs occurring on Tinian.
- The existing condition models are intended to be used for high-level master planning purposes. The models are not intended to perform spot inspection at individual households. Each node in the model represents a cluster of demands; as such it does not reflect each and every costumer that CUC has.

- The model assumes that the metered water demand is distributed evenly throughout the TSA. This assumption may in some cases place a higher or lower demand in areas. Without pressure data, it is difficult to fine tune distribution of demand between water meters. It should also be stated that the customer metered flow only represents about 30 percent of the water produced.
- The model's default friction valves for PVC, DIP and ACM were used. In reality, these values vary and can change over time, but were held constant at the default model values for the purpose of this conceptual level modeling effort. These values can be updated in the future if additional data collected by CUC indicates that other values would be more accurate for the water system analysis.
- Water demand data was only available for 30 percent of the water system. The model was calibrated based on an approach where the system demand was forced to match the well production data. To meet this mass/flow balance requirement, water demands were inferred/estimated for nearly 70 percent of the system.

Data Gaps and Potential Sources of Error

With any modeling effort, it is important to capture the data gaps and sources of potential error in the model so that the model accuracy can be improved upon over time and so that model results can be interpreted within the context of the quality of the input data. The following summarizes some of the data gaps and potential sources of error for the modeling effort:

- As can be seen from Table 2.2.3-2 and Table 2.2.3-3, the amount of unaccounted for water (un-metered water) is extremely high, with an average of over 70 percent un-metered water island-wide.
- This difference between produced water and metered water posed a challenge for hydraulic modeling. The project team distributed the metered demand within the two tank service areas, but was still left with an additional 70 percent (or 4,825 gpm) of water to distribute. The following assumptions were used to distribute the water demands in the hydraulic model:
  - Agricultural uses are not completely metered throughout Tinian and some agriculture areas are billed based on a flat usage rate, making determining the agricultural demands challenging. Current aerial photographs were used to identify where agriculture use exists. An agricultural land use demand was applied to the model node closest to the identified agricultural areas. The actual water demands applied to the agricultural node were based on the size of the area of agricultural land use, engineering estimates of agricultural water demands and an iterative process of balancing water demand and production.
  - Leakage through existing/aged infrastructure account for some fraction of the overall water loss. Additional "fake" demand nodes were placed at nodes in areas known to have aging water supply infrastructure in order to account for water loss via leakage.

Metering data is limited and there are errors in the flow meter data collection process. This is evident through frequent meter failure.

Existing Model

In any modeling undertaking, the static condition must first be understood in order to properly gage the existing water system. In reality, water systems are constantly changing based on demand and inflow. The static condition assumes that the demand and inflow is held constant for an instantaneous moment. This snap shot allows the modeler to evaluate hydraulic grades to see if they are consistent with measured and theoretical field conditions. The industry movement is toward integrating real-time sensor data into the system model to improve real-time system operation knowledge.

Existing Model – Extended Period Simulations

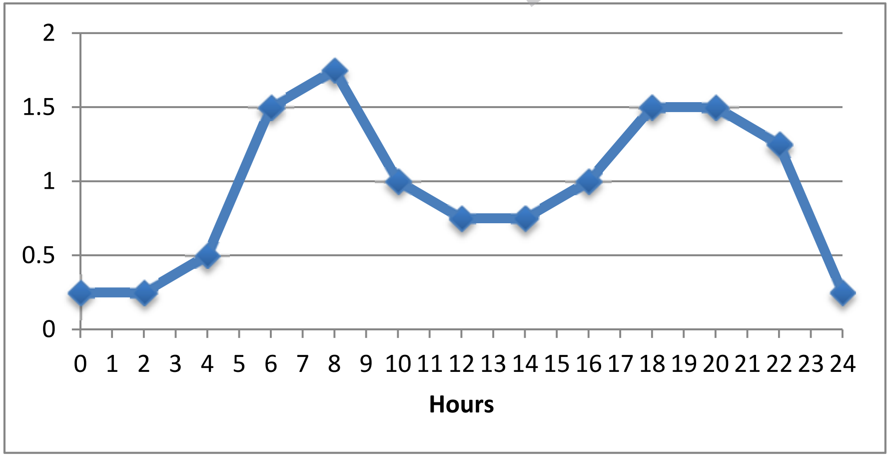
Once the static condition is set, the modeler may begin to analyze the model under an extended period simulation (EPS). Such a condition is critical for mass balance. The static analysis does not analyze the inflow verses outflow. This is critical in evaluating a water system. An EPS helps set the following:

- Mass balance between the inflow and outflow is essential for model calibration. As discussed earlier, there is upwards to 70 percent of unaccounted for water. If one does not account for this in the model then actual head losses and water balance will be not be correct. Further discussion on this is provided under model calibration.
- It is not possible to fully calibrate a water model unless there is some change in condition. For the purposes of this analysis the project team used pressure as the variable. The nature change in system pressure resulting from demand was used to calibrate the model. Since pressure data wasn't available for this modeling exercise, this is an area of the model development that should be improved upon as time goes on.

Diurnal Patterns

To run extended period simulation diurnal patterns are needed. Typical diurnal pattern for residential uses have two peaks: one in the morning and one around 6pm. In order to generate a residential diurnal demand pattern for the model, the project team used the approach outlined in the Saipan Drinking Water Master Plan. Wastewater flow leading to Saipan's Tottotville sewer pump station was measured over one week and the daily trend was extracted. It was assumed the wastewater diurnal curve tracked closely with residential water demand. Tottotville was chosen as it is on 24-hour water service and is a relatively newer subdivision with majority residential use. Figure 2.2.3-1 presents the residential diurnal patter developed.

Figure 2.2.3-1. **Residential Diurnal Pattern**



This pattern was applied to all residential uses within Tinian. Other diurnal patterns include the following:

- Commercial and government patterns assumed demand during working hours with peaks occurring at noon. Low to no flow was assumed during the early morning hours.

Fixed (continues flow) demand patterns were used for areas suspected of having heavy water loss through leaks, agricultural use, and possibly poorly functioning meters.

Future Distribution Model – Extended Period Simulations

The model results shown below are for the distribution system which consists of the distribution water lines serving CUC customers. This includes the 2 system water tanks.

Correction of the constant overflow of water from the QMT results in a 100-150 gpm reduction in demand. This reduction may be considered a reserve and be allocated for future needs. The amount of pump time at the Maui II well will be reduced once the overflow at the QMT is corrected. This will result in power savings to CUC.

The model demands used in the EPS model runs reflect a maximum water production of 1MGD. This production is larger than the 2030 water demand projections and therefore representative of future distribution and transmission system conditions.

Results

Distribution System

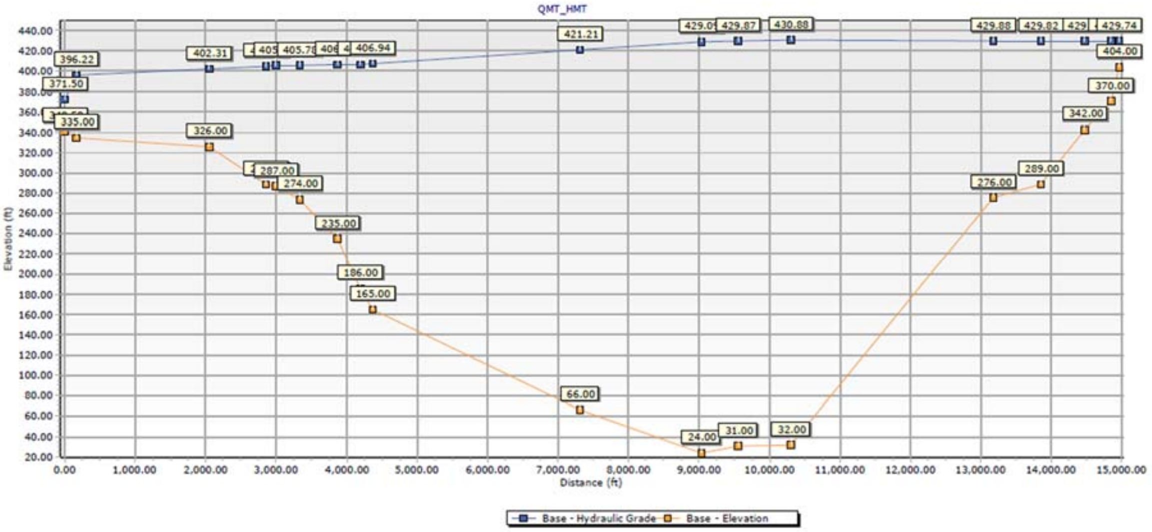
The following sections provide important findings based on the existing model analysis. Copies of additional profiles generated through the existing model can be found in Appendix H. All models were run for 5 days. The results shown below represent a snapshot in time where a notable observation was made. The profiles shown below include the ground elevation, hydraulic grade line (HGL), elevation and discrete elevations.

Flow from HMT to QMT

The hydraulic profile in Figure 2.2.3-2 indicates that water is flowing to the QMT from the HMT. The HGL slope increases as it reaches the QMT and then has a sharp drop once is gets to the QMT. This indicates that the HMT is setting the grade, but the QMT is pulling it down. This is confirmed in the field where one can observe the QMT constantly overflowing.

CUC operators attempt to mitigate this overflow by choking the gate valve at the dormant Maui I well site. This procedure does not offer control for the wide range of flows seen in a typical day.

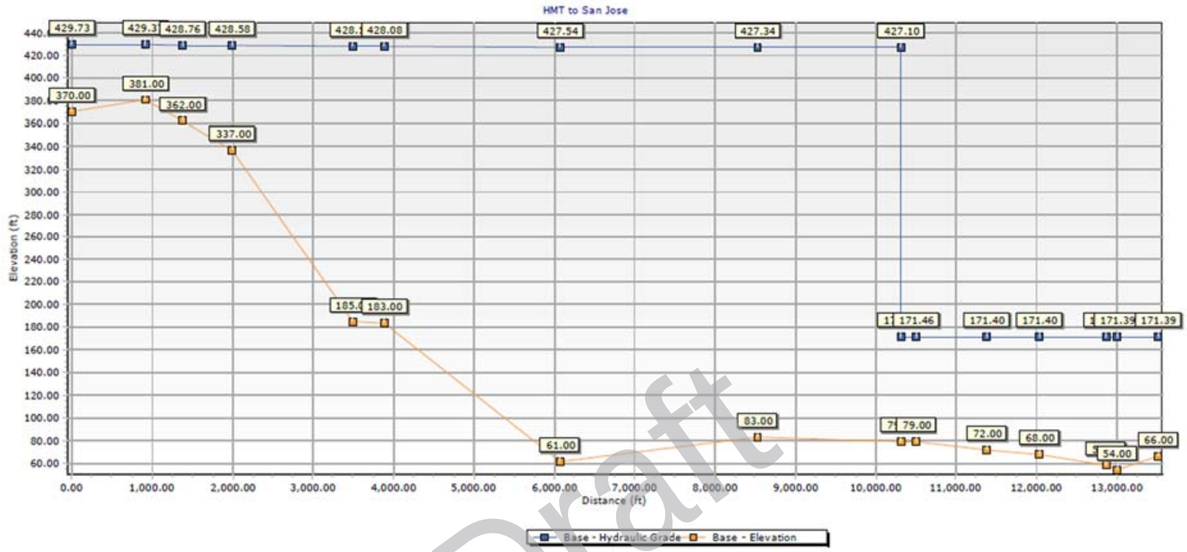
Figure 2.2.3-2. **Model Output of HGL from HMT to QMT**



Flow from HMT to San Jose Village

There is a PRV that sets the HLG to the San Jose Village; the hydraulic profile for this portion of the distribution system is shown in Figure 2.2.3-3. This villiage is the most populated village with over 60 percent of the population situated in San Jose. This is where the bulk of the meterd water demand is sent. Flow there comes from the HMT, which is fed from the Maui II pump station. A 250-foot drop in the HGL is needed to provide pressure to the San Jose Village. This is more than half of the total HGL of 420 feet. More than half of the power is spent by cutting the HGL at the PRV. The folllowing profile illusrates this.

Figure 2.2.3-3. **Model Output of HGL from HMT to San Jose**



Recommendations

Flow from HMT to QMT

A short term correction to the constant overflow from the QMT is to install a pressure-control valve that is operated by the pressure grade in the QMT TSA. This valve will automatically control the inflow to the QMT TSA. The long-term correction for this is to simply remove the QMT from CUC system and allow the HMT to serve the Marpo area. Model results indicate that the pressure would increase in this area, but would still be within the criteria set forth in this master plan.

HGL from HMT to San Jose

The current system is operating in an acceptable condition. However, there is signifact power savings that can be had with the following upgrades. The intent is to set a new HGL for San Jose at a new Tank and new TSA. The following will be needed for this upgrade:

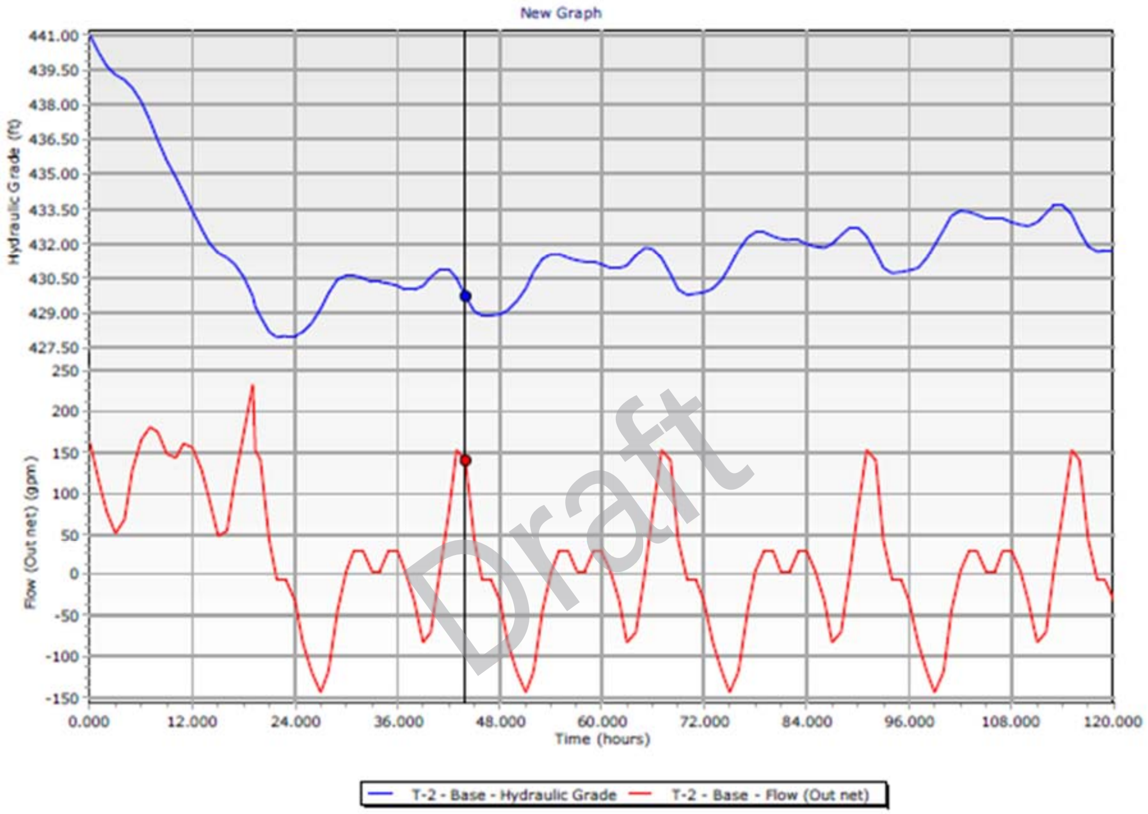
- New 0.5MG tank at elevation 180 feet to serve San Jose and surrounding terrian.
- Approximatly 6,000 feet new 8-inch Transmission line to serve both the existing HMT and the new San Jose tank. New Altitude valves will be needed at each tank.

This is a suggestion for future power savings. This project might qualify for energy efficient grants. Appendix G presents the TSA configuration for the existing system; Appendix I presents the proposed future TSAs associated with the suggested upgrade.

Storage Analysis

Figure 2.2.3-4 presents the hydraulic grades, inflow and outflow from the storage tanks used in the Tinian water distribution system. The results shown below are for 5 day runs. In some cases, it took 24 hours for the model to balance. This is due to the initial elevation condition of the tank. Discussion on each tank operating condition is also provided. Refer to the 20-year flow projections included in Section 3.2 for more information future tank sizing. The Commonwealth Ports Authority (CPA) owns and operates the airport storage tank. This airport tank was not part of this analysis.

Figure 2.2.3-4. **HMT Tank Hydraulic Grade and Inflow/Outflow**

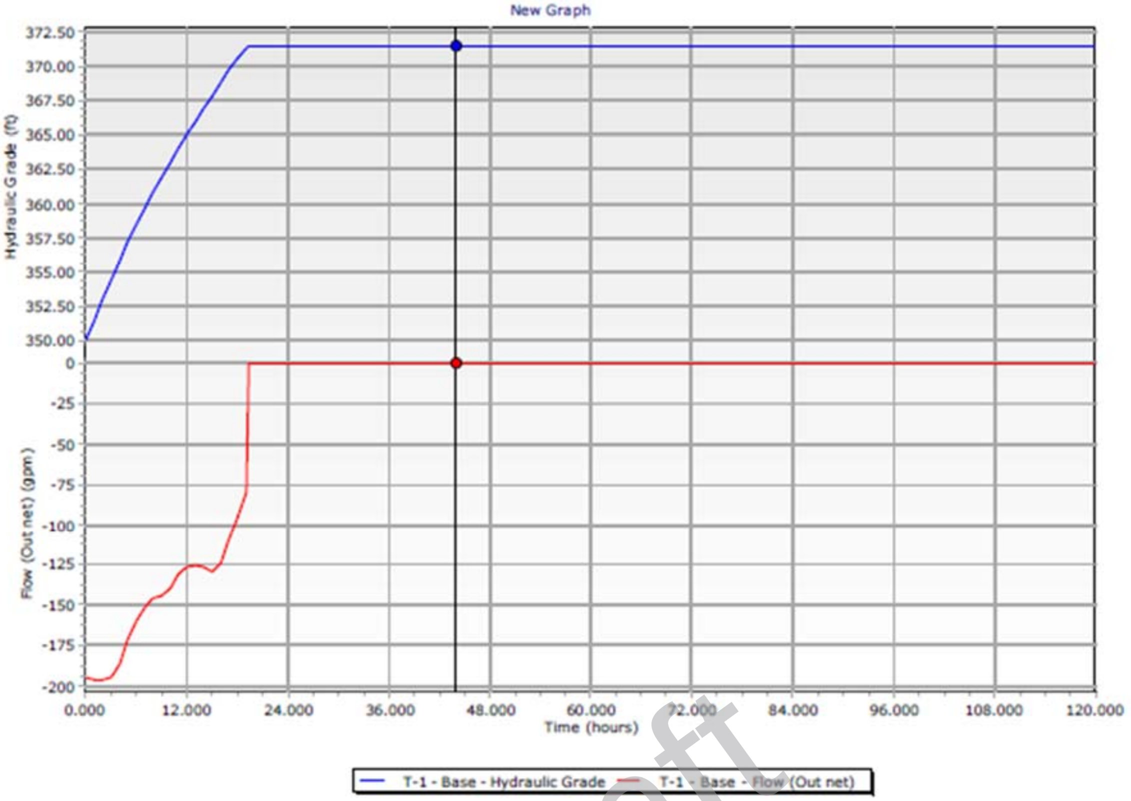


The HGL of the HMT ranges between 428 ft to 433 ft. The finished grade of this tank is 404. The increase in HGL indicates that there is a slight imbalance in the model; too much water is being input to the model. The results generated are stable and match the field conditions observed during the site assessments. The size of this tank is adequate for the TSA.

QMT

The HGL of the QMT tops off at 372, the maximum setting in the model for the QMT. The finished grade of this tank is 338. This indicates that too much water is sent to this tank and that overflow can be expected. This is the observed condition of this tank. Based on this graph approximately 100 gpm is discharged from this tank constantly. An overflowing tank indicates that the system controls are not working and/or the tank is not at a correct grade for the TSA configuration. Recommendation provided earlier addresses this modeled condition.

Figure 2.2.3-5. **QMT Tank Hydraulic Grade and Inflow/Outflow**



Water Transmission System

Water pumped from the primary and only water supply, the Maui II Well, is transmitted to the Half Million Gallon Tank (HMT) located in the Carolina Homestead and there are customers taking water along the way

Booster Pump Station

The Maui II water booster pump station is located in the Marpo wetlands area. These booster pump stations are used to transmit water from the Maui II well to the HMT TSA.

The Maui II pump station was installed in 1997. According to the plans reviewed, this pump station was designed with four 350 gpm, axial-type pumps each with a TDH of 526 feet. Table 2.2.3-5 summarizes the data that were used to model this pump station.

Table 2.2.3-5. **Summary of Data Used for Modeling Pump Station**

Wet Well	0	ft	Static Head	435.00	ft
Distribution Tank Elevation	435	ft	Design Flow	350.00	gpm
Transmission line size	8	in	Friction	24.93	ft
Transmission Line Length	4800	ft	TDH	459.93	ft
Material Type	PVC		Velocity	2.23	ft/s

This pump station is operated on the level of the HMT and one pump is continuously run with a second that comes online during peak demand. The design flow for each pump is 350 gpm at 526 feet of head. The model flow of 422 gpm is the equivalent of one pump operating with a second operating for short durations (between 1 and2 hours). The model results have a lower TDH than the pump was designed for. It is likely that the existing pump is pumping more than the design flow and no upgrades or replacement of the pump is needed.

Recommendations

- A short term correction to the constant overflow from the QMT is to install a flow control valve which is operated by the pressure grade in the QMT TSA. This valve will automatically control the flow to the QMT TSA.
- The long-term correction to the constant overflow from the QMT is to remove the QMT from CUC system and allow the HMT to serve the Marpo area. Model results indicate that the pressure would increase in this area, but would still be within the criteria set forth in this master plan.
- The current system is operating in an acceptable condition. However, there is signifact power savings that could be realized if the system configuration was modified. If a new HGL for San Jose was set at a new Tank. The following will be needed for this upgrade:
  - New 0.5MG tank at elevation 180 ft to serve San Jose and surrounding area.
  - Approximatly 6000 ft of new 8-inch transmission line to serve both the existing HMT and the new San Jose tank. New altitude valves will be needed at each tank.

Path Forward

The model files will be turned over to CUC together with GIS files. These tools must be updated and used on a regular basis. New and additional information may be placed in the model and analyzed by CUC planners and engineers. Future system modifications and optimization can be evaluated with the use of the model and GIS tools. The model developed for this Master Plan is not all inclusive. Improvements to water demand, diurnal curves and friction value inputs will increase the accuracy of the model for ongoing use.

2.2.4 Water System Infrastructure Geographic Information System

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 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 Master Plan preparation provides for the development of a GIS of CUC drinking water and wastewater systems.*

The GIS developed under this Master Plan work for CUC water systems on Saipan, Tinian, and Rota provides the following products:

- Existing water system facilities information in GIS format for Saipan, Tinian, and Rota featuring the location, layout and inventory with photos of water wells, storage tanks/reservoirs, transmission lines and appurtenances, pump stations, and distribution lines and appurtenances based on available documentation and data obtained from field investigation.

- 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 Desktop, Version 10.1 containing the above information with appropriate GIS layers as described below.

The completed GIS will yield the following byproducts:

- The capability to identify, catalog, and track geo-referenced components of the water system(s) graphically and/or by tabulation according to location, function, type, material composition, size, and capacity.
- 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 water systems.
- Provide data and support in the preparation, update, and operation of computerized water 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 water system Tank Service Areas (TSAs).

The GIS program is intended to be managed, operated, maintained, and updated by CUC personnel as part of the obligations for the project; designated CUC personnel have been trained in the operation, maintenance, and use of the GIS. Organizational recommendations are discussed under Section 3.5, "Assessment of Current CUC Management Policies, Procedures and Operating Rules and Regulations for Water and Wastewater Systems."

GIS Input and Mapping Methodology

Available Data

Drinking water 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 Desktop 10.1 to create an editable geodatabase as follows:

- Digitized or plotted if in hard copy/document format
- Imported into the GIS platform if in compatible electronic drawing format
- Converted into compatible electronic drawing format and then imported into the GIS platform

Dueñas Camacho & Associates, Inc. (DCA) had developed preliminary GIS databases in tabular and graphic format of a large portion of existing CUC water 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 database resulting from the desktop effort was validated and corrected to the extent possible by actual field surveys.

The CNMI water system geodatabase was created from AutoCAD-based maps provided by CUC. The imported water system data included annotations, point and polyline features in CAD format already in the native 1966 Mariana Islands (MI) Coordinate System spatial reference. *Data fields conforming to water system features were established as part of the data importing effort*. Water system features were identified and categorized to populate the fields with data derived directly from the CUC drawings. Archive images (dated 8/17/11) containing scanned drawings of CUC water systems were geo-referenced and used to update the water system geodatabase at the start of the master planning effort.

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 J.

Field Verification of Water Infrastructure Appurtenances

The location of major water infrastructure appurtenances that are visible must be geographically referenced to ensure accurate representation. The scope of work required that visible major water and wastewater system components on the islands of Saipan, Tinian, and Rota be field-located/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:

- Fire hydrants
- Major water control valves
- Water wells
- Water reservoirs

The surveys included taking photographs of aboveground water system features.

Field Survey Equipment

Field surveys were conducted using the Ashtech Mobile Mapper 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 K for a description of the GPS equipment used in the field surveys.)

Field Surveys

GPS surveys of the CUC Tinian water system were conducted from March 27 through March 30, 2012.

Concurrent Asset Inventory

The GPS field surveys were integrated with the asset inventory data gathering task of the master planning effort, which included recording the asset description, size, capacity, and condition.

GIS Mapping Process

The CUC water system assets were mapped using the most recent available rectified aerial maps for the base background. Base map source descriptions are described in Appendix L. CUC drinking water 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 2.2.3-6 describes the specific features of the CUC drinking water system components contained in the geodatabase. Appendix M contains the Asset Feature Class descriptions and data fields for drinking water system assets. See Appendix N for a sample database of selected water system components.

Tinian Water System Infrastructure

The GIS geodatabase development and mapping of the CUC water system assets for all three islands has been completed. Figures 2.2.3-6 and 2.2.3-7 are sample plots of from the GIS-based water system map.

Table 2.2.3-6. **Sample Plots**

CUC Drinking Water System Features	Used
Abandoned Water Lines	
Abandoned Appurtenances (Points)	
Water Casings (Waterline Encasements)	
Water Line Construction (Improvements)	
Water Network Control Valves	✓
Water Service (Connection) Valves	
Water (Asset) Elevation	
Water Fittings	✓
Water (Fire) Hydrants	✓
Water (Service) Laterals	✓
Water (Distribution) Mains	✓
Water Network Structures (Treatment Plants, etc.)	✓
Water Operational Areas (Ops Area Boundaries)	
Water Pressure Zones	✓
Water Pumps	✓
Water Sampling Stations	✓
Water Service Connections (e.g., Meter Locations)	
Water System Valves (Non-pressure Valves)	
Water (DEQ) Test Stations	✓
Water Well Points	✓
Water Point Sources	✓

Figure 2.2.3-6. **Critical Components of the Tinian Water System**

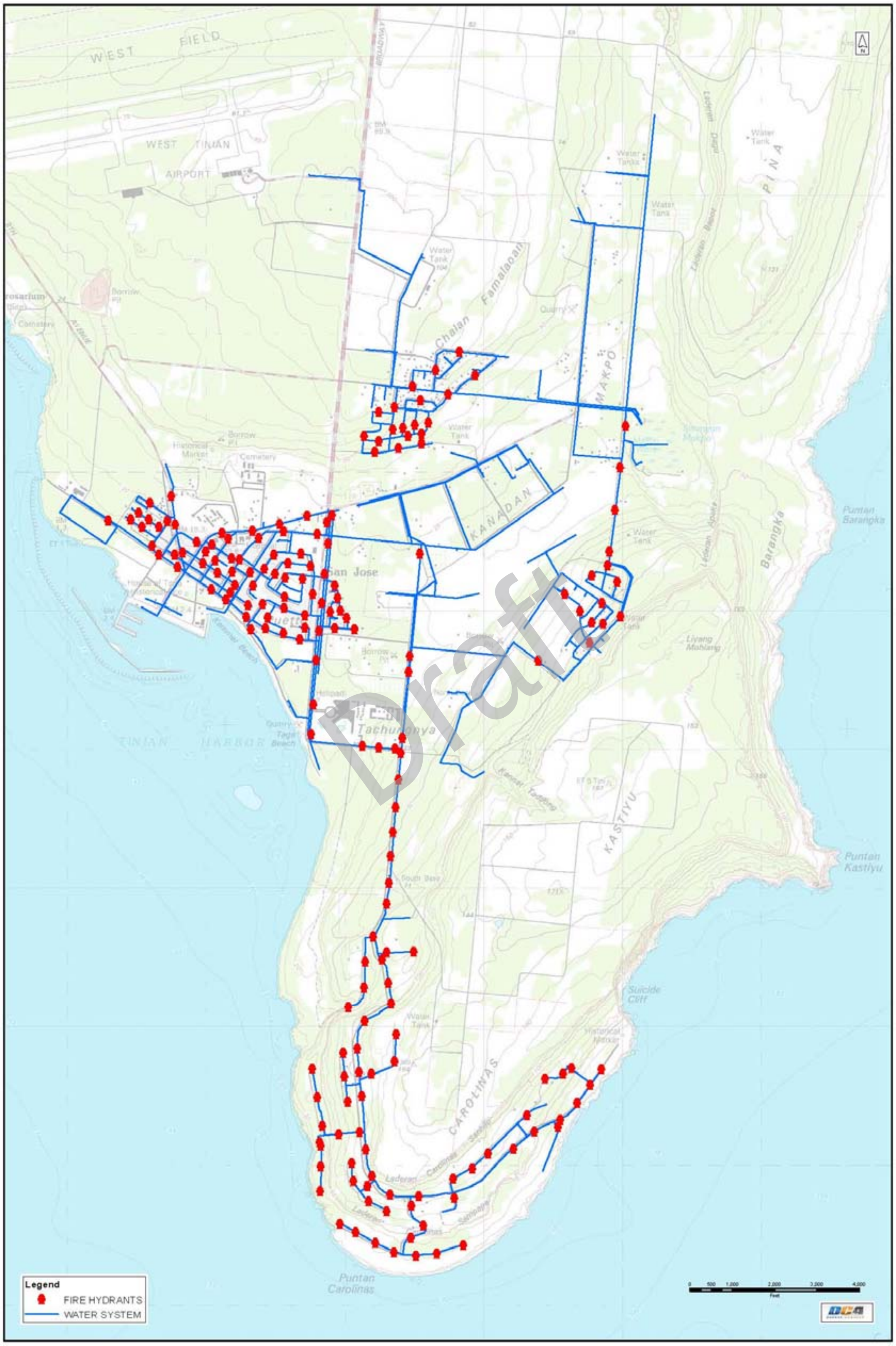
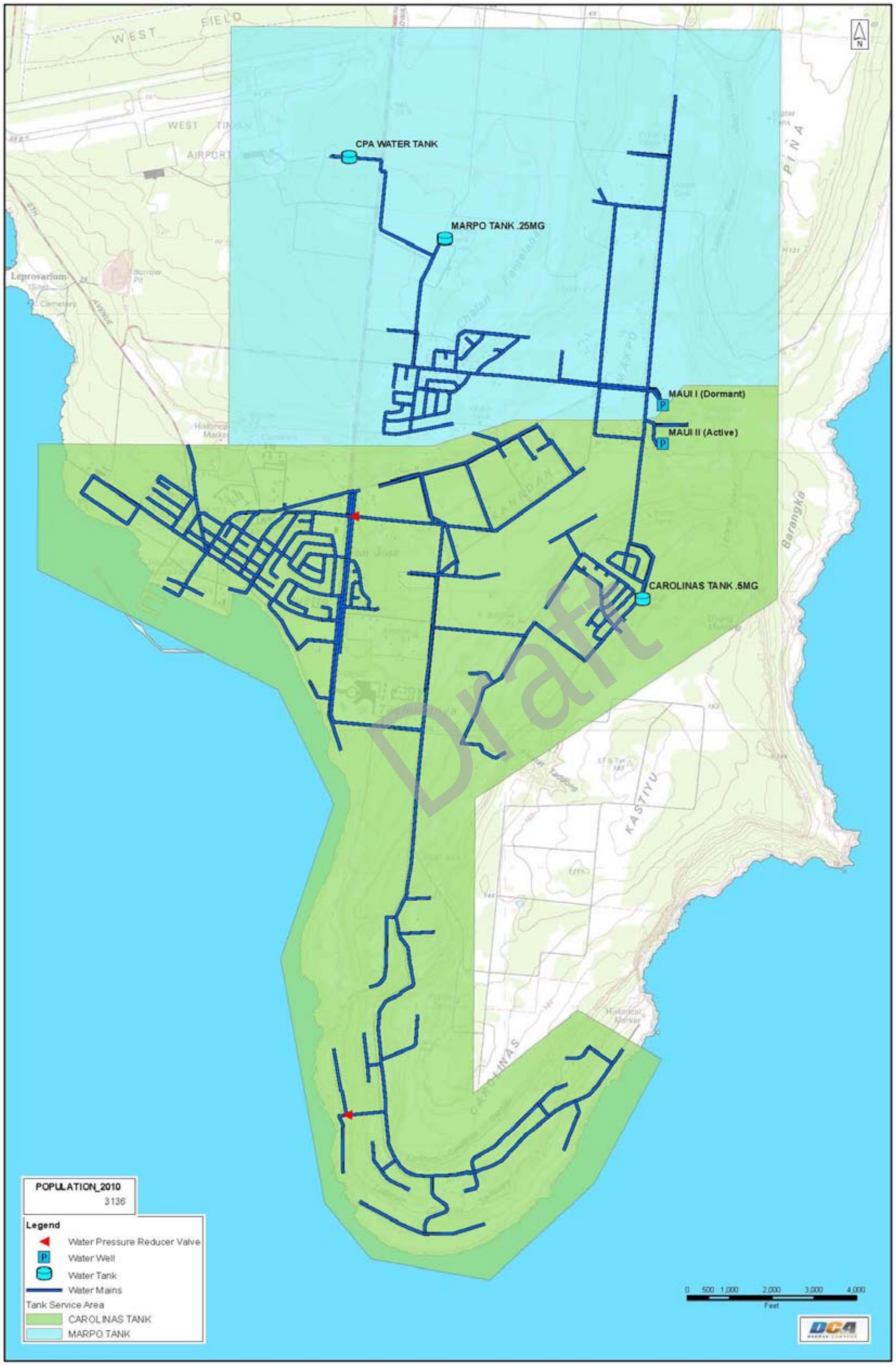


Figure 2.2.3-7. **Map of Tinian Water System**



Note: Population sum based on 2010 Census Designated Place

Tinian Water System

GIS Use and Operation

The development of the GIS program for the CUC water and wastewater system is complete and was used to support other master planning tasks. The GIS system is functional as follows:

- The GIS will identify, catalog, and track geo-referenced components of the existing water system(s) for Saipan, Rota and Tinian graphically and/or by tabulation according to location, function, type, material composition, size and capacity.
- The GIS will 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 GIS database 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 2.2.3-6.
- The GIS will provide supporting data for the set-up and operation of the computerized water and wastewater system infrastructure models.

The complete, final GIS work station turnover occurred in December 2012. The fully-functional GIS work station consists of computer hardware, ArcGIS software (and license) and the completed geodatabase files. Training of CUC personnel in the use, operation and maintenance of the system was performed upon turnover.

Land Ownership

Section 8194, “Title to Property; Easement Rights of the Commonwealth Code” (CNMI Law Revision Commission) provides for the conveyance or 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.

The project team recommends that easements, right-of-way corridors, and real estate (land parcels) on public lands containing CUC water 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 water system asset. The project team also recommends include that CUC undertake the following process for documenting its real property interests utilizing the GIS program where appropriate:

1. 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.
2. Establish a prioritized list of CUC water system assets by island that need real estate ownership documentation, keeping DPL in the information loop.
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 water 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 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.
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.

2.2.5 Asset Risk Assessment

This section presents the results of the asset risk assessment performed by the project team and CUC on the Tinian water system. The analysis of risk assessment results helped to form the basis of the recommendations for the CIPs. 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 processes and all three islands are mentioned in this section of the report. The detailed results from the Saipan water system, Saipan wastewater system and Rota 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"(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, operations and maintenance (O&M), and salvage costs. Asset management focuses on identifying risk so that costs can be minimized while maintaining the 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 2.2.5-1 provides key concepts for effective asset management.

Table 2.2.5-1. **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 of this Master Plan used many of the concepts detailed in Table 2.2.5-1.

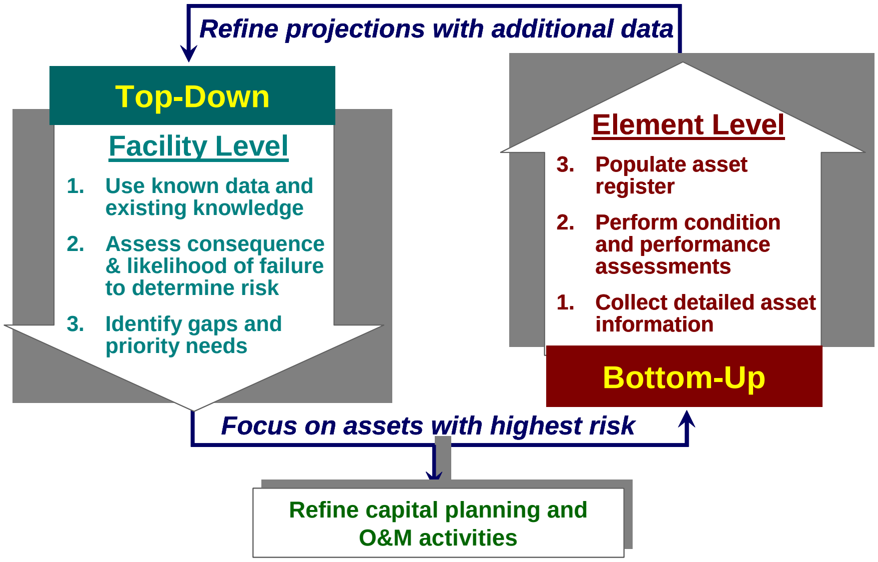
Asset Management Strategy

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 and included herein as Appendix O.

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 used the following sources of information to build the complete list of assets: condition assessments of tanks, booster pump stations, and chlorination facilities; GIS, hydraulic model, and information gathered during CUC workshops and meetings.

The top-down approach focuses on analysis first, at a system or facility level where institutional knowledge and existing data are readily available. This differs from the bottom-up approach, which focuses on detailed data collection. 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 2.2.5-1 provides a high-level overview of the top-down, bottom-up interaction.

Figure 2.2.5-1. **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 is 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 booster pump stations) and "horizontal assets" (e.g., underground pipes for water distribution).

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 approach is discussed in greater detail below.

Level of Service Categories

Levels of service (LOS) 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. LOS can be qualitative and quantitative and must align with customer expectations. LOS 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 to prevent overlap and to 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 2.2.5-2 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, 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.*

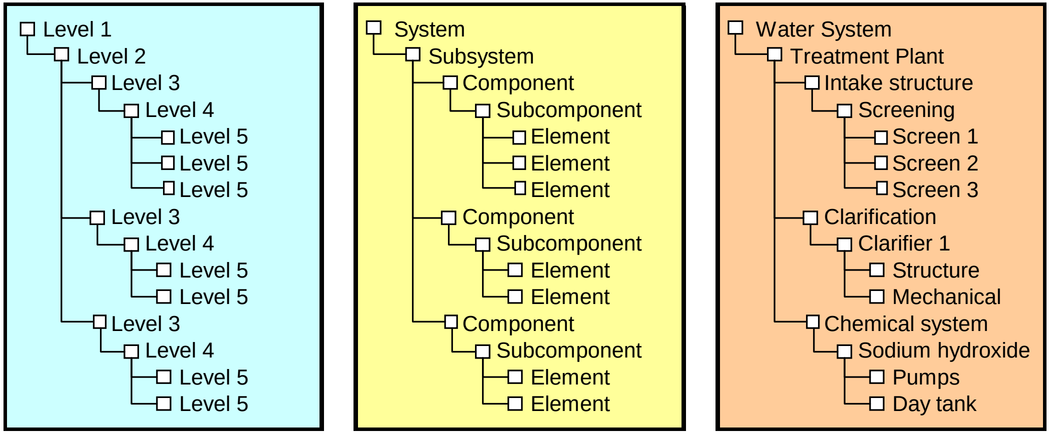
Table 2.2.5-2**. CUC Levels of Service for the Drinking Water System.**

Level of Service Category	**Target Value**
Financial Impact *Weighting Factor*: 20%	Less than $1,000 required to remediate the asset failure
System Reliability *Weighting Factor*: 25%	No loss of service. Would not cause wide spread water discoloration, taste, or odors. No water leaks (maintain water conservation).
Regulatory Compliance/Health *Weighting Factor: 45%*	Primary and secondary drinking water standards met. No federal permit violations. No potential adverse health effects.
Public Image and Customer Service *Weighting Factor: 10%*	Would not trigger complaints or media coverage. Affects no more than one customer and no major customers. Fire protection not impacted. No traffic interruption.

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 2.2.5-2). The parent-child relationship can be established based on location or function. An asset hierarchy does not need 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 2.2.5-2. **Sample Asset Hierarchy**



The full asset hierarchy for Tinian's water system is included as Appendix P. The project team determined which assets should be developed to a fourth level of detail based on available information.

Risk Assessment

Risk assessment is a key element 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 Definition and Quantification

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 distribute drinking water to Tinian residents, resulting in an unsatisfied customer base. 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's 2.2.5-3 shows the consequence matrix and scoring system used to evaluate CUC water 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. Each category 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, a health and safety LOS consequence, when no potential for injuries or adverse health effects associated with an asset failure was anticipated (that is, the target LOS), 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.

Table 2.2.5-3. **Consequence of Failure (COF) Scoring Matrix**

COF Category	Wt.	Negligible = 1	Low = 4	Moderate = 7	Severe = 10
Financial Impact	20%	<$1k	Between $1k and $10k	Between $10k and $50k	Greater than $50k
System Reliability	25%	No loss of service. Would not cause wide spread water discoloration, taste, or odors. No water leaks (maintain water conservation).	Minimal to some loss of service for up to 8 hours. May cause some minimal water discoloration, taste, or odors (less than 10 customers). Water leakage up to 10,000 gal.	Some loss of service for 8 to 72 hours. May cause localized water discoloration, taste, or odors (10 to 50 customers). Water leakage 10,000 to 50,000 gal.	Will cause loss of service for greater than 72 hours. May cause wide spread water discoloration, taste, or odors (greater than 50 customers). Water leakage greater than 50,000 gal.
Regulatory Compliance/ Health	45%	Primary and secondary drinking water standards met. No federal permit violations. No potential adverse health effects.	Technical violation. Possible notice of violation but enforcement action is unlikely. May present acute or chronic health hazard.[1] May involve Tier 3 public notice.	Violation of DEQ's secondary standard. Probable enforcement action but fines unlikely. Presents acute/chronic health hazard; might cause "boil water" notice.[1] May involve Tier 2 public notice.	Violation of primary MCL. Enforcement action with fines likely. Will result in documented human disease event; likely to cause "boil water" notice.[1] May involve Tier 1 public notice.
Public Image and Customer Service	10%	Would not trigger complaints or media coverage. Affects no more than one customer and no major customers. Fire protection not impacted. No traffic interruption.	Might trigger wide spread complaints or media coverage. Affects 1 to 10 customers or one to two major customers. Fire protection potentially affected. Only local and temporarily traffic interruption.	Likely to trigger wide spread complaints or media coverage. Affects 10 to 50 customers or several major customers. Fire protection affected and contingency plans implemented. Generally local but possibly major traffic interruption for days or weeks.	Most certain to trigger wide spread complaints or media coverage. Affects > 50 customers or multiple major customers. Fire protection affected and contingency plans implemented. Major extended traffic interruption for extended period.

1. Health hazard criteria from CNMI SDW Infrastructure Grant Program Documentation.

Table 2.2.5-4 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 were 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 LOF category scores were determined based on the results of the condition assessment inspections performed by the project team, with input from GIS and modeling activities and CUC staff's knowledge of asset condition and performance histories. The weighting factor reflects the relative importance for each category.

Asset Risk Assessment Approach

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 Tinian Master Plan. In order 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 P 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.

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.

COF *(or LOF)* = sum of (Wi x Si)

where,

Wi = the weight for each COF (or LOF) category (percentage)

Si = the score for each COF (or 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)
- Thursday, November 3, 2011 – Water and Wastewater Facilities final scoring and adjustments

Note that Tinian wastewater facilities were not evaluated; Tinian employs privately owned and maintained septic fields only.

Table 2.2.5-4. **Likelihood of Failure Scoring Matrix**

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 accessible; spares mostly available; CUC may do maintenance in-house.	Site has some access constraints; equipment not easily accessed (requires mobilization of equipment); some spares available; maintenance may require a third party.	Site is difficult to access; equipment not easily accessed (requires mobilization of 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 equipment), no spares at CUC or on-island, maintenance requires a third party.

Water Asset Risk Scoring

Figures 2.2.5-3 through 2.2.5-7 illustrate the relative risk scores for key groups of CUC water assets. Upper and lower boundaries were defined for identifying risk categories (i.e., low, medium, and high risk) based on the range and spread of risk scores for all of CUC's water assets on all three islands. 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 at these high risk assets due to financial restrictions. Table 2.2.5-5 summarizes the frequency distribution of water asset risk scores.

Assets that have a risk score greater than 50 have been labeled as high-risk assets and should be CUC's top priorities for maintenance and operational improvements or capital improvements in the immediate future. Those assets with a risk score between 22 and 50 are identified as medium risk assets, and assets with a risk score less than 22 are considered low risk assets. The categorization of CUC's assets into these three risk categories will aid CUC in implementing a long-term capital improvement plan, which is discussed in Section 4.3 of this Master Plan. The high, medium, and low risk assets are delineated in Figures 2.2.5-3 through 2.2.5-7 with red and yellow horizontal lines that break the assets into categorized risk groups.

Table 2.2.5-5. **Frequency Distribution of CUC Water Risk Scores**

	Frequency (n)	**Frequency (%)**
Risk ≤ 22	226	89%
22 < Risk < 50	17	7%
Risk ≥ 50	10	4%

The risk scores for all drinking water assets for the islands of Saipan, Rota, and Tinian are summarized together in Figures 2.2.5-3 and 2.2.5-4. The HMT (aka Carolinas Tank) is a medium risk asset for CUC, and it is the highest risk asset on Tinian due to the consequences of this tank failing, in addition to the current condition of the tank. A detailed tank assessment is included in Section 2.2.2 of this Master Plan; which provides a detailed analysis on the condition of CUC's storage tanks. The Maui II well in Tinian is also identified as a medium level risk for CUC, primarily due to the high consequences of this well failing, which would result in loss of drinking water service to customers.

Figure 2.2.5-3. **Risk Scores for All CUC (Saipan, Rota, and Tinian) Water System Level 5 Assets – Part 1 (scores 12 and over)**

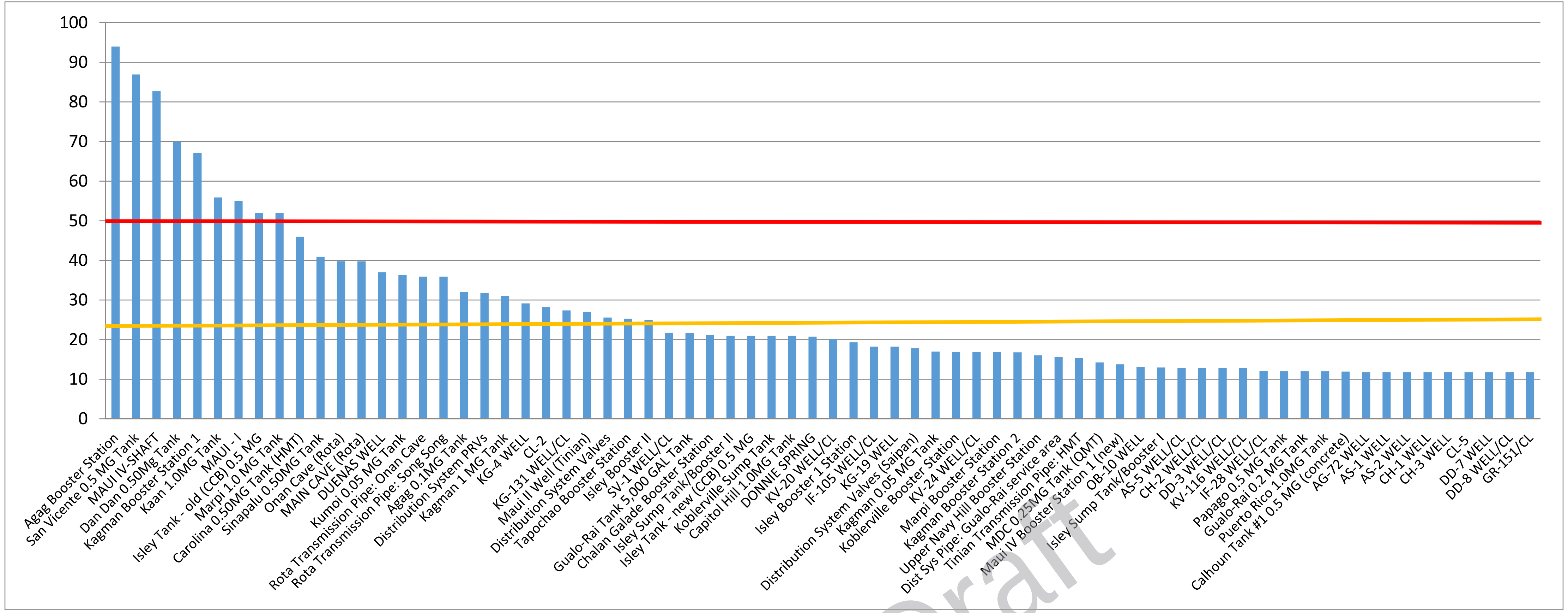


Figure 2.2.5-4. **Risk Scores for All CUC (Saipan, Rota, and Tinian) Water System Level 5 Assets – Part 2 (scores under 12)**

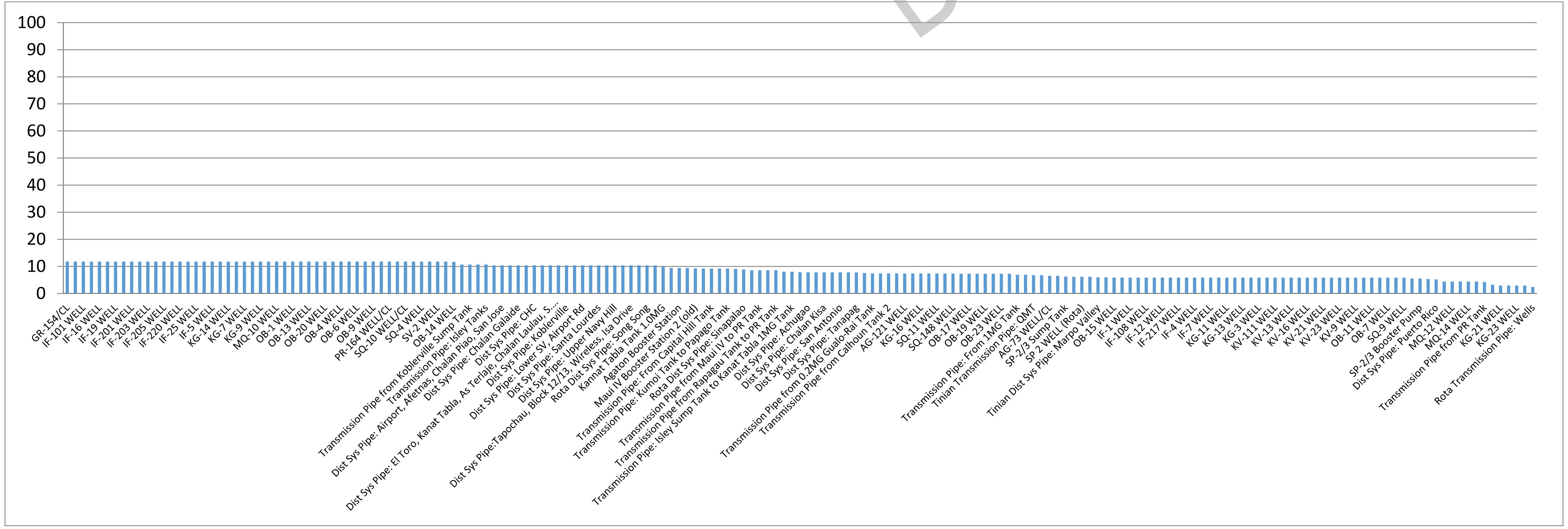


Figure 2.2.5-5. **Risk Scores for Rota and Tinian Drinking Water Sources**

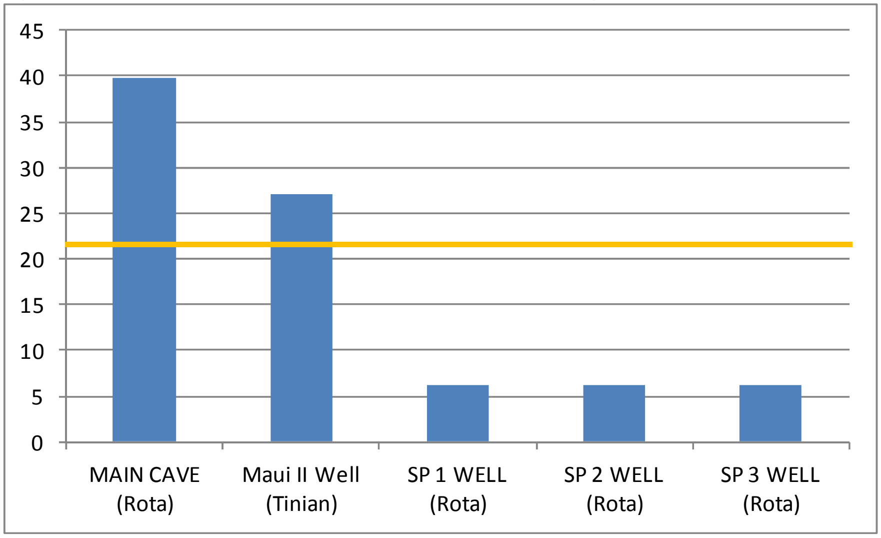


Figure 2.2.5-6. **Risk Scores for Saipan, Rota, and Tinian Water System Storage Tanks**

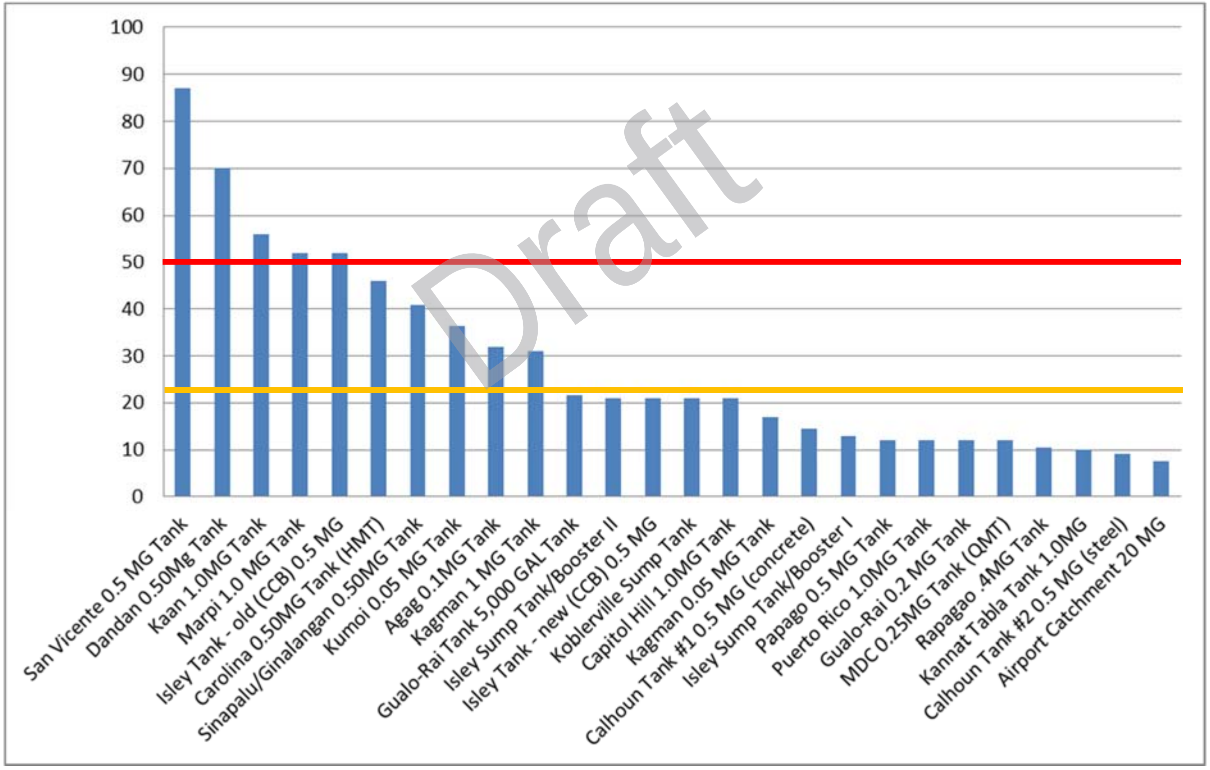


Figure 2.2.5-7. **Risk Scores for Rota and Tinian Transmission and Distribution Pipes**

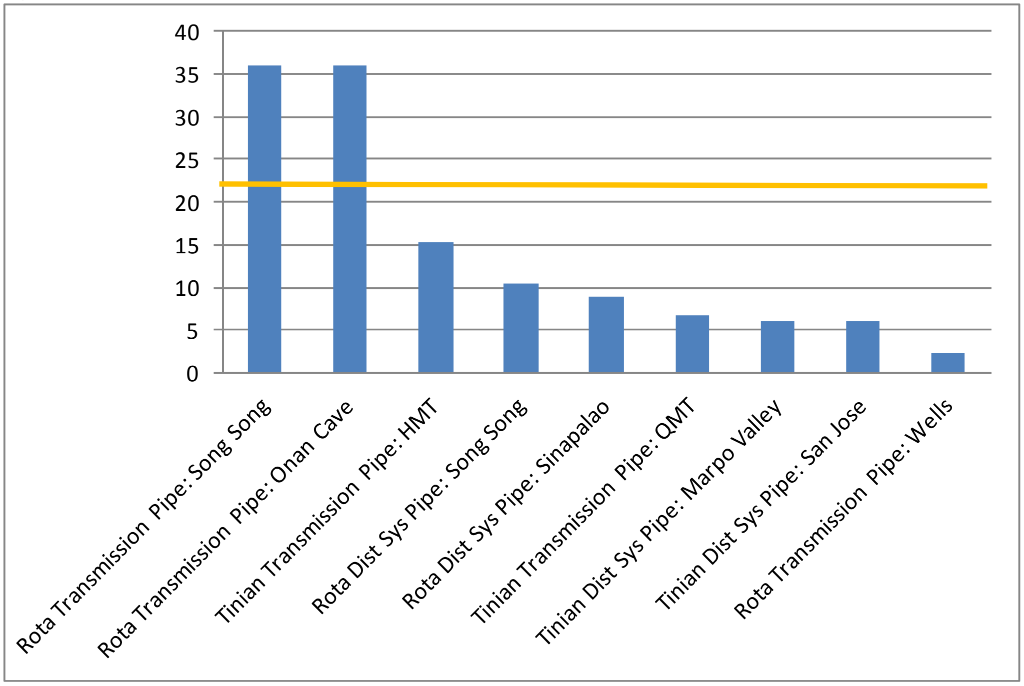


Figure 2.2.5-7 summarizes the risk scores assigned to the transmission and distribution pipes within the Rota and Tinian distribution systems. The transmission pipes are considered to be those higher-capacity pipes that convey water from a water storage tank to a distribution system that delivers water to an area or neighborhood. The distribution pipes include those smaller capacity pipes within a service area that deliver water to individual customers. The appurtenances of the Tinian distribution system and their associated risk scores are not included in Figure 2.2.5-7; all of these appurtenances are classified as low-risk assets. The range of scores calculated for these assets, which includes air relief valves (ARVs), blowoff valves, hydrants, meters, pressure relief valves (PRVs), sample taps, and other valves are summarized in Table 2.2.5-6 for the Tinian distribution system.

Table 2.2.5-6. **Tinian Distribution System**

		Tinian
ARVs		
	Min	1.5
	Max	2.0
Blowoff Valves		
	Min	1.5
	Max	2.0
Hydrants		
	Min	3.3
	Max	4.4
Meters		
	Min	1.5
	Max	2.0

Table 2.2.5-6. **Tinian Distribution System**

		Tinian
PRVs		
	Min	4.9
	Max	4.9
Sampling Taps		
	Min	N/A
	Max	N/A
Valves		
	Min	8.0
	Max	9.5

Summary of Risk Assessment Key Findings and Recommendations

The key information provided by the risk assessment exercise is the prioritization of assets based on relative risk scores and the identification of high risk assets. There were no high risk assets identified on Tinian. The information provided in this section provided critical information to the project team during the process of identifying short-term and long-term capital improvement projects (see Section 4.3). 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 system to develop a list of projects, as well as O&M improvements, deemed necessary.

Condition Assessment Recommendations

The risk assessment result can be used to help guide future condition assessment activities. The assets with relatively high risk score that have not had a detailed inspection should be considered for future inspection activities to identify the repairs and rehabilitation required to decrease the likelihood of asset failure.

Recommendations for Improving Risk Scores

This section provides recommendations for CUC to consider if it wishes to continue with a risk-based asset management program in the future. The recommendations include asset management best practices as well as specific recommendations for CUC that were developed based on the information gathered during the asset risk scoring workshops and analysis of the asset hierarchy risk scores.

There is additional work to the asset hierarchy file that, if completed, will result in more accurate and complete risk scores for many CUC assets of which little information was known. The following items should be considered if more accurate risk scores are desired:

- Currently, the LOF scores for water system motor control centers (MCCs) and generator are estimates based on assessments done on other electrical equipment throughout the Saipan water system. The project team did not perform a complete electrical condition assessment for these assets on Tinian. It is recommended that CUC perform electrical system condition assessments for the Maui II booster station, similar to what was accomplished for the wastewater lift station electrical equipment in Saipan. After condition data are collected in the field, the asset hierarchy should be updated with revised LOF scores.

- The risk scores for the water system's transmission pipes and distribution pipes are currently best guesses based on the project team's best engineering judgment to assign LOF scores. It is recommended that as additional condition/age/material information is determined for water, the asset hierarchy be updated accordingly.
- The COF scores for the drinking water system's transmission and distribution pipes may not be completely accurate. During the risk assessment workshops with CUC, COF scores were assigned without the benefit of having the completed tank service area schematics to review. To update the COF scores, the following information is needed:
  - Redundant sources of water for certain areas; this will affect the system reliability and public image COF score.
  - Population in the tank service area neighborhoods; this will affect the public image COF score.

Knowledge Transfer

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 written down or 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 to transfer all of 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 require updating as frequently, but every 3 to 5 years the COF scoring matrix should be reviewed to ensure levels of service have not drastically changed.

2.3 Wastewater Infrastructure System Condition Assessment

CUC does not operate or maintain any wastewater infrastructure on the island of Tinian, so condition assessments of Tinian’s wastewater assets is not applicable to this Master Plan.

SECTION 3

Master Planning Criteria

The contents of Section 3, “Master Planning Criteria” are as follows:

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  3.1.1 Estimating Tinian’s Current Population as of January 2012 3-3
  3.1.2 Projecting Tinian’s Population as a Result of Economic Growth through Business Initiatives by the CGCNMI and Local Businesses 3-5
  3.1.3 Projecting Tinian’s Population as a Result Economic Growth Generated by External Stimuli 3-7
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3.1 Twenty-Year Population Projections

The population projections for Tinian (as well as for Saipan and Rota) are intended for use in planning new and improved water and wastewater 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 and wastewater services, such as places of employment, other places of congregation, and tourist venues, are not included in this analysis.

Three factors will affect the population growth of Tinian:

- Natural growth rate through births and deaths.
- Immigration and emigration resulting from economic growth due to initiatives by the government of 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 influences population growth differently for Tinian than it does for Saipan or Rota,

The basis for these population projections is the year 2010 census for the 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 Tinian's Current Population as of January 2012

Before population projections can be developed for Tinian, it is first necessary to determine the current population as of January 2012. Tinian has witnessed a substantial decline in population over the past 12 years. As shown in Table 3.1.1-1, between 2000 and 2010 alone, population declined by 11.4 percent.

Table 3.1.1-1. **Population of Tinian from 2000 through 2010**

Year	Census	Change since 2000 (percent)	Source
2000	3,540	--	U.S. Census Bureau
2010	3,136	- 11.4	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 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**

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**[a]

[a]This tally does not include citizens of the Freely Associated States.

No data are available to allocate these aliens among Tinian, Saipan, and Rota. However, in discussions with officials from Tinian and Rota, where the relatively small land area and low population permits empirical evidence, it is estimated that approximately 800 aliens (Liu, 2012) resided on Tinian and approximately 600 aliens (Mendiola, 2012) resided on Rota during year 2010, leaving approximately 19,459 (say, 19,500) on Saipan.

These legal aliens are now in the process of transitioning from their former status under CNMI immigration law to complying with U.S. immigration regulations. U.S. Citizenship and Immigration Services (USCIS) recently announced that it will extend parole for Commonwealth-only worker applicants whose petitions had not been adjudicated by the time their parole expired on January 31, 2012 (Eugenio, 2012b). 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 Tinian, it would be necessary to determine how many of those aliens have remained in Tinian since the Department of Interior report in 2010. Those data are unavailable. The 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 by island in April 2010 when the census was taken, the number of aliens currently in the CNMI or by island, or the number of aliens who petitioned for continued residency (Gulick, 2012).

Therefore, it is necessary to rely on a consensus of opinion regarding the number of formerly legal aliens who remain in Tinian as of January 2012. Several sources were contacted to ascertain the mostly likely estimate of legal aliens in Tinian during the April 2010 census as well as in January 2012. Those sources included a meeting with a representative of the Tinian Mayor’s Office in Tinian (Farrell, 2012) as well as communication with the office of Senator Hofschneider, the CNMI office of the Attorney General, the Tinian Office of the CNMI Department of Community and Cultural Affairs (which tracks food stamp benefits), and the General Manager of the Tinian Dynasty Hotel and Casino, Tinian’s largest employer (Liu, 2012).

Based on this empirical evidence, it is estimated that 850 legal aliens resided on Tinian during the 2010 census and approximately 750 remained as of January 2012, indicating a net loss of 100 legal aliens during that period. Further, some shift in non-alien population also likely occurred as a result of the recent economic downturn in construction and tourism, both in Tinian and CNMI-wide. Some residents are likely to have left in search of jobs, but at least 10 employees relocated from Saipan to Tinian (Liu, 2012). Therefore, these projections will consider such in-migration and out-migration to be equal.

It should be noted that two tracks 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 Gregorio Kilili Camacho 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.

Tinian has also experienced a loss of 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 estimates 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 Plan. For purposes of this projection, legal and illegal aliens will be held to be without growth between 2010 and 2012.

The natural decrease for permanent residents between years 2010 and 2012 yields a change in population of:

- For year 2011 = 2,286 less 2.55 percent (58) = 2,228
- For year 2012 = 2,228 less 1.49 percent (33) = 2,195

In sum, the estimated population on Tinian for January 2012 is 2,945 based on the following:

- Year 2010 permanent residents of 2,286 less years 2011 and 2012 decrease of 2.55 percent and 1.49 percent = 2,195
- Plus aliens of 750 plus years 2011 and 2012
- Therefore, 2,195 plus 750 = 2,945

3.1.2 Projecting Tinian's Population as a Result of Economic Growth through Business Initiatives by the CGCNMI and Local Businesses

The government of CNMI and the Tinian 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 additional casinos, and U.S. Department of Defense installations and operations. 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 Tinian's leading industry, tourism will continue to play an important role for the island's economic growth. The primary attraction for tourists to Tinian are gambling and vacationing at the Dynasty Hotel and Casino and, to a lesser degree, WW II historical sites. For the short term, CNMI tourism is tracking approximately 15 percent below previous activity and has declined 30 percent from 2005 to 2009, and Tinian's experience is similar (Taitano, 2012).[1]

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[1] Personal communication. Perry Taitano, Managing Director, Marianas Visitors Authority. January 19, 2012

Looking forward, improvements to the Tinian airport, such as a refueling facility and other support structures, are needed before more substantial aircraft can be scheduled on a regular basis. The funding and timeline for implementation of these improvements are uncertain.

Inasmuch as tourist arrivals have been hovering around the break-even 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. 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 or similar tourism industry attractions. 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 within 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 commercial development opportunities. The probability for second homes or retirement homes to aliens with commensurate visa privileges is unlikely, due to the absence of full-scale medical facilities. 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.
- **Additional Casinos.** Two additional casinos are already approved for Tinian; however, development plans have not been announced. Reasons for a delay in start-up are speculative; however, they may include financing, Tinian airport issues, Tinian harbor issues, CNMI tourist declines, possible Article 12 amendments, and unfilled capacity at the Dynasty Hotel and Casino. Each of these issues is significant on its own merit, and when considered cumulatively they present a substantial challenge to growth. Consequently, no additional population is projected as a result of more casinos for the 2015, 2020, and 2030 horizons.
- **U.S. Department of Defense Operations.** Tinian is likely to benefit from the pending U.S. military build-up on Guam due to the likelihood of increased use of land encumbered by the Tinian lease agreement with the U.S. military. That lease covers two-thirds of the island. One example of increased economic activity in advance of the Guam buildup planned to occur in May and June 2012 during a training exercise for Marine Aircraft Group 12 (MAG-12) involving about 400 Marines. (Eugenio, 2012a). MAG 12 is an active air group of the United States Marine Corps tasked with providing assault support aircraft. It is currently part of the 1st Marine Aircraft Wing (1st MAW), itself an integral part of the III Marine Expeditionary Force, and based at MCAS Iwakuni in Japan. The mission of the Marine Aircraft Group 12 is to conduct anti-air warfare and offensive air support operations in support of Fleet Marine Forces from advanced base, expeditionary airfields or aircraft carriers and conduct such air operations as may be directed. Similar types of training are expected to occur regularly on Tinian once the Guam military build-up is operational, as well as the possibility of establishing an Air Force Divert Base on land leased by the military (Farrell, 2012). Due to the probability of increased military operations on Tinian, new population growth is projected at 25 for 2015, 50 more for 2020, and 100 more for 2030.

3.1.3 Projecting Tinian's Population as a Result Economic Growth Generated by External Stimuli

In addition to local initiatives to generate economic development that might increase population, the CNMI economy, and Tinian'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 buildup on Guam is likely to occur before 2020, analyses by others indicate 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.

3.1.4 Projecting Tinian's Population as a Result of Economic Growth Generated by Local Initiatives and External Stimuli

In summary, local initiatives and external stimuli can be expected to account for the population increases listed in Table 3.1.4-1.

Table 3.1.4-1. **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 (50)
Additional Casinos	0	0	0
U.S Dept. of Defense Operations	25	50	100
U.S. Federal and International Stimuli	0	0	Possible (100)

To account for the projected increase in population resulting from U.S Department of Defense Operations an additional 25 in population will be projected for year 2015, and additional 50 in population for year 2020, and an additional 100 in population for year 2030. Additionally, to account for possibility of increase in population for the Article 12 and as well as U.S. federal and international stimuli, another 100 are projected for year 2030. These projections are made 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 Tinian, Saipan and Rota for both employment and family reasons; however, the net change appears to be inconsequential.

3.1.5 Projecting Tinian's Population for Year 2015

Inasmuch as only one local initiative, U.S. Department of Defense Operations, is expected to add 25 people to Tinian's population between year 2012 and year 2015, the island's population will be affected primarily by two other factors: the natural growth rate of permanent residents and aliens and the disposition of some 750 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 averages to 0.61 percent 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 Plan. 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 2012 and 2015.

No data are available to estimate the number of aliens who will be approved for residency: it could be all 750, half, or none (although it is unlikely that no applications will be approved). For purposes of this projection, therefore, high, medium, and low ranges of projections are offered:

- **High Range.** Permanent residents at a natural growth rate of 0.61 percent or the years 2012 to 2015 plus all 750 of the alien applications are approved, with no natural growth rate for aliens.
- **Medium Range**. Permanent residents at a natural growth rate of 0.61 percent for the years 2012 to 2015 plus half (375) of the alien applications are approved, with no natural growth rate for aliens.
- **Low Range.** Permanent residents at a natural growth rate of 0.61 percent for the years 2012 to 2015 plus one-quarter (188) of the applications are approved, with no natural growth rate for aliens.

With these assumptions, the population projections for Tinian for year 2015 are as follows:

- Year 2015 high range: 2,984
  - Year 2012 permanent residents of 2,195 less year 2013 @ -0.44 percent, plus year 2014 @ 0.61 percent, plus year 2015 @ 1.66 percent = 2,195 + 39 = 2,234
  - Year 2012 aliens of 750 at no natural growth
  - Therefore, 2,234 + 750 = 2,984
- Year 2015 medium range: 2,609
  - Year 2012 permanent residents of 2,195 less year 2013 @ -0.44 percent, plus year 2014 @ 0.61 percent, plus year 2015 @ 1.66 percent = 2,195 + 39 = 2,234
  - Year 2012 aliens of 375 at no natural growth
  - Therefore, 2,234 plus 375 = 2,609
- Year 2015 low range: 2,216
  - Year 2012 permanent residents of 2,195 less year 2013 @ -0.44 percent, plus year 2014 @ 0.61 percent, plus year 2015 @ 1.66 percent = 2,195 + 39 = 2,234
  - Year 2012 aliens of 188 at no natural growth
  - Therefore, 2,234 + 188 = 2,422

With these assumptions, the population projections for Rota for Year 2015 are as follows:

- Year 2015 high range: 2,984
- Year 2015 medium range: 2,609
- Year 2015 low range: 2,422

With respect to the variance in permanent residents between the 2010 census and the 2015 estimate, this component of Tinian's population declined by 6.04 percent (3,136 census less 800 aliens = 2,336 permanent residents in year 2010 versus 2,195 in year 2015).

3.1.6 Projecting Tinian's Population for Year 2020

Inasmuch as only one local initiative, U.S. Department of Defense Operations, is expected to add 50 people to Tinian's population between year 2015 and year 2020, the island's population will be affected primarily by two other factors: the natural growth rate of permanent residents and aliens and the disposition of some 750 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 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 the 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).

Nonetheless, in the absence of evidence to the contrary and the precaution taken 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 Tinian'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 = 2,234 plus 2.12 percent = 2,281
- For year 2017 = 2,281 plus 2.03 percent = 2,327
- For year 2018 = 2,327 plus 1.93 percent = 2,372
- For year 2019 = 2,372 plus 1.84 percent = 2,416
- For year 2020 = 2,416 plus 1.76 percent = 2,459

With these assumptions, the population projections for Tinian for year 2020 are as follows:

- Year 2020 high range: 3,259
  - Year 2020 permanent residents = 2,459
  - Year 2020 aliens of 750
  - Year 2020 new growth from local initiatives and external stimuli of 50
  - Therefore, 2,459 + 750 + 50 new = 3,259
- Year 2020 medium range: 2,884
  - Year 2020 permanent residents = 2,459
  - Year 2020 aliens of 375
  - Year 2020 new growth from local initiatives and external stimuli of 50
  - Therefore, 2,459 + 375 + 50 new = 2,884
- Year 2020 low range: 2,697
  - Year 2020 permanent residents = 2,459
  - Year 2020 aliens of 188
  - Therefore, 2,459 + 188 + 50 new = 2,697

With these assumptions, the population projections for Rota for year 2020 are:

- Year 2020 high range: 3,259
- Year 2020 medium range: 2,884
- Year 2020 low range: 2,697

With respect to the variance in permanent residents between the 2010 census and the 2020 projections, this component of Tinian's population increased by 5.27 percent (3,136 census less 800 aliens = 2,336 permanent residents in year 2010 versus 2,459 in year 2020).

3.1.7 Projecting Tinian's Population for Year 2030

Year 2030 population projections reflect two local initiatives: Article 12 amendments at 50 additional people and U.S. Department of Defense operations at 100 additional people, as well as and U.S. federal and international stimuli at 100 additional people.

The natural growth rate for the CNMI was projected by the U.S. Census Bureau (no distinction among islands) for years 2021 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.

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.

The natural increase for permanent residents between years 2021 and 2030 yields a change in population of:

- For year 2021 = 2,459 plus 1.65 percent = 2,500
- For year 2022 = 2,500 plus 1.53 percent = 2,538
- For year 2023 = 2,538 plus 1.43 percent = 2,574
- For year 2024 = 2,574 plus 1.34 percent = 2,608
- For year 2025 = 2,608 plus 1.27 percent = 2,641
- For year 2026 = 2,641 plus 1.21 percent = 2,673
- For year 2027 = 2,673 plus 1.17 percent = 2,704
- For year 2028 = 2,704 plus 1.13 percent = 2,735
- For year 2029 = 2,735 plus 1.09 percent = 2,765
- For year 2030 = 2,765 plus 1.07 percent = 2,795

With these assumptions, the population projections for Tinian for year 2030 are as follows:

- Year 2030 high range: 3,695
  - Year 2030 permanent residents = 2,795
  - Year 2030 aliens of 750
  - Year 2030 new growth from local initiatives and external stimuli of 150
  - Therefore, 2,795 + 750 + 150 = 3,695
- Year 2030 medium range: 3,320
  - Year 2030 permanent residents = 2,795
  - Year 2030 aliens of 375
  - Year 2030 new growth from local initiatives and external stimuli of 150
  - Therefore, 2,795 + 375 + 150 = 3,320
- Year 2030 low range: 3,133
  - Year 2020 permanent residents = 2,795
  - Year 2020 aliens of 188
  - Year 2020 new growth from local initiatives and external stimuli of 150
  - Therefore, 2,795 + 188 + 150 = 3,133

With these assumptions, the population projections for Tinian for year 2030 are:

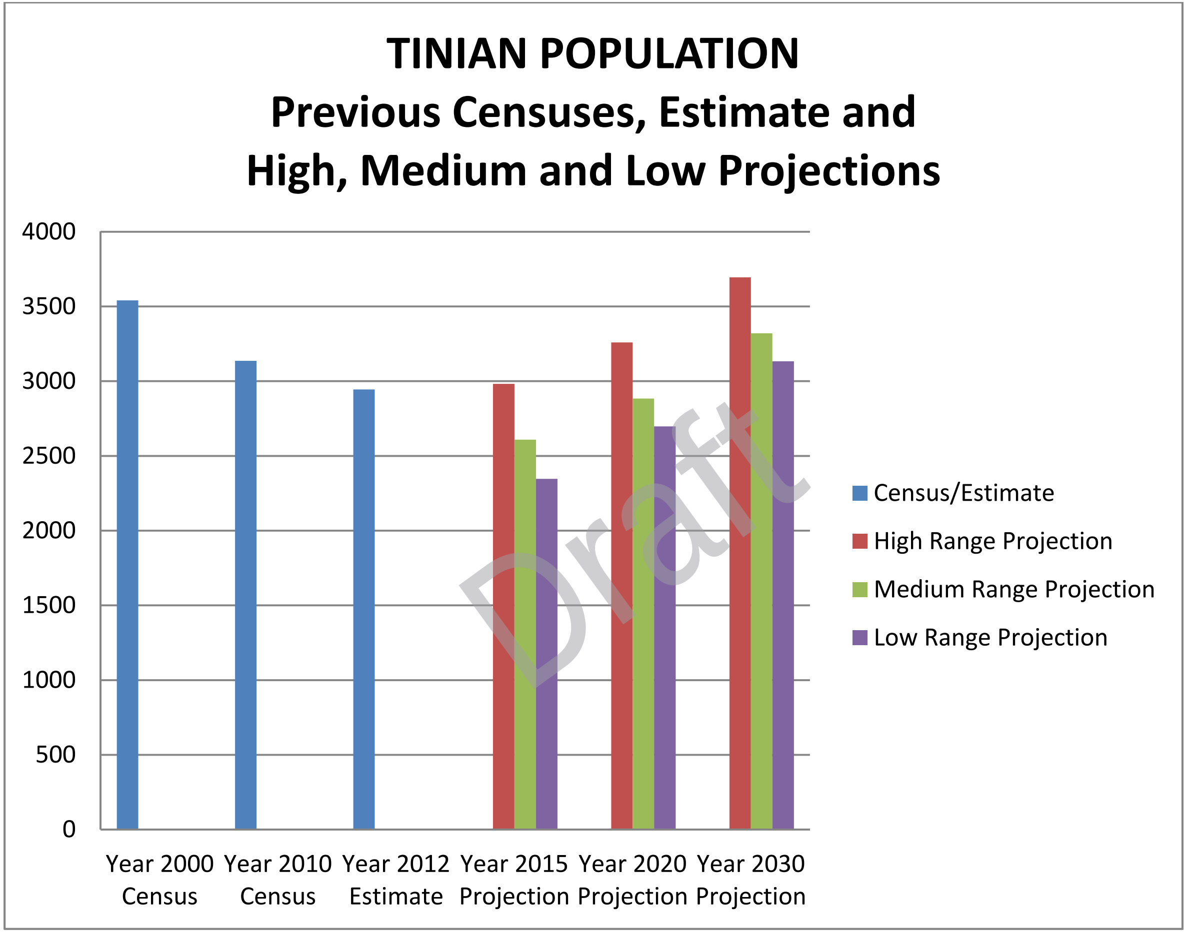
- Year 2030 high range: 3,695
- Year 2030 medium range: 3,320
- Year 2030 low range: 3,133

With respect to the variance in permanent residents between the 2010 census and the 2030 projections, this component of Tinian's population increased by 19.65 percent (3,136 census less 800 aliens = 2,336 permanent residents in year 2010 versus 2,795 in year 2030).

3.1.8 Summary of Actual and Estimated Population Data for 2000 through 2030

Figure 3.1.8-1 presents a chart of the year 2000 and year 2010 censuses, the estimated population in 2012, and high, medium, and low projections for years 2015, 2020, and 2030.

Figure 3.1.8-1. **Actual, Estimated, and Projected Population Data from 2000 through 2030**



3.1.9 Allocating Tinian Islandwide Population Projections among Census Designated Places for Year 2015

With the high, medium, and low ranges of population projections established islandwide for Tinian, these figures must be allocated among the island's 8 Census Designated Places (CDPs). Those CDPs, along with their 2010 census projections, are shown in Table 3.1.9-1.

Table 3.1.9-1. **Tinian Census Designated Places and Year 2010 Census**

Census Designated Place	Population
Aguijan village	-
Carolinas village	27
Carolinas Heights village	336
Eastern Tinian (Marpo Valley) village	155
Marpo Heights village	679
Northern Tinian village	-
San Jose (Tinian Municipality) village	1,939
Western Tinian village	-
TOTAL	**3,136**

The following methodology was employed for this allocation for the year 2015 projections, which are as follows: High Range at 2,984; Medium Range at 2,609; and Low Range at 2,342.

- The High Range population for year 2015 is 2,984 or 154 less than the year 2010 census of 3,136. This decrease of 152 to the year 2010 census is expected to occur in Marpo Heights Village (100) and in San Jose (Tinian Municipality) Village (54).

  See Table 3.1.9-1, Tinian Population Projections for Year 2015 by Census Designated Place - High Range, at the end of this document.

- The Medium Range population for year 2015 is 2,609 or 527 less than the year 2010 census of 3,136. This decrease of 527 from the year 2010 census is expected to occur in Marpo Heights Village (327) and in San Jose (Tinian Municipality) Village (200).

  See Table 3.1.9-2, Tinian Population Projections for Year 2015 by CDP - Medium Range, at the end of this document.

- The Low Range population for year 2015 is 2,342 or 794 less than the year 2010 census of 3,136. This decrease of 794 from the year 2010 census is expected to occur in Marpo Heights Village (300) and in San Jose (Tinian Municipality) Village (494).

  See Table 3.1.9-3, Tinian Population Projections for Year 2015 by CDP - Low Range, at the end of this document.

3.1.10 Allocating Tinian 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 3,259; Medium Range at 2,884; and Low Range at 2,679.

- The High Range population for year 2020 is 3,259 or 123 more than the year 2010 census of 3,136. This increase of 123 to the year 2010 census is expected to occur in the Carolinas Village at the Carolinas Agricultural Subdivision, which is already served by water and power infrastructure.

Both San Jose (Tinian Municipality) Village (at 1,939) and Marpo Heights Village (at 679) are not expected to grow significantly beyond the 2010 census due to constraints for in-fill and expansion.

See Table 3.1.10-1, Tinian Population Projections for Year 2020 by Census Designated Place - High Range, at the end of this document.

- The Medium Range population for year 2020 is 2,884 or 252 less the year 2010 census of 3,136. This decrease of 252 to the year 2010 census is expected to occur in Marpo Heights Village (152) and in San Jose (Tinian Municipality) Village (100).

  See Table 3.1.10-2, Tinian Population Projections for Year 2020 by Census Designated Place – Medium Range, at the end of this document.

- The Low Range population for year 2020 is 2,697 or 439 less than the year 2010 census of 3,136. This decrease of 493 from the year 2010 census is expected to occur in Marpo Heights Village (200) and in San Jose (Tinian Municipality) Village (239).

  See Table 3.1.10-3, Tinian Population Projections for Year 2020 by Census Designated Place - Low Range, at the end of this document.

3.1.11 Allocating Tinian 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 3,694; Medium Range at 3,320; Low Range at 3,133.

- The High Range population for year 2030 is 3,694 or 1,284 more than the year 2010 census of 3,136. This increase of 558 to the year 2010 census is expected to occur in the Carolinas Village at the Carolinas Agricultural Subdivision.

  See Table 3.1.11-1, Tinian Population Projections for Year 2020 by Census Designated Place - High Range, at the end of this document.

- The Medium Range population for year 2030 is 3,320 or 184 more than the year 2010 census of 3,136. This increase of 184 to the year 2010 census is expected to occur in the Carolinas Village at the Carolinas Agricultural Subdivision.

  Both San Jose (Tinian Municipality) Village and Marpo Heights Village are not expected to grow significantly beyond their 2015 projections due to constraints for in-fill and expansion.

  See Table 3.1.11-2, Tinian Population Projections for Year 2030 by Census Designated Place - Medium Range, at the end of this document.

- The Low Range population for year 2030 is 3,133 or 3 less than the year 2010 census of 3,136. This variance is de minimis and need be allocated to the year 2010 census.

  See Table 3.1.11-3, Tinian Population Projections for Year 2030 by Census Designated Place - Low Range, at the end of this document.

Figure 3.1.11-1 presents a map of Tinian’s CDPs along with year 2010 census population, housing units, and group quarters.

3.1.12 Population by Tinian Water Regions for Years 2015, 2020, and 2030 for High, Medium, and Low Ranges

With the population projections by CDPs for all three horizon years, population can be allocated among Tinian's two Water Regions for the high and low ranges. Tinian's two Water Regions are Water Region 1, which comprises Carolinas Heights, Marpo Heights, and San Jose (Tinian Municipality), and Water Region 2, which comprises all other Tinian villages.

See Table 3.1.12-1 for allocations of projected population to Tinian Water Regions for years 2015, 2020, and 2013.

3.1.13 Population by Tinian Sewersheds for Years 2015, 2020 and 2030

As there is only one sewershed on Tinian, the islandwide population projections for years 2015, 2020, and 2030 described earlier in this section present those data.

Table 3.1.9-1. **Tinian Population Projections for Year 2015 by Census Designated Place - High Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2015 BY CDP - HIGH RANGE

2015 HIGH RANGE TARGET PROJECTION = 2,982 THIS PROJECTION = 2,982

Census Designated Place	2010 = 3,136	2015 High Range	CDPs with natural growth	CDPs with expected decrease in population
Aguijan village	-	-	-	
Carolinas village	27	27	27	
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	579		100
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,885		54
Western Tinian village	-	-	-	

Table 3.1.9-2. **Tinian Population Projections for Year 2015 by Census Designated Place - Medium Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2015 BY CDP - MEDIUM RANGE

2015 MEDIUM RANGE TARGET PROJECTION = 2,609 THIS PROJECTION = 2,609

Census Designated Place	2010 = 3,136	2015 Medium Range	CDPs with natural growth	CDPs with expected decrease in population
Aguijan village	-	-	-	
Carolinas village	27	27	27	
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	352		327
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,739		200
Western Tinian village	-	-	-	

Table 3.1.9-3. **Tinian Population Projections for Year 2015 by Census Designated Place - Low Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2015 BY CDP - LOW RANGE

2015 LOW RANGE TARGET PROJECTION = 2,347   THIS PROJECTION = 2,342

Census Designated Place	2010 = 3,136	2015 Low Range	CDPs with natural growth	CDPs with expected decrease in population
Aguijan village	-	-	-	
Carolinas village	27	27	27	
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	379		300
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,445		494
Western Tinian village	-	-	-	

Table 3.1.10-1. **Tinian Population Projections for Year 2020 by Census Designated Place - High Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2020 BY CDP - HIGH RANGE

2020 HIGH RANGE TARGET PROJECTION = 3,259   THIS PROJECTION = 3,259

Census Designated Place	2010 = 3,136	2020 High Range	CDPs with natural growth	CDPs with expected increase in population
Aguijan village	-	-	-	
Carolinas village	27	150		123
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	679	679	
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,939	1,939	
Western Tinian village	-	-	-	

Table 3.1.10-2. **Tinian Population Projections for Year 2020 by Census Designated Place - Medium Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2020 BY CDP - MEDIUM RANGE

2020 MEDIUM RANGE TARGET PROJECTION = 2,884 THIS PROJECTION = 2,884

Census Designated Place	**2010 = 3,136**	**2020 Medium Range**	**CDPs with natural growth**	**CDPs with expected decrease in population**
Aguijan village	-	-	-	
Carolinas village	27	27	27	
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	527		152
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,839		100
Western Tinian village	-	-	-	

Table **3**.1.10-3. **Tinian Population Projections for Year 2020 by Census Designated Place - Low Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2020 BY CDP - LOW RANGE

2020 LOW RANGE TARGET PROJECTION = 2,697 THIS PROJECTION = 2,697

Census Designated Place	**2010 = 3,136**	**2020 Low Range**	**CDPs with natural growth**	**CDPs with expected decrease in population**
Aguijan village	-	-	-	
Carolinas village	27	27	27	
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	479	-	200
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,700		239
Western Tinian village	-	-	-	

Table 3.1.11-1. **Tinian Population Projections for Year 2030 by Census Designated Place - High Range**

TINIAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP - HIGH RANGE				
2030 HIGH RANGE TARGET PROJECTION = 3,695 THIS PROJECTION = 3,694				
Census Designated Place	2010 = 3,136	2030 High Range	CDPs with natural growth	CDPs with expected increase in population
Aguijan village	-	-	-	
Carolinas village	27	585		558
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	679	679	
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,939	1,939	
Western Tinian village	-	-	-	

Table 3.1.11-2. **Tinian Population Projections for Year 2030 by Census Designated Place - Medium Range.**

TINIAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP - MEDIUM RANGE				
2030 MEDIUM RANGE TARGET PROJECTION = 3,320 THIS PROJECTION = 3,320				
Census Designated Place	2010 = 3,136	2030 Medium Range	CDPs with natural growth	CDPs with expected increase in population
Aguijan village	-	-	-	
Carolinas village	27	211		184
Carolinas Heights village	336	336	336	
Eastern Tinian (Marpo Valley) village	155	155	155	
Marpo Heights village	679	679	679	
Northern Tinian village	-	-	-	
San Jose (Tinian Municipality) village	1,939	1,939	1,939	
Western Tinian village	-	-	-	

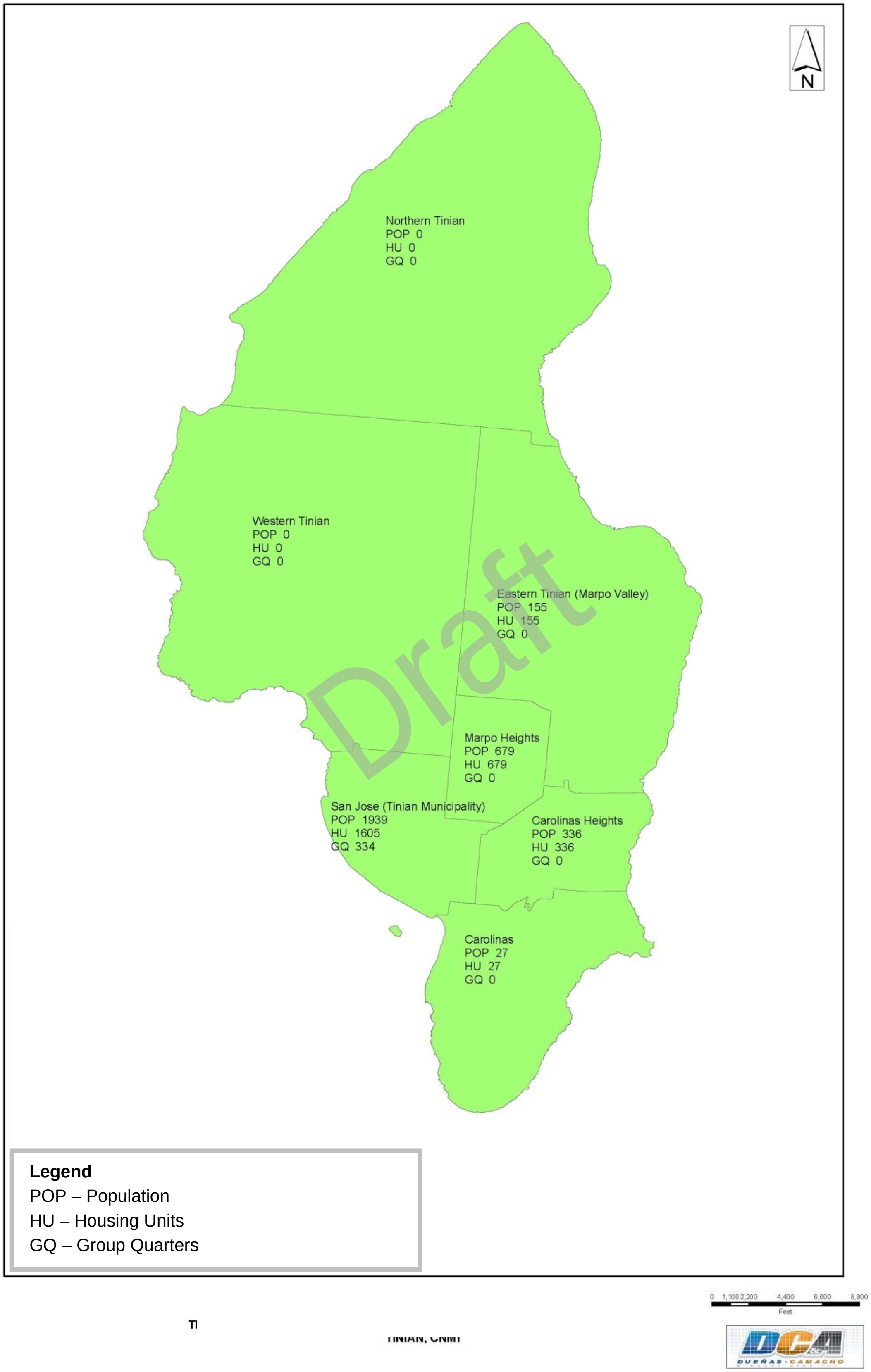
Table 3.1.11-3. **Tinian Population Projections for Year 2030 by Census Designated Place - Low Range.**

<table>
<tr><th colspan="4">TINIAN POPULATION PROJECTIONS FOR YEAR 2030 BY CDP - LOW RANGE</th></tr>
<tr><th colspan="4">2030 LOW RANGE TARGET PROJECTION = 3,133   THIS PROJECTION = 3,136</th></tr>
<tr><th>Census Designated Place</th><th>2010 = 3,136</th><th>2030 Low Range</th><th>CDPs with natural growth</th></tr>
<tr><td>Aguijan village</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Carolinas village</td><td>27</td><td>27</td><td>27</td></tr>
<tr><td>Carolinas Heights village</td><td>336</td><td>336</td><td>336</td></tr>
<tr><td>Eastern Tinian (Marpo Valley) village</td><td>155</td><td>155</td><td>155</td></tr>
<tr><td>Marpo Heights village</td><td>679</td><td>679</td><td>679</td></tr>
<tr><td>Northern Tinian village</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>San Jose (Tinian Municipality) village</td><td>1,939</td><td>1,939</td><td>1,939</td></tr>
<tr><td>Western Tinian village</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Table 3.1.12-1. **Tinian Population Projections by CDP for 2015, 2020, and 2030 High and Low Ranges**

Census Designated Place	2015 High Range	2015 Low Range	2020 High Range	2020 Low Range	2030 High Range	2030 Low Range	Census Designated Place
Aguijan village	-	-	0	-	-	-	Aguijan village
Carolinas village	27	27	150	27	585	27	Carolinas village
Carolinas Heights village	336	336	336	336	336	336	Carolinas Heights village
Eastern Tinian (Marpo Valley) village	155	155	155	155	155	155	Eastern Tinian (Marpo Valley) village
Marpo Heights village	579	379	679	479	679	679	Marpo Heights village
Northern Tinian village	-	-	0	-	-	-	Northern Tinian village
San Jose (Tinian Municipality) village	1,885	1,445	1,939	1,700	1,939	1,939	San Jose (Tinian Municipality) village
Western Tinian village	-	-	0	-	-	-	Western Tinian village

Figure 3.1.11-1. **Tinian 2010 Census of Population, Housing, and Group Quarters by Census Designated Places**



3.2 Water Demand and 20-Year Projections

"Per capita" use is the average volume of water utilized per person, per day. The current estimated per capita use rate that will be used for the island of Tinian for this Master Plan is 125 gpd/capita. It is clear from Table 3.2-1 that the average production is significantly higher than the one would expect for a community of this size. Further, the amount billed is much lower than one would expect.

Table 3.2-1. **Basis for Per-Capita Estimate**

Average Water Production Oct-Dec 2011 (gpd)	932,423
Average Water Metered Oct-Dec 2011 (gpd)	244,881
2010 Population (Census Data)	3,136
Per Capita Production (gpd/capita)	297
Per Capita Metered Demand (gpd/capita)	78
Estimated Demand Per Capita[1] (gpd/capita)	125

[1] Selected for the analysis for this Master Plan.

3.2.1 Production and Metered per Capita Demands

Per capita use rate estimates for CNMI used in this Master Plan were determined by taking the amount of water metered by CUC for each island and dividing it by the 2010 population for that island as obtained from census data. This approach assumes that all customers receive the water produced for the island of Tinian.

Based on well production data compared to existing customer (metered) demand data, "non-revenue water" is estimated to be 70 percent of the total water produced. This water loss can be attributed to leaks, unbilled/unauthorized water connections, and/or overuse of agricultural water that is billed at a flat rate. Based on CUC records, the existing unaccounted for water rates throughout the Tinian are quite large when compared to other jurisdictions. It is CUC's goal to significantly reduce the amount of "non-revenue water" through system improvements, effective system operation and maintenance, leak detection, and enforcement of water use regulations.

Water use varies between regions throughout the United States. Water usage can be as low as 62 gpd/capita (Oregon) and as high as 218 gpd/capita (Utah). The 297 gpd/capita metered production value determined for Tinian is greatly affected by unaccounted-for water. The 78 gpd/capita (metered) value grossly underestimates the true demand due to inconsistencies in metering as well as unaccounted for demands (including water lost through leaks). The rate of correcting leaks and overflows has slowed over the last year, but is expected to continue at a steady pace. Improvement in billing will lead to a higher capture of metered demands. Leak detection will lower well production. For the purpose of this Master Plan, a value of 125 gpd/ capita demand will be used. This demand valve should be monitored in the next 2 years and adjusted as needed.

3.2.2 Tank Service Area Population and Water Demand Projections

Table 3.2.2-1 presents the projected populations for the census designation areas using a high estimate for population growth. The high estimate has been used to present a conservative development approach and to reduce the possibility of under sizing the tank service area infrastructure, which could potentially result in the need for premature future capacity improvements.

Table 3.2.2-1. **Projected Population Growth per Village for Tinian**

Census Designation	2010	2015	2020	2030
Aguijan village	-	-	0	0
Carolinas village	27	27	150	585
Carolinas Heights village	336	336	336	336
Eastern Tinian (Marpo Valley) village	155	155	155	155
Marpo Heights village	679	579	679	679
Northern Tinian village	-	-	0	0
San Jose (Tinian Municipality) village	1,939	1,885	1,939	1,939
Western Tinian village	-	-	0	0
TOTAL	3,136	2,982	3,259	3,694

Table 3.2.2-2 presents the population project placed into the tank service area. Note that while there are two TSA shown, it is really one tank, the HMT, which is physically serving all areas.

Table 3.2.2-2. **Projected Population**

Growth per TSA for Tinian	Population Projections			
Existing Tank Service Areas	2010	2015	2020	2030
HMT TSA	2,302	2,248	2,425	2,860
QMT TSA	834	734	834	834
Total	3,136	2,982	3,259	3,694

Using per capita demand and population projections, the average water demands for 2015, 2020 and 2030 can be calculated. Table 3.2.2-3 presents the estimated projected demands for the existing tank service areas.

Table 3.2.2-3. **Projected Population Water Demands per TSA for Tinian**

Existing Tank Service Areas	2010	2015	2020	2030
HMT TSA	287,750	281,000	303,125	357,500
QMT TSA	104,250	91,750	104,250	104,250
Total	392,000	372,750	407,375	461,750

Note: Flows based on the per capita demand value of 125 gal/capita/day.

Revision to the tank service areas have been recommended as part of this Master Plan, see Appendix I. Tables 3.2.2-4 and 3.2.2-5 present the revised TSAs with the population reallocated and the corresponding flows. The overall system water demands remain unchanged, but the spatial distribution is changed through the development of the new TSAs.

Table 3.2.2-4. **Projected Population per Updated TSA for Tinian**

Proposed Tank Service Areas	2010	2015	2020	2030
HMT TSA	363	363	486	921
QMT TSA	834	734	834	834
New San Jose TSA	1,939	1,885	1,939	1,939
Total	3,136	2,982	3,259	3,694

Table 3.2.2-5. **Projected Population Water Demands per Updated TSA for Tinian**

Proposed Tank Service Areas	2010	2015	2020	2030
HMT TSA	45,375	45,375	60,750	115,125
QMT TSA	104,250	91,750	104,250	104,250
New San Jose TSA	242,375	235,625	242,375	242,375
Total	392,000	372,750	407,375	461,750

3.2.3 Summary

A new water storage tank to serve the San Jose Village area has been recommended as part of this Master Plan. The new San Jose Village TSA will be served through a new half million-gallon tank located at an elevation of 150ft. Further discussion on this recommendation is provided in section 4.3 of this master plan. This recommendation is for operation and maintenance cost savings and isn't considered an "urgent" project. The prioritization of this project is also discussed in Section 4.3.

3.3 Wastewater Flow Projections

Analysis of future wastewater flows is not discussed in this Master Plan. Tinian currently relies entirely on private septic systems for disposal and treatment of wastewater. It is possible in the future that CUC may want to convert some or all residents from septic system usage to using CUC-owned sewers for disposal of wastewater. This would require construction of entirely new infrastructure, including collection systems, lift stations, and treatment facilities. A wastewater collection and treatment needs analysis study was identified and included in the CIP development section of this report (Section 5.3).

3.4 Status of "Construction Works in Progress"

Table 3.4.1 lists the construction projects that have been in progress or been completed since 2011.

Table 3.4-1. Ongoing CUC Water and Wastewater Projects as of May 11, 2012

CUC Project Number	Project Name	Project Description	Funding Source	Project Status
Water12-003	Tinian Valve and PRV Replacement	Valve replacement or installation is needed at various locations within the water system. Most notably are pressure-reducing valves that either do not serve any customers or serve an entire pressure zone.	EPA	Design
Water12-012	Well and Lift Station Transformer Upgrades	This project will correct electrical problems at existing well and lift stations caused by improper installation of electrical service, where 3-phase motors are being driven in an "open delta" configuration where only two transformers are installed. Incorrect 3 phase installations can lead to premature motor failure, which CUC has experience in numerous wells and lift stations. This project will include the purchase and installation of 3-phase transformers and necessary appurtenances at wells and lift stations located throughout Saipan, Tinian, and Rota.	EPA	Design

3.5 Assessment of Current CUC Management Policies, Procedures, and Operating Rules and Regulations for Water and Wastewater Systems

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

3.5.1 Management Organization

This subsection focuses on the overall CUC organization, the organization of the Engineering Department within CUC, and the Water Task Force.

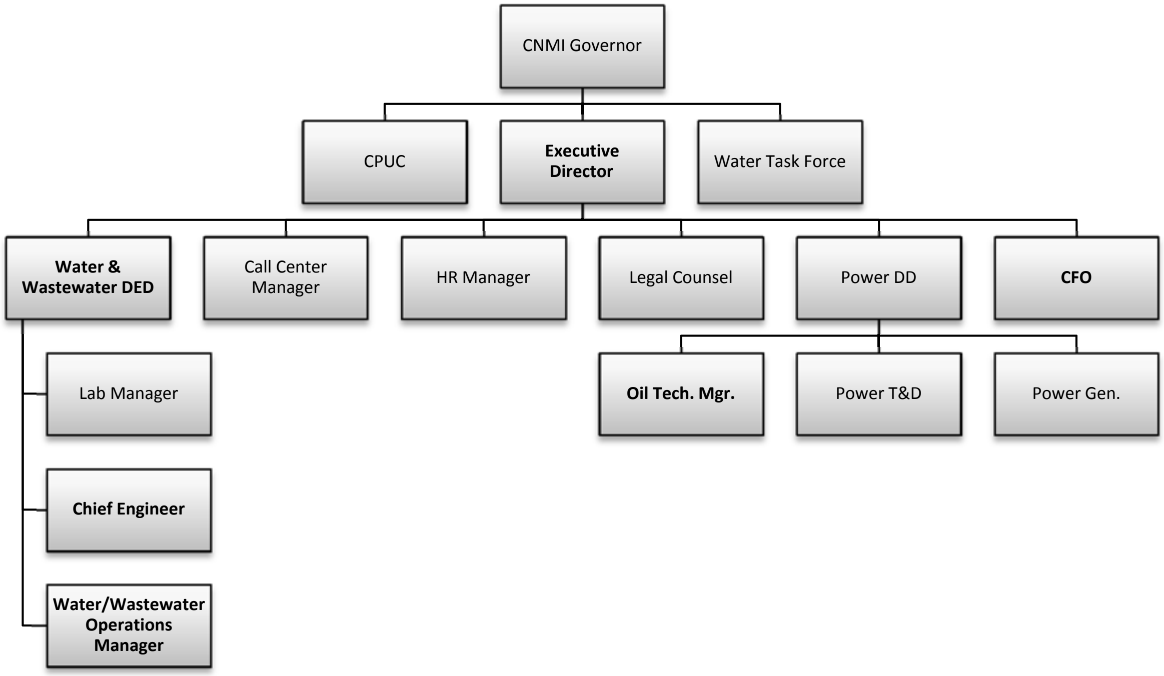
CUC Organizational Structure

The current upper management layer of CUC is shown in Figure 3.5.1-1.

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 3.5.1-1 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 3.5.1-1. **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.

3.5.2 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 Q. 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.

3.5.3 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.

3.5.4 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.

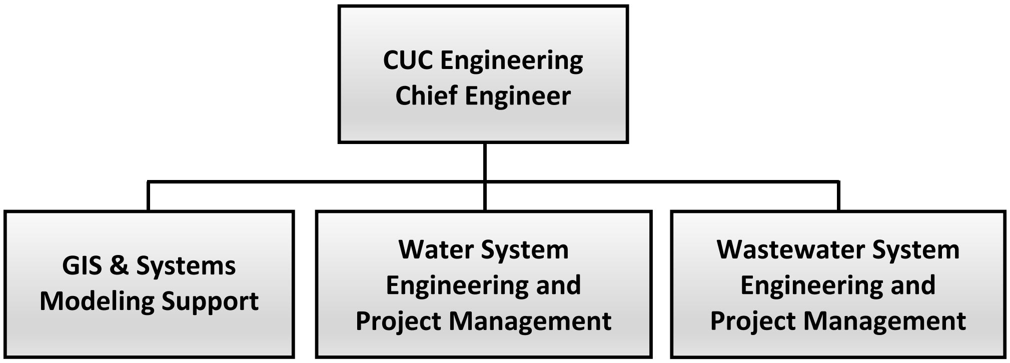
Management Structure: Engineering and the Integration of the Water Task Force, GIS, and Systems Modeling Under the Engineering Function

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 3.5.4-1 is a proposed organization chart that reflects the above recommendations.

Figure 3.5.4-1. **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

Drinking Water System Master Plan

The contents of Section 4, “Drinking Water System Master Plan” are as follows:

4.1 Stipulated Order Planning and Compliance Requirements for the Drinking Water Master Plan 4-3
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4.1 Stipulated Order Planning and Compliance Requirements for the Drinking Water 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, for both water and wastewater systems.

Table 4.1-1. **Requirements of the Stipulated Order**

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Tinian Water and 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, CH2M	3.4, 3.5	Tinian Master Plan
III.B.B1.51	Wastewater Assessment	Wastewater Master Plan	N/A	N/A	N/A
III.B.B1.52	Condition Assessment for the Wastewater Systems	Wastewater Master Plan	N/A	N/A	N/A
III.B.B1.53	Drinking Water Assessment	Drinking Water Master Plan	CUC, CH2M	3.1.2, 3.1.3, 3.1.6	2.2
III.B.B1.54	Assessment of Drinking Water Technological Alternatives	A comprehensive review of available technologies, identify preferred alternatives, and technological alternatives to improve systems' pressures and delivery.	CUC, CH2M	3.4.3, 3.4.4	2.2.2, 2.2.3, 4.2
III.B.B1.55	Condition Assessment of Drinking Water Systems	Drinking Water Master Plan	CUC, CH2M	3.1.2, 3.1.3	2.2.2
III.B.B1.56	Assessment of Drinking Water Systems Improvement Alternatives	A comprehensive assessment of the drinking water systems' improvement needs and alternatives for meeting the appropriate standards in the next 20 years.	CUC, CH2M	3.4.2, 3.4.3, 3.4.4	2.2.2, 2.2.3, 4.3
III.B.B1.57a	Hydraulic Capacity Assessments (Wastewater)	Wastewater Master Plan	N/A	N/A	N/A

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Tinian Water and Wastewater Master Plan
III.B.B1.57b	Hydraulic Capacity Assessments (Drinking Water)	Drinking Water Master Plan	CUC, CH2M	3.1.7, 3.4.5	2.2.3
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	N/A	N/A	N/A
III.B.B1.59	Reliability Assessment	Assessment of reliability of drinking water and wastewater systems to ensure continuous operation	CUC, CH2M	3.4.2, 3.4.3,3.4.4, 3.4.5	2.2
III.B.B2.60a	Develop Plans for Upgrades and Repairs to Drinking Water Systems	See Drinking Water Master Plan	CUC, CH2M	3.4.6	4.3
III.B.B2.60b	Develop Specific Recommendations Based on Water Hydraulic Monitoring	See Drinking Water Master Plan	CUC, CH2M	3.4.5, 3.4.6	2.2.3, 4.3.1
III.B.B2.60c	Develop Schedule for Repair, Rehabilitation, and Replacement	Priorities and schedules for drinking water and wastewater systems components to provide continuous operation	CUC, CH2M	3.4.6	4.3
III.B.B2.61	Develop an Asset Inventory	Drinking Water Master Plan; Wastewater Master Plan	CUC, CH2M	3.1.2, 3.2.2	2.2.5
III.B.B2.62	Development of a Geographic Information System (GIS)	Drinking Water Master Plan; Wastewater Master Plan	CUC, CH2M	3.1.8, 3.2.5	2.2.4
III.B.B2.63	Develop Recommendations	Specific evaluations and recommendations	CUC, CH2M	3.4.1, 3.4.4	3.5.3, 4.3.1

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Tinian Water and Wastewater Master Plan
	for an Alternative Control System	for process control system improvements			
III.B.B2.64a	Develop a Drinking Water Infrastructure Improvement Plan	Drinking Water Master Plan	CUC, CH2M	3.4.4, 3.4.6, 3.6.3	4.3
III.B.B2.64b	Develop a Wastewater Infrastructure Improvement Plan	Wastewater Master Plan	CUC, CH2M	3.5.6. 3.6.3	5.3
III.B.B2.65	Develop Final Financial Plan	Estimated Annual Budget for next 5-years; Revenue Plan for All Compliance Activities	CUC, CH2M	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5	See Financial Plan
III.B.B3.66a	Develop Scope of Work and Request for Proposals	Scope of Work and Request for Proposals (RFPs)	CUC, CH2M	This refers to the RFP for the development of this MP. Not relevant.	N/A
III.B.B3.66b	Selection of Contractors	Selection and approval of contractors	CUC, CH2M	This refers to the contractor for the development of this MP. Not relevant.	N/A
III.B.B3.66c	Drafts of Master Plan	See Drinking Water and Wastewater Master Plans	CUC, CH2M		Tinian Master Plan
III.B.B3.66d	Final Draft of the Master Plan and Financial Plan	Master Plans	CUC, CH2M		
III.B.B3.66e	Public Comment on Master Plan	Press release and public notice in local newspaper	CUC, CH2M		
III.B.B3.66f	Completion of Master Plan	Completed Master Plan addressing Public Comments	CUC, CH2M		
III.B.B4.67a	Develop and Implement a Groundwater Management and Protection Program - Interagency Coordination	Coordination of all CNMI resources agencies involved with groundwater resources	CUC		Groundwater Management and Protection Plan (separate document)

Stipulated Order Reference	Task	Description of End Product	Task Lead	CH2M SOW Reference	Tinian Water and Wastewater Master Plan
III.B.B4.67b	Develop and Implement a Groundwater Management and Protection Program - Groundwater Restoration	Programs and Projects to restore contaminated wells and groundwater resources	CUC		Groundwater Management and Protection Plan (separate document)
III.B.B4.67c	Develop and Implement a Groundwater Management and Protection Program - Compliance with Applicable CNMI Statutes and Regulations	Demonstration of compliance with CNMI Regulations	CUC		Groundwater Management and Protection Plan (separate document)
III.B.B4.67d	Develop and Implement a Groundwater Management and Protection Program - Sustainable Withdrawals of Groundwater	Programs to manage groundwater withdrawals	CUC		Groundwater Management and Protection Plan (separate document)
III.B.B4.67e	Develop and Implement a Groundwater Management and Protection Program - Leakage Reduction	Projects that monitor and reduce leakage in water distribution lines	CUC		Groundwater Management and Protection Plan (separate document)
III.B.B4.67f	Develop and Implement a Groundwater Management and Protection Program - Capacity Building	Recruitment of a qualified groundwater hydrologist	CUC		Groundwater Management and Protection Plan (separate document)

4.2 Water System Planning and Design Criteria

The intent of this section is to provide water system planners and designers with a guide for planning and designing water system infrastructure improvements. Information provided in this section was used as the basis for the recommended water capital improvements plan (CIP). Design criteria for design period, pipe pressures, system demands, pipe velocities, tank storage sizing, control elevations, and water treatment are discussed in this section. The information and guidance provided herein may be referenced in the scopes of work for water system design in CNMI. References to AWWA Standards and the Great Lakes – Upper Mississippi River Board's 2012 Recommended Standards for Waterworks (10 States Standards) are 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 into consideration when developing basic design criteria for the recommended water system capital improvement projects, including current and projected future water demands, period of design, and financial capabilities of CUC. In general, the design criteria are based on conformance to current standards and waterworks practices. This Section lists the key design criteria used to identify recommended water distribution system improvements and to develop conceptual water supply and treatment alternatives.

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 water 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 period assumed for specific water system components is based on factors such as ease of expansion/upgrade, service life of the system, and the financial capabilities and resources of CUC.

Piping and structural components of treatment facilities, pumping stations, and distribution storage facilities are normally expected to remain functional for 50 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 water demands, and financial capabilities of CUC.

Water distribution mains are components that have a relatively high construction cost. However, once in place, distribution mains cannot be expanded to meet increased demands. Secondary parallel pipelines must be installed, or pressure must be increased in the existing mains to meet increased demands, invariably resulting in an increase in energy costs. As such, pipe sizing during the design phases of the capital improvement projects must account for anticipated future increases in water demand. Installation of larger-size pipes that exceed current demand requirements to account for future demand considerations can be accomplished at a minimal or modest increase in construction cost. The capital improvement projects recommended in this Master Plan call for the installation of water distribution mains that account for projected future demands.

4.2.2 Phased Upgrades

The mechanical components, such as pumps and motors, of treatment facilities and pumping 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 whether the first phase can be integrated and placed online without subsequent phases occurring until later in the future. Construction of dormant improvements should be discouraged because of rapid deterioration associated with systems being out of service.

4.2.3 System Pressures

System design pressures for ordinary service should be greater than 35 psi and preferably in the 60 to 80 psi range (10 States Standards). During extreme conditions, a minimum residual pressure of 20 psi should be maintained in the system (10 States Standards).

Site topography must be considered when designing water distribution systems. Hilly or mountainous areas require higher pressures to supply higher elevations, often resulting in excessive pressures in adjacent areas with lower elevations. To prevent this condition, pressure zones must be established to separate areas of higher elevation from areas of lower elevation. High-pressure zones require the use of costly system components such as high pressure-rated piping, fittings, and valves. In general, pressures in excess of 80 psi should be avoided. However, in those situations when high pressures cannot be avoided, installation of individual household pressure regulators is recommended.

4.2.4 System Control Elevations

The topography throughout CNMI is rugged. As a result, the CUC water system is best served by strategically establishing multiple water tank service areas with separate hydraulic grades. It is good engineering practice to have hydraulic grades set by the water level of tanks rather than by a pump or a closed (direct feed) system. The current CUC water system CIP has focused on the installation of dedicated water transmission and distribution lines, resulting in the hydraulic grades of about 90 percent of Saipan's water service areas being controlled by storage tank elevations. The following are water system control-related recommendations:

- Wherever feasible, CUC water customers should be served by a distribution line connected to a storage tank. Pressure Reducing Valves (PRVs) are suggested to reduce high pressures to preferred service pressures (see Section 2.2.2 for a description of “high” pressures).
- Some of the smaller and isolated areas within the CUC system cannot be included in a tank service area. These areas currently use a booster pump system to provide the needed pressure (head). For such systems, the following are recommended:
  - Pump systems and pneumatic tanks sized according to the 10 States Standards.
  - Air relief valves (ARVs) located at the upper portion of the areas served by the booster pump.
  - The designer must pay careful attention to conditions on the suction side of the pump system. The pump should not cause a drop in system pressure below the recommended pressure listed.

Table 4.2-1 provides the existing and proposed hydraulic grades for the Saipan tank service areas. The (new) hydraulic grades were established for the Master Plan CIP.

Table 4.2-1. **Existing and Proposed Hydraulic Grades for the Tinian Tank Service Areas**

Service Area	Existing Tank Finished Elevation (ft)	Average Existing Hydraulic Grade	Proposed (New) Hydraulic Grade
HMT TSA	404	432	432
QMT TSA	338	372	-[1]

New San Jose TSA	180	-[2]	200

[1] This tank may be taken out of service

[2] This is a proposed TSA with no existing conditions

4.2.5 Distribution System Piping and Appurtenances

All potable water piping, fittings, and valves should comply with the latest standards issued by the American Society for Testing and Materials (ASTM) and/or AWWA as follows:

- Minimum line size of water distribution mains: 6 inches in diameter.
- All material in direct contact with potable water will be National Sanitation Foundation (NSF) certified for potable water use.
- Water main velocities should range between from 2 to 5 feet per second (ft/s). However, in some cases, velocities up to 7 ft/s may be used. Such cases include peak flows along laterals serving four to five households. Velocities up to 10 ft/s can occur during extreme events but should not be the normal system condition. Planners and designers must avoid creating conditions where high velocities (> 5 ft/s) pass by low-flow laterals. Such a condition can and does result in a Venturi effect where the pressure in the lateral drops, resulting in a back-siphoning effect and potential cross connection.
- Water valves along new/upgraded distribution mains will be provided, at a maximum, every 750 feet for commercial use and every 1,000 feet for residential use. Dead ends should be avoided wherever possible. If a dead end must be installed, a means for flushing the dead-end piping must be provided.
- Disinfection of newly installed and/or upgraded water distribution systems or their components will follow the requirements set forth in the latest edition of AWWA C651 (2005).
- Pressure testing of newly installed and/or upgraded distribution system will follow AWWA C600 requirements (2010).
- New and rehabilitated water mains must be kept at a safe distance from possible sources of contamination and cross connection. Water mains will be installed at least 10 feet from (edge to edge) existing manholes, storm water collection lines, and sewage disposal systems such as septic tanks and leaching fields. In cases where it is not practical to meet such separation, CUC may consider a waiver on case-by-case basis. In such cases, additional protection measures such as concrete encasement or encasing in a segment of large pipe may be required.
- Where crossings occur, the water line will be placed above the possible source of contamination. A minimum separation of 18 inches (edge to edge) will be provided. In addition, water line joints will be installed such that maximum separation is provided between the crossing and joints.

It is recommended that the AWWA Manual M22 Sizing Water Service Lines and Meters (2004) be used as the basis for sizing laterals and meters.

Distribution Storage

The sizing of all future storage tanks shall follow guidelines provided in the latest edition of the Ten-State Recommended Standards for Water Works. Applicable provisions are as follows:

- The minimum size for the distribution storage tanks should be equal to the average daily consumption of a tank's service zone rounded up to the next largest nominal tank size (i.e., 0.25, 0.5, 1.0 MG).

- Disinfection and testing of newly installed potable water storage tanks will follow the requirements of AWWA for the appropriate tank type.

Water Tank Construction

There has been recent discussion among CUC officials with respect to the use of concrete as the material of choice for new and replacement water tanks. The lifespan of a properly-constructed concrete tank is typically longer than that of a steel tank. Given the current poor condition of the majority of CUC steel tanks and the corrosive effects of the local environment, the use of concrete is recommended. However, cost and site constraints may preclude the use of concrete. Steel tanks generally have a lower capital cost than that for concrete, but have a shorter lifespan and require comparatively more maintenance. CUC should, on a project-by-project basis, compare the 20-year lifecycle cost of steel and concrete in the context of available funding to determine the tank material of choice.

The hydraulics and inlet and outlet configuration of any new or rehabilitated tank must be carefully analyzed, taking into account factors such as mixing, system controls, and operations. The following are suggested for tank hydraulic configurations:

- Use of separate inlet and outlet lines should be considered, having the inlet and outlet located at opposite ends of the tank.
- Provisions for tank bypass should be installed to allow periodic cleaning and physical inspection of the tank.
- Tank baffling or alternative mixing technology should be considered, particularly for tanks with storage capacity of 1 million gallons or greater.
- Inlet controls such as pressure sustaining valves and/or altitude valves must be carefully designed with much care given to avoid overdesign. In addition, due consideration must be given to accommodate low-flow bypasses.

4.2.6 Supply

CUC utilizes an infiltration gallery to provide for and meet the potable water demand for Tinian. In 2011, the average daily CUC water production on Tinian was 0.93 MGD. Of this amount, only 26 percent was metered. It is presumed that a significant percentage of the 74 percent of unaccounted for water is lost though leakage, theft, and overflow.

Efforts to control leaks, theft, and overflow have not yet been initiated in Tinian. These efforts, which include leak detection, metering, and improved system operations, should be initiated. The need for new water wells and or other supply sources may become unnecessary if efforts are made to reduce water loss. Additional discussion on this topic can be found in Section 2.2.2, “Leak Detection and Drinking Water Conservation Programs.”

4.2.7 Water Treatment (Disinfection)

Chlorine disinfection is currently the primary form of water treatment used by CUC. The typical disinfection system consists of an ejector, rotameter, chlorinator, scale, tubing, and booster pump. It has been common practice to eliminate the use of a booster pump and discharge the chlorinated solution to a free water surface (spring or infiltration gallery), a method that is not recommended and should be corrected. Good engineering practice should be used when sizing the chlorine booster pumps. This commonly requires the system back-pressure and chlorine feed rate be thoroughly evaluated. Typical sizes within the CUC water system can range between ¾ and 2 hp. In addition, the chlorine booster pump must be elevated at least 2 inches above the chlorine station's finished floor surface.

Chlorine cylinder scales and automatic switch-over controls should be provided at every chlorination station. Furthermore, a chlorine detection alarm should be provided at each chlorination station as well as other locations where chlorine is stored. Chlorine sensors and data processors should be installed downstream of all chlorination stations.

4.2.8 Water Quality

The CUC water system is permitted through the EPA and must adhere to the local and federal regulations for potable water systems. At a minimum, the following must be applied:

- A DEQ-approved Sampling Plan that establishes a routine distribution sampling event that is representative of the entire distribution system.
- A detectable disinfection residual, or Heterotrophic Plate Counts below 500 colony forming units, must be maintained at all times in all locations throughout the water distribution system. CUC will monitor and record disinfection residual as part of its sampling plan. CUC must establish clear operating procedures for sites that require a booster pump to activate the chlorination equipment. This operating procedure must have scenarios developed for point failure of these chlorination systems. In most cases, automatic switch-over and system shutdown should be incorporated into each chlorination system. Chlorination facilities should have continuous chlorine monitoring in place to document the level of chlorine residual at all entry points into the distribution system.
- CUC will have an action plan to respond to internal corrosion and deposition problems within the distribution system. At a minimum, this plan should include:
  - Sampling and monitoring for pH, alkalinity, conductivity, phosphates, silicates, calcium, and metals
  - Procedure for iron and lead control
  - Guidelines for controlling corrosion-related byproducts
- CUC will develop a systematic flushing program that takes into account the current condition of the distribution system, hydraulic capacity, dead ends, low flow areas, aesthetic water quality problem areas, and other known problem areas.

4.2.9 Summary of Key Water System Design Criteria

Table 4.2.9-1 presents the key water system design criteria and associated metrics.

Table 4.2.9-1. **Summary of Key Water System Design Criteria**

Criteria		Metric
I.	Design Period	
A.	Planning for future capital improvements	20 years
B.	Useful life of mechanical equipment	10 to 20 years
C.	Piping	50 years
II.	System Pressures	
A.	Minimum normal service	35 psi
B.	Normal service	60 to 80 psi

Table 4.2.9-1. **Summary of Key Water System Design Criteria**

Criteria	Metric
C. Not-to-exceed (provide PRV)	100 psi
D. 24-hour transitional systems or unusual events	20 psi (minimum)
III. System Demands	
A. Average per capita use in Rota	125 gpd/capita
B. Unaccounted-for water in Rota	84 percent
IV. Distribution System Piping and Appurtenances	
A. Distribution main pipe diameter (minimum)	6 inches in diameter
B. Dead ends	Equip with adequate flushing devices to provide flows with minimum velocity of 2.5 fps. Flushing devices will not be directly connected to the sewer.
C. Gate/shut-off valve spacing	
1. Commercial	750 feet (maximum)
2. Other districts	1 block or 1,000 feet (maximum)
3. Serving widely scattered customers	1 mile (maximum)
D. Air-relief and blow-off valves	Provide air-relief valves at high points and blow-off valves at low points. Manual valves are recommended.
E. Separation distances (from sewer, septic tank, or subsoil treatment systems)	
1. Parallel installation	10-feet horizontal, edge to edge. When this is not practical, the reviewing authority may allow deviation if supported by data provided by the design engineer.
2. Other districts	18-inches vertical, edge to edge. A water main is preferred to be above a sewer. One full length of pipe will be located so that the joints on each end will be located as far away from the sewer as possible.
F. Surface water, drainage structure and bridge (above-grade) crossings	
1. Above-grade crossings	Provide adequate supports/anchors, protection from vandalism and damage while remaining accessible for repair/replacement.
2. Underwater, underwater course crossings	Minimum 5 feet of cover; if crossing length exceeds 15 feet, requires flexible, restrained, or watertight joints, valves at both ends, and permanent taps for metering to determine leakage and to obtain water samples on each side of the valve closest to the supply source.

Table 4.2.9-1. **Summary of Key Water System Design Criteria**

Criteria			Metric
	G.	Interconnections	Interconnections between potable water supplies must be approved by the reviewing authority with differences in water quality to be considered. Appropriate backflow prevention devices must be installed. CUC has drafted a cross-connection manual that will establish requirements and guidelines for all interconnections.
	H.	Service meters	Each service connection will be individually metered.
	I.	Pipe Friction (Hazen-Williams) Coefficients ("C")	
		1. Existing pipes 12 inches and smaller (for modeling)	100
		2. Existing pipes 12 inches and smaller (for modeling)	100
		3. New pipes 12 inches and smaller	120
		4. New pipes 14 inches and larger	120
V. Distribution Storage			
	A.	Capacity	To meet project future demand requirements in each sub-region with the total volume to meet the daily demand.
	B.	Disinfection and testing	Disinfection and testing of newly installed potable water storage tanks will follow the requirements of AWWA 652 for the appropriate tank type.
VI. Supply			
	A.	Wells Capacity (Primary Supply)	Total developed groundwater source capacity will meet or exceed the design maximum day demand with the largest producing well offline.
	B.	Surface Water Capacity (Primary Supply)	Meet maximum projected water demand of the service area based on calculations of a 1 in 50-year drought or the extreme drought of record, with multiple year droughts considered.
		1. Meet maximum projected water demand of the service area based on calculations of a 1 in 50-year drought or the extreme drought of record, with multiple year droughts considered.	
		2. Surplus for projected growth.	
		3. Adequate to compensate for losses (seepage, silting, evaporation, etc.).	
VII. Water Treatment			
	A.	Groundwater	Disinfection (as required)
	B.	Surface water	Appropriate technology based on water quality followed by disinfection

4.3 Drinking Water System Recommendations

This section of the Master Plan presents the methodology for identification of projects to be included in the capital improvement plans, as well as the development of cost estimates and implementation schedule for the water capital improvement projects.

4.3.1 Drinking Water System Project Identification and Prioritization

This section presents the results of a series of project identification and prioritization workshops conducted in June 2012 and February 2015 for CUC. The objects of the workshops were the water and wastewater systems of 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 20-year CIPs.

During the week of February 9 through 13, 2015, the project team, CUC, DEQ, and USEPA Region 9 met to conduct a complete reassessment of the water capital improvement projects for Saipan, Tinian, and Rota. These workshops were held due to the significant amount of capital improvement work performed over the prior 3 years since the original assessment, staffing changes, and the need to reexamine the original list of CIP projects and the addition of other projects.

Over the previous 4 years, 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 Master Plans as part of the 2-year, 5-year, and 20-year capital improvement plans.

This section describes the effort to identify all projects and rank them based on decision criteria that were developed specifically for CUC's water system. This process is a completely separate ranking process from that documented in the Risk Assessment Section (2.2.5), 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 divided into the following subsections:

- Project Identification. Development of a list of projects designed to rehabilitate and improve the water 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 water 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 Drinking Water Infrastructure Needs Survey (DWINS) Project Prioritization List
    - DOI and OIA Project List
- CUC-Identified Projects

Each is discussed below.

Condition Assessment Field Reports

Early in the project the project team performed condition assessments in the field of CUC's drinking water infrastructure, including both "vertical" assets (e.g., above-ground assets such as booster pump stations) and "linear" assets (e.g., below-ground assets such as distribution 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 water system. Many of these proposed projects are documented in Section 2.2.2, "Condition Assessment of Existing Water Facilities," of this Master Plan.

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 water 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 Section 2.2.5 of this Master Plan. 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 water distribution transmission and distribution systems. These proposed projects were appended to the master project list after undergoing review.

Drinking Water Infrastructure Needs Survey Projects

The Safe Drinking Water Act requires that the EPA conduct an assessment of the national public water system capital improvement needs every 4 years, called the Drinking Water Infrastructure Needs Survey (DWINS). The purpose of the survey is to document the 20-year capital investment needs of public water systems that are eligible to receive Drinking Water State Revolving Fund (DWSRF) monies. The survey reports infrastructure needs that are required to protect public health, such as projects to ensure compliance with the Safe Drinking Water Act (SDWA). As directed by the SDWA, EPA uses the results of the survey to determine the allocation of the hundreds of millions of annual DWSRF dollars to the states and tribes for helping build and improve the nation's infrastructure for delivering safe drinking water. The SRF dollars cannot be used for operation, maintenance, or monitoring related projects.

CUC last completed DWINS in 2011 for Saipan, Rota, and Tinian needs. The proposed projects are identified by CUC and then scored in accordance with scoring criteria established by CNMI Division of Environmental Water Quality (DEQ). The scoring of projects results in a prioritized list that is submitted for review and approval by EPA Region 9. Projects proposed by CUC in the 2011 DWINS and approved by DEQ and EPA—but not yet implemented—were added to the master project list for further consideration and scoring.

Miscellaneous Grant Projects

CUC provided the project team with a list of additional projects that were submitted for grant funding consideration by the Department of Interior (DOI), and the Office of Insular Affairs (OIA). Appendix R provides the list of DOI and OIA grant-funded projects. These projects were added to the master project list for ranking if they were not already implemented.

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 two sets of criteria to help determine the relative merits of proposed water projects. These criteria were further refined to distinguish the varying needs of Saipan, Tinian, and Rota. Each major criterion will be discussed separately.

Water System Criteria

The primary consideration for potential water projects was driven by the criteria DEQ employs under the DWINS framework. CUC project management elected to incorporate the DWINS criteria exactly as written by DEQ; this DEQ document is included as Appendix T. The DWINS criteria include public health and system improvement considerations:

- Public Health
  - Mitigation of current public health issue(s)
- System Improvements
  - Increases water conservation
  - Provides 24-hour water
  - Improves water quality (in regards to secondary standards)

  - Provides water to another tank service area allowing for well abandonment
  - Improves infrastructure inadequacies
  - Increases safety to the public and/or operators

In addition to the DWINS criteria that CUC is mandated to use to receive SRF funding, CUC decided to include supplementary criteria that CUC has identified as important considerations for developing and approving projects in-house. The CUC criteria was proposed and defined by CUC engineering and field staff. The CUC-identified criteria are as follows:

- Increases water quality (in regards to primary standards)
- Removes potential or known cross-connections or negative pressure issues
- Supports Emergency Response Plan (ERP)
- Population served
- Reduces energy consumption
- Right-of-way issues
- Meets stipulated order requirements
- Protects water resources
- Environmental factors
  - Environmental permits/process required
  - Environmental impacts

The CUC-specific criteria are defined in further detail in Appendix U. The environmental criteria included there originated from the DWINS criteria document (Appendix T), but were not considered mandatory by DEQ. For this reason, the environmental factors are considered CUC-identified criteria. 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 DWINS criteria were assigned based on the DWINS criteria documents drafted by DEQ (Appendix T). CUC management and staff provided the final weightings for CUC-identified criteria for the water 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.

Water System Criteria Weighting

The maximum possible water project score was 320 points; the point contribution associated with each criterion is discussed below:

- Public Health (EPA required) – 100 points: As dictated by DWINS requirements
- System Improvements (EPA required) – 60 points: As dictated by DWINS requirements; consists of six 10 point sub-criteria; however, it's important to note that when used by DEQ for SRF awards, only three may be considered for a maximum of 30 points. All six have been included in the project prioritization process to provide the fullest range of information about a project.
- Environmental Impacts (EPA non-mandatory) – 60 points: CUC elected to proportion 24 and 36 points respectively for the two environmental sub-criteria
- CUC Identified (not required) – 100 points: The individual points allotted among these sub criteria were determined in workshops and reflect differing priorities among the islands. Right-of-way issues, for example, are far more important on Rota than either Saipan or Tinian.

Table 4.3.1-1 summarizes the point distribution, or weighting, of the criteria and sub-criteria for the water project scoring process.

Table 4.3.1-1. **Water Project Scoring Criteria and Weighting**

Category	Criteria	Maximum Points	Sub-criteria	Maximum Points	Maximum Points	Maximum Points
EPA Required						
	Public Health	**100**				
			Mitigate Current Public Health Issues	100		
	System Improvements	**60**				
			Increases Water Conservation	10		
			Provides 24-Hour Water	10		
			Improves Water Quality re: Secondary Standards	10		
			Provides Water to Another TSA Allowing for Well Abandonment	10		
			Improves Infrastructure Inadequacies	10		
			Increases Safety - Public & Operators	10		
CUC Identified						
	Environmental Impacts	**60**		**Saipan**	**Rota**	**Tinian**
			Environmental Permits/Process Required	24	24	24
			Environmental Impacts	36	36	36
	CUC	**100**				
			Increases Water Quality re: Primary Standards	13	12	12
			Removes Potential/Known Cross-Connections or Negative Pressure Issues	18	13	13
			Support of ERP	7	7	7
			Population Served	10	8	9
			Reduces Energy Consumption	15	14	16
			Right-of-way (eliminates trespassing)	10	19	16
			Meets Stipulated Order Requirements	14	14	14
			Protects Water Resources	14	14	14
TOTAL		**320**		**100**	**100**	**100**

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 water 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 water 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.

Figure 4.3.1-1. **Tinian Water System Project Scores and Ranking**

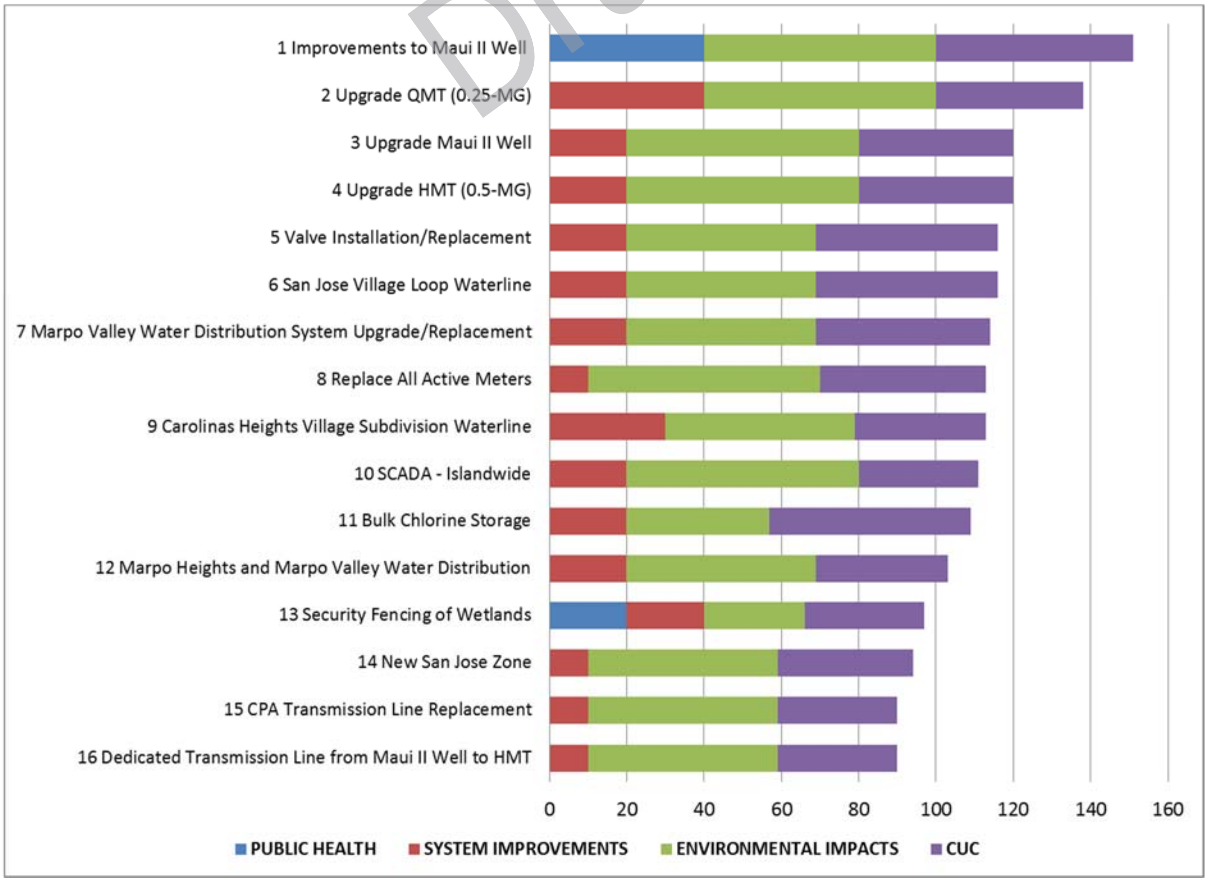


Figure 4.3.1-2. **Saipan Water System Project Scores and Ranking**

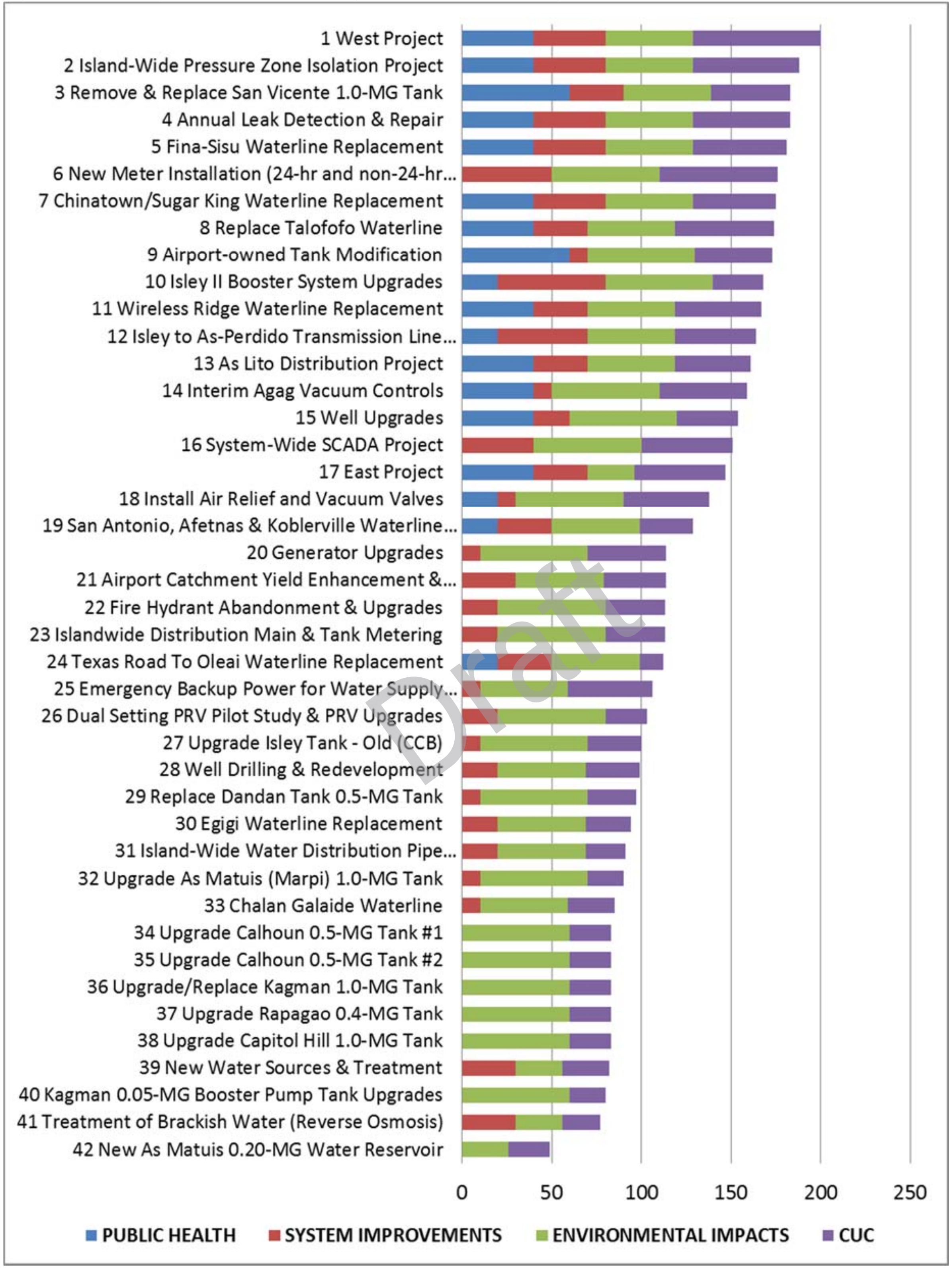
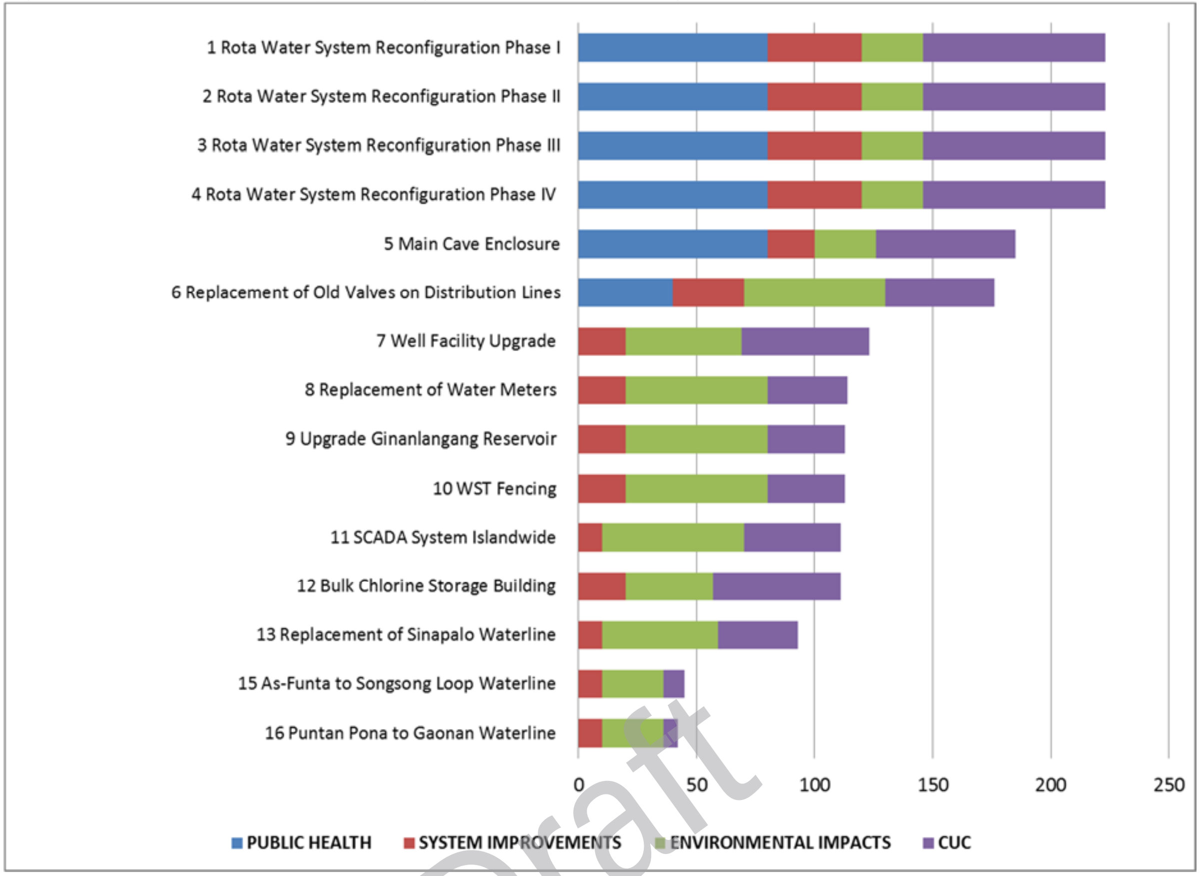


Figure 4.3.1-3. **Rota Water System Project Scores and Ranking**



CUC Tank Risk and Project Prioritization

To more accurately place tank projects into the CIP, which is an integral part of the Master Plan, it was decided that the individual tank risk scores would be evaluated in comparison to the CIP tank project rankings. Because the CIP project scoring criteria do not take into consideration the risk of failure of the assets affected by the proposed project, some tanks that are in severely poor condition did not make it to the top of the CIP project rankings. These tanks are critical to providing service to CUC customers. To ensure tanks in severe condition are prioritized in the CIP schedule, it is not possible to look at the CIP project rankings alone. As such, the risk scores for all tanks were assessed and those tanks that have a high risk of failure are prioritized in the CIP schedule to ensure that they are addressed in a timely fashion.

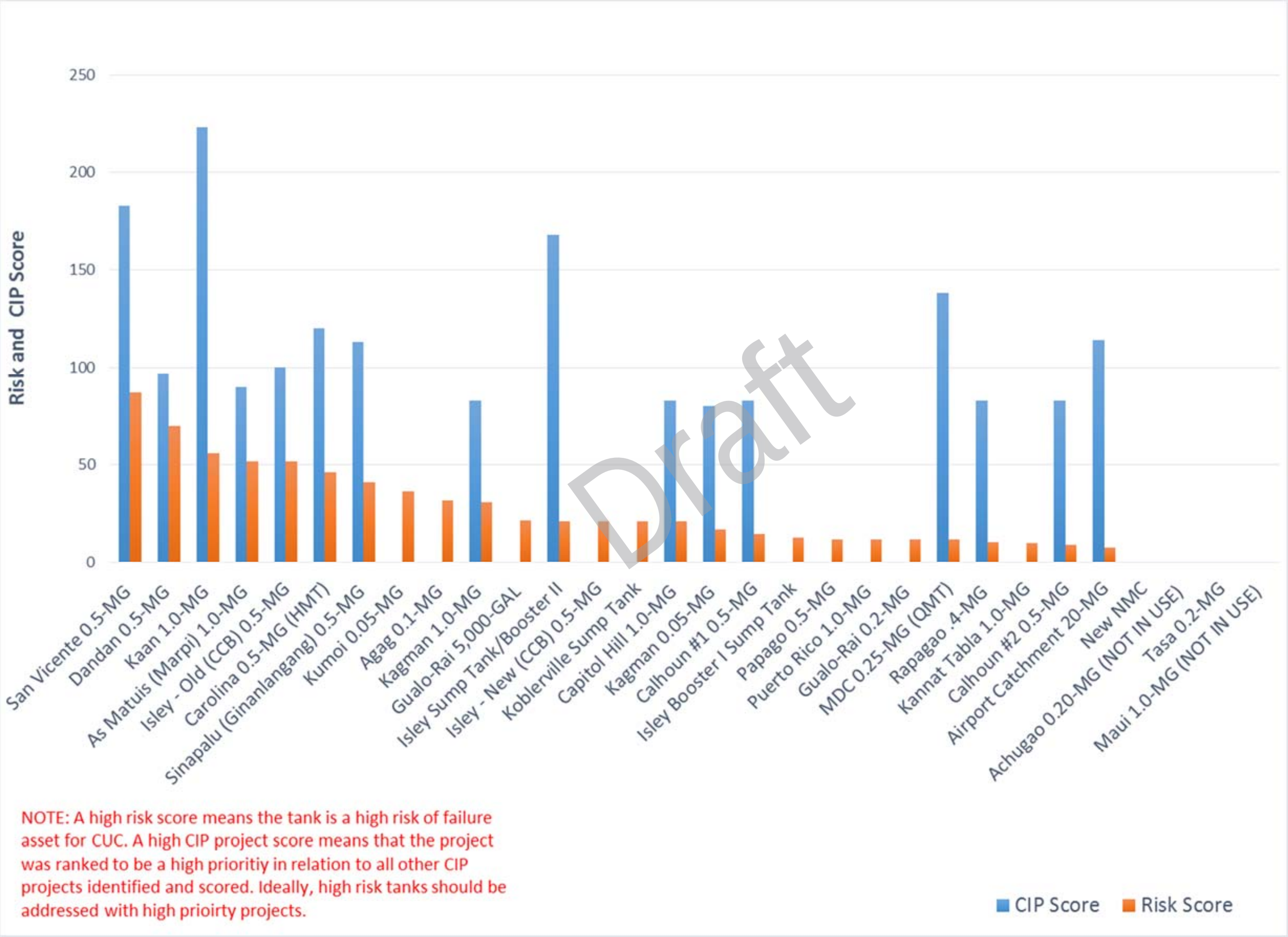
At the time of the final project ranking and prioritization workshop, it had been nearly 3 years since the asset risk scores were developed. During that 3 year period additional ACI inspections were performed on several tanks and additional knowledge was obtained; for this reason the observed condition of many tanks had changed since the initial risk assessments. To account for changing conditions, during the February 2015 project ranking workshops the tank risk scores were reassessed, specifically the likelihood of failure scores. Once the likelihood of failure scores, and thus the risk scores, for the tanks were updated, the risk scores were compared to the CIP project prioritization scores (Figures 4.3.1-1, 4.3.1-2, and 4.3.1-3). Several tanks do not have a corresponding CIP project; these tanks are listed below along with the reason they have not been included in a CIP project:

- Kumoi (0.05-MG) - currently being relocated.
- Agag (0.1-MG) - will be abandoned as part of the East Project.
- Gualo-Rai (5,000 gal) - tank is considered temporary.
- Isley Tank New (0.5-MG) - recently refurbished by CUC.
- Koblerville Sump Tank - to be abandoned.
- Isley Sump Tank/Booster 1 - very low risk tank; no project has been identified that will provide upgrades to this tank.
- Papago (0.5-MG) - new tank is under construction.
- Puerto Rico (1.0-MG) - new tank is under construction.
- Gualo-Rai (0.2-MG) - currently under design for replacement.
- Old NMC - To be replaced as part of the new West Project.
- Kannat Table (1.0-MG) - newly constructed.
- Kaan (1.0-MG) – this tank will be demolished as part of the Rota Water System Reconfiguration Phase II project.
- Ginanlangan Reservoir (Sinapalu Tank, 0.5-MG) - this tank will be replaced and relocated under the Rota Water System Reconfiguration Phase I project.

The highest-risk tanks for all three islands as listed below (in order of descending risk scores) are prioritized in the CIP and are scheduled during one of the next two 5-year CIP cycles:

- San Vicente (0.5-MG)
- Dan Dan (0.5-MG)
- Marpi (1.0-MG)
- Isley Tank Old (0.5-MG)
- Carolina/HMT (0.5-MG)

Figure 4.3.1-4. **Tank CIP Project Scores versus Tank Risk Scores**



NOTE: A high risk score means the tank is a high risk of failure asset for CUC. A high CIP project score means that the project was ranked to be a high prioritiy in relation to all other CIP projects identified and scored. Ideally, high risk tanks should be addressed with high prioirty projects.

4.3.2 Cost Development of Drinking Water System Prioritized Projects

This section and the associated Appendix V present the cost estimates and cost estimating approach for the projects identified in the Project Identification and Prioritization section of this Master Plan (4.3.1). The cost estimates will be used, in conjunction with the project prioritization results, to develop the 2-year, 5-year, and 20-year capital improvement plans as required by the Stipulated Order. 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 the costs and CIP development for Saipan, Rota, and Tinian are presented together in this Master Plan.

This section summarizes the results of the cost estimating effort for those projects chosen for inclusion in the Master Plan 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 water and wastewater systems

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, a location adjustment factor of 0.83 was used for Tinian.

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 Cost – the cost to operate and maintain the water or 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 water and 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 does 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 water or 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. Therefore, no O&M costs are presented in the section are attached in Appendix V.

The Association for the Advancement of Cost Engineering (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 viability, 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 appendix 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 provide the cost estimate details for the water systems, respectively. 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% – 5% of Capital Costs
Contingency	20%

4.3.3 CIP Project Identification and Costs

Projects were ranked (Section 4.3.1) based on a methodical scoring process after which the top ranking projects were selected for inclusion in the cost estimate exercises. The full project descriptions can be found in Appendix S. Capital and O&M costs were estimated for each of these projects utilizing the methodology and assumptions discussed previously.

The project ranking results (Section 4.3.1) are crucial 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 CIP due to budget and scheduling restraints; it is not feasible to be able to complete all 73 projects that were identified and scored within the 20-year CIP implementation period. The project team consulted with CUC management to identify those projects to be included in the cost estimation exercise based on the project scoring results shown in Figures 4.3.1-1 through 4.3.1-3. 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. As discussed in Section 4.3.1, the tanks with the highest risk scores were given special consideration for inclusion in the CIP and were included in the cost estimates.

The final projects selected for cost estimates were as follows:

- **Saipan water.** Cost estimates were developed for projects 1 through 25 on the ranked project list, as well as three projects that will reduce the risk of three high-risk tanks (As Matuis, Dan Dan, and Isley Tank old - CCB).
- **Rota water.** Cost estimates provided for projects 1 through 7 on the ranked project list.
- **Tinian water.** Cost estimates provided for projects 1, 2, and 4 on the ranked project list.

4.3.4 Prioritized Water 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. 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 water is presented in Table 4.3.4-1.

Table 4.3.4-1. **Assumed Available Budget for Capital Improvement Projects**[a]

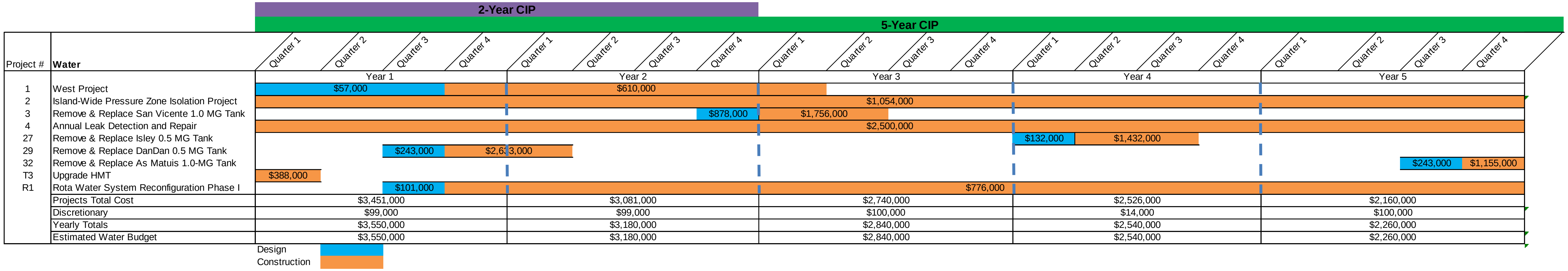
	FY2016	FY2017	FY2018	FY2019	FY2020
Water Grant Funding	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000

[a] Budgets were rounded to 3 significant figures. Actual budget estimates can be found in the Financial Plan.

2 and 5-Year CIP Development

Based on priority, projects for water were chosen for the 2- and 5-year plans and each project was divided into two phases (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. For the water projects, one of the top Tinian water projects was included in the 5-year CIP as presented in Figure 4.3.4-1. For the water 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. 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 according to the projects' relative prioritization. The complete prioritized projects are provided in Figures 4.3.1-1 through 4.3.1-3. Those projects in bold font are specific to Tinian.

Figure 4.3.4-1. **Project Sequencing for First 5-Year CIP (FY2016-FY2020)**



Project #	**Water**	Year 1	Year 2	Year 3	Year 4	Year 5
1	West Project	$57,000	$610,000			
2	Island-Wide Pressure Zone Isolation Project			$1,054,000		
3	Remove & Replace San Vicente 1.0 MG Tank		$878,000	$1,756,000		
4	Annual Leak Detection and Repair			$2,500,000		
27	Remove & Replace Isley 0.5 MG Tank				$132,000 $1,432,000	
29	Remove & Replace DanDan 0.5 MG Tank	$243,000 $2,633,000				
32	Remove & Replace As Matuis 1.0-MG Tank					$243,000 $1,155,000
T3	Upgrade HMT	$388,000				
R1	Rota Water System Reconfiguration Phase I	$101,000		$776,000		
	Projects Total Cost	$3,451,000	$3,081,000	$2,740,000	$2,526,000	$2,160,000
	Discretionary	$99,000	$99,000	$100,000	$14,000	$100,000
	Yearly Totals	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000
	Estimated Water Budget	$3,550,000	$3,180,000	$2,840,000	$2,540,000	$2,260,000

Design 🟦
Construction 🟧

20-Year CIP Development

For the 20-year CIP, it was assumed that the available funding assumed for the fiscal year 2018 would remain constant through the 20 year period for water. The 20-year CIP for water is presented in Table 4.3.4-2; projects specific to the island of Tinian are presented in bold in the table.

Table 4.3.4-2. **20-Year Water CIP Projects and Associated Costs**

Project Location	Project #[a]	Project Description[b]	1st 5-Year CIP (FY2016-2020)[c]	2nd 5-Year CIP (FY2021-2025)[c]	3rd 5-Year CIP (FY2026-2030)[c]	4th 5-Year CIP (FY2031-2035)[c]
Saipan	1	West Project	$ 667,000			
Saipan	2	Island-wide Pressure Zone Isolation Project	$ 1,054,000			
Saipan	3	Remove and Replace San Vicente 1.0-MG Tank	$ 2,634,000			
Saipan	4	Annual Leak Detection and Repair	$ 2,500,000			
Saipan	27	Upgrade Isley Tank – Old (CCB)	$ 1,564,000			
Saipan	29	Replace Dan Dan 0.5-MG Tank	$ 2,876,000			
Saipan	32	Upgrade As Matuis (Marpi) 1.0-MG Tank	$ 1,398,000			
Rota	1	Rota Water System Reconfiguration Phase I	$ 877,000			
Tinian	**4**	**Upgrade HMT (0.5-MG)**	$ 388,000			
		5-Year Total	**$ 13,958,000**			
Saipan	5	Fina-Sisu Waterline Replacement		$ 1,722,000		
Saipan	6	New Meter Installation (24-hr and non-24-hr zones)		$ 1,525,000		
Saipan	7	Chinatown/Sugar King Waterline Replacement		$ 1,485,000		
Saipan	8	Replace Talofofo Waterline		$ 220,000		
Saipan	9	Airport-owned Tank Modification		$ 8,000		
Saipan	10	Isley II Booster System Upgrades		$ 980,000		
Saipan	14	Interim Agag Vacuum Controls		$ 29,000		
Saipan	18	Install Air Relief and Vacuum Valves		$ 33,000		
Saipan	20	Generator Upgrades		$ 378,000		
Saipan	32	Upgrade As Matuis (Marpi) 1.0-MG Tank		$ 1,478,000		
Rota	1	Rota Water System Reconfiguration Phase I		$ 309,000		
Rota	2	Rota Water System Reconfiguration Phase II		$ 2,521,000		
Tinian	**1**	**Improvements to Maui II Well**		$ 60,000		
Tinian	**2**	**Upgrade QMT Tank (0.25-MG)**		$ 163,000		
		5-Year Total		**$ 10,911,000**		

Table 4.3.4-2. **20-Year Water CIP Projects and Associated Costs**

Project Location	Project #[a]	Project Description[b]	1st 5-Year CIP (FY2016-2020)[c]	2nd 5-Year CIP (FY2021-2025)[c]	3rd 5-Year CIP (FY2026-2030)[c]	4th 5-Year CIP (FY2031-2035)[c]
Saipan	7	Chinatown/Sugar King Waterline Replacement			$ 2,969,000	
Saipan	8	Replace Talofofo Waterline			$ 1,982,000	
Saipan	11	Wireless Ridge Waterline Replacement			$ 1,755,000	
Saipan	16	System-wide SCADA Project			$ 800,000	
Rota	2	Rota Water System Reconfiguration Phase II			$ 2,522,000	
Rota	3	Rota Water System Reconfiguration Phase III			$ 572,000	
Rota	4	Rota Water System Reconfiguration Phase IV			$ 141,000	
Rota	5	Main Cave Enclosure			$ 69,000	
Rota	6	Replacement of Old Valves on Distribution Lines			$ 89,000	
		5-Year Total			**$10,899,000**	
Saipan	12	Isley to As-Perdido Transmission Line Replacement				$ 7,545,000
Saipan	13	As Lito Distribution Project[d]				$ 392,000
Saipan	15	Well Upgrades				$ 2,208,000
Saipan	16	System-wide SCADA Project				$ 578,000
Saipan	25	Emergency Backup Power for Water Supply Systems				$ 130, 000
Rota	7	Well Facility Upgrade				$43,000
		5-Year Total				**$10,896,000**
	Discretionary Project Funds		$ 412,000	$ 389,000	$ 401,000	$ 404,000
	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] The project numbers correspond to the project prioritization rankings developed in Section 4.4.1. Projects were added to the 20-year CIP in order of highest priority to lowest priority (1 being the highest priority) when possible. Some projects with high capital costs were excluded from the CIP to include more projects, some of which had a lower project priority ranking. The high risk tanks were incorporated into the 20-year CIP regardless of the tank project priority ranking to ensure that these tank projects are included in the first two 5-year phases of the CIP.

[b] Complete project descriptions for Tinian drinking water can be found in Appendix S.

[c] All costs have been rounded to the nearest thousand. Actual cost estimates for Tinian drinking water projects can be found in Appendix V.

[d] Only engineering costs were included in the 20-year CIP.

4.4 Drinking Water System Operations and Maintenance Improvement Recommendations

Throughout the course of developing the Drinking Water Master Plan for Tinian, a number of non-capital improvement recommendations were identified that fall under general O&M activities. The combined CUC/DCA Master Plan Team identified the drinking water system O&M activities described below.

4.4.1 Chlorination Facilities

- Continue to use the newly installed chlorine injection and pump system.
- Provide proper signage, such as high voltage and chlorine, at each of the sites as applicable.
- Install or relocate existing chlorine alarms to be audible and/or visible outside the booster pump stations.
- Relocate mechanical vent switches to outside of the chlorine building so buildings do not need to be entered to turn on the mechanical vent.
- Install automatic chlorine tank switchovers.
- Install amperometric chlorine analyzers at the entry point into the distribution system.

4.4.2 Chlorine Storage Facilities

- Install a permanent chain system to secure the full and empty cylinders.

4.4.3 Booster Pump Stations

- Install a level control (combination pressure reducing/sustaining) valve to the site piping at the dormant Maui I well site. Upgrade the piping as its condition is considered poor.
- Keep at least two redundant pumps online at the Maui II site at all times.
- Decommission the piping to and within the Maui I station after CUC completes installation of a control valve in the piping along the main road leading to the station.
- Inspect the Maui II slow actuating check valves to ensure proper operation.

4.4.4 Booster Pump Stations Electrical System Recommendations

- Consider installing Transient Voltage Surge Suppressors (TVSSs) at the service entrance equipment.
- Perform a complete assessment of the facility grounding system and correct deficiencies as required.
- 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 (corrosive environment, wet location rated, damp location rated, etc.)
- Ensure compliance with code-required working clearances for all electrical equipment.
- Where applicable, determine the cause of water intrusion into electrical/generator rooms and permanently rectify the condition.
- Remove all electrical equipment no longer in use rather than abandoning in place.
- Comply with NEC color-coding requirements.
- Cover all unused conduit openings.

- 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.

4.4.5 Distribution System

- Replace fiberglass PVC lines.
- Provide air relief valves at high points and blow-off valves at low points. Manual valves are recommended.
- Properly abandon or replace the existing network of older, smaller water lines that makes up approximately 28 percent of the Tinian water system.
- Install individual household pressure regulators where high pressures cannot be avoided.
- Wherever feasible, serve CUC water customers using a distribution line connected to a storage tank.
- Install pressure-reducing valves (PRVs) to reduce high pressures to preferred service pressures.
- Some of the smaller and isolated areas within the CUC system cannot be included in a tank service area. These areas currently use a booster pump system to provide the needed pressure (head). For such systems, the following are recommended:
  - Size pump systems and pneumatic tanks according to the 10 States Standards.
  - Locate air relief valves (ARVs) at the upper portion of the areas served by the booster pump.
  - Pay careful attention to conditions on the suction side of the pump system so that the pump does not cause a drop in system pressure below the recommended pressure listed.

4.4.6 PRVs

- Specify aluminum or stainless steel pilot piping for reapers, upgrades, and replacements.
- Conduct additional training on the maintenance and operation of PSVs.

4.4.7 Water Meters

- Purchase and evaluate both the Sensus accuSTREAM and the Badger Disc Meter while continuing to test the Sensus iPerl meter, then select a system-wide meter based on actual performance.

4.4.8 Tanks

- Compare the 20-year lifecycle cost of steel and concrete in the context of available funding to determine the tank material of choice on a project-by-project basis. Given the current poor condition of the majority of CUC steel tanks and the corrosive effects of the local environment, the use of concrete is recommended.
- Install a flow control valve, which will be operated by the pressure grade in the QMT TSA, as a short-term correction to the constant overflow from the QMT.

4.4.9 Cross Connection Control and Protection

- Install a level control valve to correct the siphoning at Maui I.

4.4.10 Asset Hierarchy and Risk Assessment

- If more accurate risk scores are desired:
  - Perform condition assessments for booster stations. After condition data are collected in the field, update the asset hierarchy with revised LOF scores.
  - Reconcile the asset hierarchy with regard to identification of transmission and distribution system pipes (i.e., document the pipe age and material in individual service areas and neighborhoods, and update COF and LOF scores).
  - Ensure that critical system knowledge is written down, recorded, and stored such that any new employee can easily access and understand the information.

  It is recommended that the asset hierarchy be updated as 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 require updating as frequently, but every 3 to 5 years the COF scoring matrix should be reviewed to ensure levels of service have not drastically changed.

4.4.11 Leak Detection

- Valve installation should continue on Tinian with a level control valve placed between the tanks
- The development of a leak detection program in Tinian is recommended; the program should be modeled after the ongoing leak detection program in Saipan.

4.4.12 GWUDI Investigations

- Because of the concerns with the rain event related water quality changes at Maui II and the lack of a rain event MPA analysis, it is recommended that additional data be collected during another complete rainy season.

4.4.13 Land Ownership

- 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 WW) 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.

4.4.14 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.

4.4.15 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.

4.4.16 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.

4.4.17 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.

SECTION 5

Wastewater System Master Plan

The contents of Section 5, “Wastewater System Master Plan,” are as follows:

5.1 Stipulated Order Planning and Compliance Requirements for the Wastewater Master Plan 5-3
5.2 Wastewater System Planning and Design Criteria 5-5
5.3 Wastewater Collection, Transmission, and Treatment System Recommendations 5-7
  5.3.1 Wastewater System Project Identification and Prioritization 5-7
  5.3.2 Cost Development of Wastewater System Prioritized Projects 5-11
  5.3.3 Prioritized Water System Modifications/Improvements Program 5-15
5.4 Drinking Water System Operations and Maintenance Improvement Recommendations 5-19

5.1 Stipulated Order Planning and Compliance Requirements for the Wastewater Master Plan

Table 4.1-1 in the “Stipulated Order Planning and Compliance Requirements for the Drinking Water Master Plan” lists the requirements for both water and wastewater portions 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.

5.2 Wastewater System Planning and Design Criteria

Currently on the island of Tinian there is no CUC-owned wastewater infrastructure; wastewater disposal and treatment is achieved through use of private septic systems. CUC does not own or operate any wastewater infrastructure in Tinian, although there is a possibility in the future that CUC could construct wastewater collections systems and treatment facilities. This is not a prioritized CIP project for the 20 year planning period though, so development of wastewater system planning and design criteria is not required at this time. The Saipan Wastewater System Master Plan discusses wastewater system planning and design criteria; this information should be uses as a basis for developing criteria for Tinian in the future, as needed.

5.3 Wastewater Collection, Transmission, and Treatment System Recommendations

Although Tinian does not have any existing CUC-owned wastewater infrastructure; projects were identified for the analysis and potential construction of future wastewater collection and treatment in Tinian. This section of the Master Plan presents the methodology for identification of wastewater projects to be included in the capital improvement plans, as well as the development of cost estimates and implementation schedule for the wastewater capital improvement projects.

5.3.1 Wastewater System Project Identification and Prioritization

This section presents the results of a series of project identification and prioritization workshops conducted in June 2012 for CUC. The objects of the workshops were the water and wastewater systems of 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 2-year, 5-year, and 20-year capital improvement plans.

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:

- State Revolving Fund (SRF) - CNMI Clean Watersheds Needs Survey (CWNS) Project Prioritization List
- CUC-Identified Projects

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 W.

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 X. 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 Y.

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 X). 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.

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 5.3.1-1 summarizes the point distribution, or weighting, of the criteria and sub-criteria for the wastewater project scoring process.

Table 5.3.1-1. **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**

Project Scoring

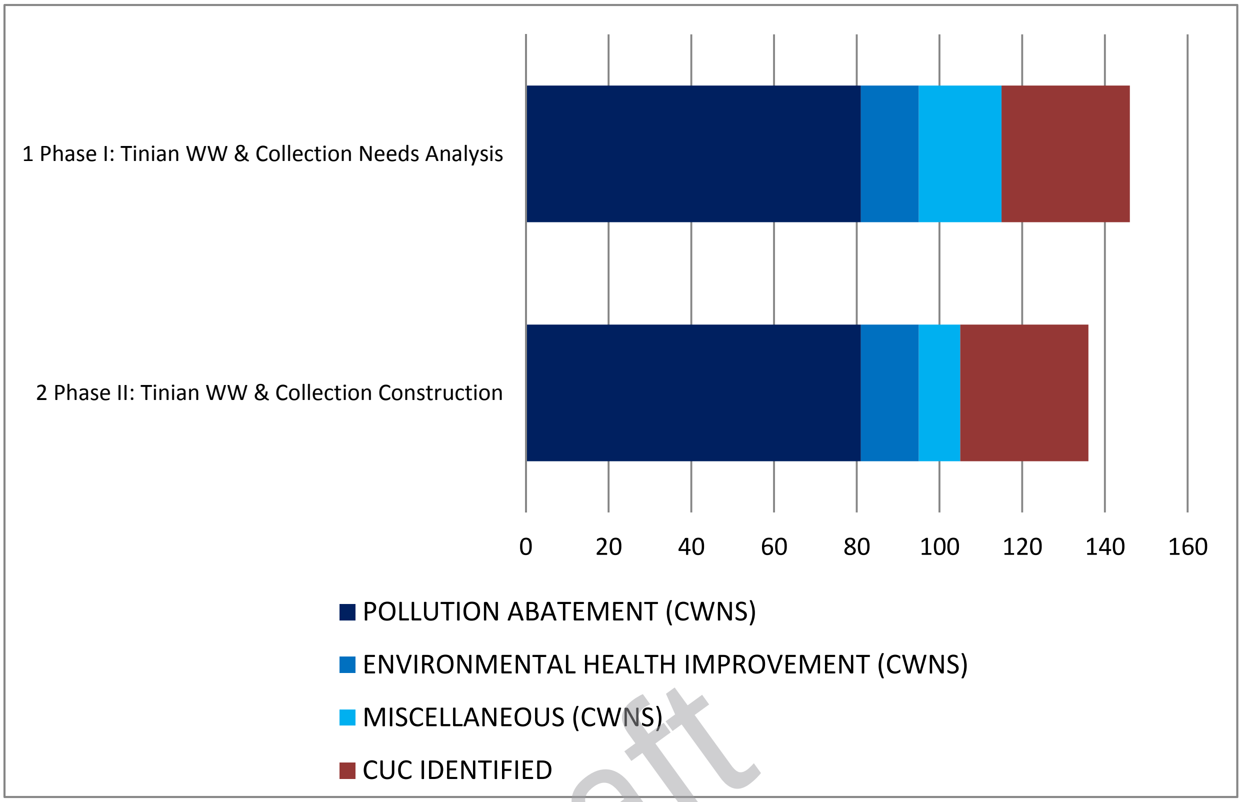
With the master project list finalized and the criteria defined and weighted, the full project group and stakeholders met over several workshops to “score” the wastewater projects. The process was identical for each project:

- 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 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 5.3.1-1.

Figure 5.3.1-1. **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 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. The initial “cut-off points were determined separately for each island.

The final projects selected for cost estimates for CUC’s wastewater systems were as follows:

- Tinian wastewater: cost estimates provided for the phase I study, 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.

5.3.2 Cost Development of Wastewater System Prioritized Projects

This section and the associated Appendix Z 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 capital improvement plans 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 water and wastewater assets, assess asset 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 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 Master Plan 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 water and wastewater systems

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 below.

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, a location adjustment factor of 0.83 was used for Tinian.

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 Cost – the cost to operate and maintain the water or 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 water and 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 does 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 water or 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. Therefore, no O&M costs are presented in the section, but are attached in Appendix Z.

The Association for the Advancement of Cost Engineering (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 viability, 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 appendix 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 5.3.2-1. 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 Z, which provide the cost estimate details for the water and wastewater systems, respectively. Deviations from any of the above assumptions can significantly affect the costs.

Table 5.3.2-1. **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 Assumptions	
O&M costs	2% - 5% of Capital Costs
Contingency	20%

Project Identification and Costs

Section 5.5.1 provides details on how wastewater projects were identified and prioritized for inclusion in the CIP. 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 W. Capital and operation and maintenance costs were estimated for each of these projects utilizing the methodology and assumptions discussed previously.

5.3.3 Prioritized Water 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 program, 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 wastewater is presented in Table 5.3.3-1.

Table 5.3.3-1. **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

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 into 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. No Tinian wastewater projects were included in the 5-year plan due to budgeting constraints relative prioritization.

20-Year CIP Development

For the 20-year CIP, it was assumed that the available funding assumed for the fiscal year 2018 would remain constant through the 20-year period for both water and wastewater. The 20-year CIP for wastewater is presented in Table 5.3.3-2. The one priority wastewater project for Tinian (Wastewater System Needs Analysis) is included in the 20-year wastewater CIP.

Table 5.3.3-2. **20 Year Wastewater CIP Capital Costs**[a]
Costs presented in 2012 dollars; Tinian project shown in bold font

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		

Table 5.3.3-2**. 20 Year Wastewater CIP Capital Costs**[a]
Costs presented in 2012 dollars; Tinian project shown in bold font

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	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**		
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 for Tinian wastewater can be found in Appendix W.

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

5.4 Wastewater System Operations and Maintenance Improvement Recommendations

Currently on the island of Tinian there is no CUC-owned wastewater infrastructure; wastewater disposal and treatment is achieved through use of private septic systems. As such, there are no recommendations for wastewater system operations and maintenance.

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