Brown AND Caldwell

Prepared for
Guam Waterworks Authority

GUAM WATERWORKS AUTHORITY

Water Resources Master Plan Update

Volume 1: Overview and Fundamentals

Final | August 2018

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Volume 1
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Guam Waterworks Authority, Mangilao, Guam
August 2018

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7Q10	7-day, 10-year low average flow
7Q20	7-day, 20-year low average flow
ADD	average day demand
AFB	air force base
AM	asset management
AMPE	asset management program evaluation
AMSC	Asset Management Steering Committee
ATARA	Alliance Transformation and Realignment Agreement
AWWA	American Water Works Association
BC	Brown and Caldwell
BMP	best management practices
BOD_5	5-day biochemical oxygen demand
BPS	booster pump station
BSP	Bureau of Statistics and Planning
CAMP	computerized asset management program
CCL	Contaminant Candidate List
CCTV	closed circuit television
CCU	Consolidated Commission on Utilities
CEC	contaminants of emerging concern
CEDS	Comprehensive Economic Development Strategy
CEPT	chemically enhanced primary treatment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIP	Capital Improvement Plan
CIS	customer information system
CLT	Chamorro Land Trust
CMCC	Civilian Military Coordination Council
CMMS	computerized maintenance management system
CMOM	capacity, management, operation and maintenance
CNMI	Commonwealth of the Northern Mariana Islands
CWA	Clean Water Act
CWMP	Comprehensive Water Monitoring Program
DBP	disinfection byproduct
DHS	U.S. Department of Homeland Security
DLM	Government of Guam Department of Land Management
DoD	Department of Defense
DODEA	Department of Defense Education Activity
DPC	distributed process control
DPRI	Defense Policy Review Initiative
DSCR	debt service coverage ratio
DWSAP	Drinking Water Source Assessment and Protection Program
EAC	Economic Adjustment Committee
EACIP	Economic Adjustment Committee Implementation Plan
EEFs	enterprise environmental factors
EIA	Environmental Impact Assessment
EIS	NAVFAC 2010 Environmental Impact Statement
ELA	Enterprise License Agreement (from Esri)
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
FEBGA	Full Employment and Balanced Growth Act
FMES	Facilities Maintenance and Environmental Services
FOG	fats, oils and grease
FSM	Federated States of Micronesia
FTAC	field telemetry and control
FTE	full time equivalent
FY	fiscal year
GAC	granular activated carbon
GARR	Guam Administrative Rules and Regulations
GCA	Guam Contractors Association
GDoL	Guam Department of Labor
GDP	gross domestic product
GEDA	Guam Economic Development Authority
GFD	Guam Fire Department
GHS	Guam Hydrologic Survey
GIS	geographic information system
GM	General Manager
GPA	Guam Power Authority
gpm	gallons per minute (flow rate)
GPS	global positioning system
GPWA	GPA and GWA

GPWA CCN	GPWA Consolidated Communication Network
GSPSSDWR	Guam Primary and Secondary Safe Drinking Water Regulations
GVB	Guam Visitors Bureau
GWA	Guam Waterworks Authority
GWQS	Guam Water Quality Standards
GWRDG	Groundwater Resource Development Group
GWUDI	Groundwater under the Direct Influence of Surface Water
HAA5	five haloacetic acids
HGR	hand grenade range
HWWTP	Hagåtña Wastewater Treatment Plant
I/I	infiltration and inflow
I/O	input/output
IFC	International Fire Code
IGPBS	Integrated Global Presence and Basing Strategy
IOC	Inorganic Compound
IRP	Installation Restoration Program
IT	information technology
JDE	J.D. Edwards
KPI	key performance indicator
LAW	local area-wide
LCR	Lead and Copper Rule
LEED	Leadership in Energy & Environmental Design
LFTRC	Live Fire Training Range Complex
LID	low impact development
LOS	level of service
Mbps	megabits per second
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDD	maximum day demand
MEC	Marianas Energy Company
MG	million gallons
mgd	million gallons per day
MHI	median household income
MHz	megahertz
MOU	memorandum of understanding
MWM	mobile workforce management
NAVFAC	Naval Facilities Engineering Command Pacific
NEIC	National Enforcement Investigations Center
NEPA	National Environmental Policy Act
NGLA	Northern Guam Lens Aquifer
NGLS	Northern Guam Lens Study
NIPP	National Infrastructure Protection Plan
NIST	National Institute of Standards & Technology
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NRW	non-revenue water
NTP	notice to proceed
NTU	nephelometric turbidity units
NWF	Andersen Air Force Base Northwest Field
O&M	operations and maintenance
OEA	Office of Economic Adjustment
OECD	Organization for Economic Co-operation and Development
OEM	original equipment manufacturer
PCA	potential contaminating activity
PCE	perchloroethylene
PEM	plant and equipment module
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic
PLC	programmable logic controller
PM/CM	preventive maintenance/corrective maintenance
PMC	performance management contract
PMCM	program management/construction management
PMO	Program Management Office
ppt	part per trillion (nanogram per liter)
PRV	pressure reducing valve
PSV	pressure sustaining valve
PUAG	Public Utility Agency of Guam
PUC	Public Utilities Commission
PWPEP	Potable Water Production Enhancement Plan
QA/QC	quality assurance and quality control
QC	Special Hotel Qualifying Certificate

QDR	Quadrennial Defense Review
RAMCAP	Risk and Resilience Management of Water and Wastewater Systems
RMI	Republic of Marshall Islands
ROD	Record of Decision
RTU	remote terminal unit
RUS	Rural Utilities Service
SCADA	supervisory control and data acquisition system
SCC	systems control center
SCC	U.S.-Japan Security Consultative Committee
SDWA	Safe Drinking Water Act
SEIS	Supplemental Environmental Impact Statement
SFP	Strategic Financial Planning
SOC	Synthetic Organic Compounds
SOP	standard operating procedure
SPORD	GPA Strategic Planning and Operations Research Division
SRF	State Revolving Fund
SSES	sanitary sewer evaluation study
SSO	sanitary sewer overflow
SUTA	Substantially Underserved Trust Area
SWDS	1994 Surface Water Development Study
SWMP	stormwater management plan
SWTP	surface water treatment plant
TEMES	Taiwan Electrical and Mechanical Engineering Services
TM	technical memorandum
TMDL	total maximum daily load
TSS	total suspended solids
TT	treatment technique
TTHM	total trihalomethane
UOG	University of Guam
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USPSSDWR	U.S. Primary and Secondary Safe Drinking Water Regulations
VA	vulnerability assessment
VOC	volatile organic compound
WERI	Water and Environmental Research Institute of the Western Pacific at the University of Guam
WHPP	Wellhead Protection Plan
WPC	Watershed Planning Committee
WRMP	Water Resources Master Plan
WRMPU	2016 Water Resources Master Plan Update
WSE	Wastewater System Evaluation
WTP	water treatment plant
WWTP	wastewater treatment plant

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Executive Summary

The Guam Waterworks Authority (GWA) 2006 Water Resources Master Plan (WRMP) summarized the condition of GWA's water and wastewater system facilities and outlined improvements needed over the subsequent 20 years to achieve regulatory compliance and improve the reliability of GWA's infrastructure and services. This Water Resources Master Plan Update (WRMPU) assesses GWA's progress towards achieving the recommendations outlined in the 2006 WRMP and further develops a capital improvement plan for the next 20 years, through 2037, to meet acceptable levels of service and maintain compliance with drinking water standards and clean water regulations.

Report Organization

This WRMPU comprises three volumes, to serve as a guide to future system development for GWA's infrastructure:

- **Volume 1** provides context and background for the master planning process. The volume summarizes the infrastructure and systems that apply to the entire GWA system and outlines recommendations for operational improvements. This volume also includes a summary of the proposed capital improvement projects and a financial program necessary to complete them.
- **Volume 2** provides a comprehensive evaluation of and presents recommendations for improvements to GWA's water system.
- **Volume 3** provides a comprehensive evaluation of and presents recommendations for improvements to GWA's wastewater system.

This Master Plan is a "living document" and is intended to be updated as needed to record progress and adjust the needs of GWA as new information is available and other external factors, such as regulatory direction and changes, become better known. Because this document is an update to the 2006 WRMP, rather than a standalone edition, relevant information from the 2006 plan is included by reference as appropriate.

Utility System Overview

GWA owns and operates an extensive network of facilities that provide water and wastewater service to most of the island residents. These facilities represent a significant investment and include substantial visible and underground infrastructure assets. The condition and performance of GWA's existing utility system assets were reviewed during master plan development.

Water System

GWA provides potable water service to most of the island's civilian population of approximately 164,900 residents. GWA's water system facilities comprise the following:

- **Supply sources:** GWA's water supply sources currently include 120 groundwater wells, the Ugum Surface Water Treatment Plant (SWTP), and one active spring. The main water supply source is the deep wells, which are in the northern and central portion of the island.
- **Piping:** the distribution system consists of approximately 586 miles of pipe constructed of a variety of pipe materials and sizes. The distribution system includes legacy systems built

principally by the Navy and then turned over to the Government of Guam to operate for the civilian population and additional systems constructed to serve Guam's development.

- **Storage tanks:** the water system has 26 active storage tanks with approximately 30.2 million gallons (MG) of capacity. The tanks provide storage for daily fluctuations in demand, fire flow storage, and emergency storage.
- **Booster pump stations:** the water system includes 27 major booster pump stations (BPSs).
- **Valves:** the water system includes control valves used to separate service areas, including pressure reducing valves (PRVs) and isolation valves.

GWA's water system includes the following areas, as shown in Figure ES-1:

- **North:** the North (brown) area is supplied by groundwater wells located in the North, where most of the island's population lives.
- **Central:** the Central (green) area is served from the Brigade BPS, which is usually supplied by groundwater from the north. Some customers within the Central area are served by a spring and U.S. Department of the Navy (Navy) water.
- **South:** the South (blue) area is usually served from the Ugum SWTP. If the Ugum SWTP is offline, this area can be served with groundwater from the north.
- **Nimitz:** the Nimitz (purple) areas are supplied by the Navy.

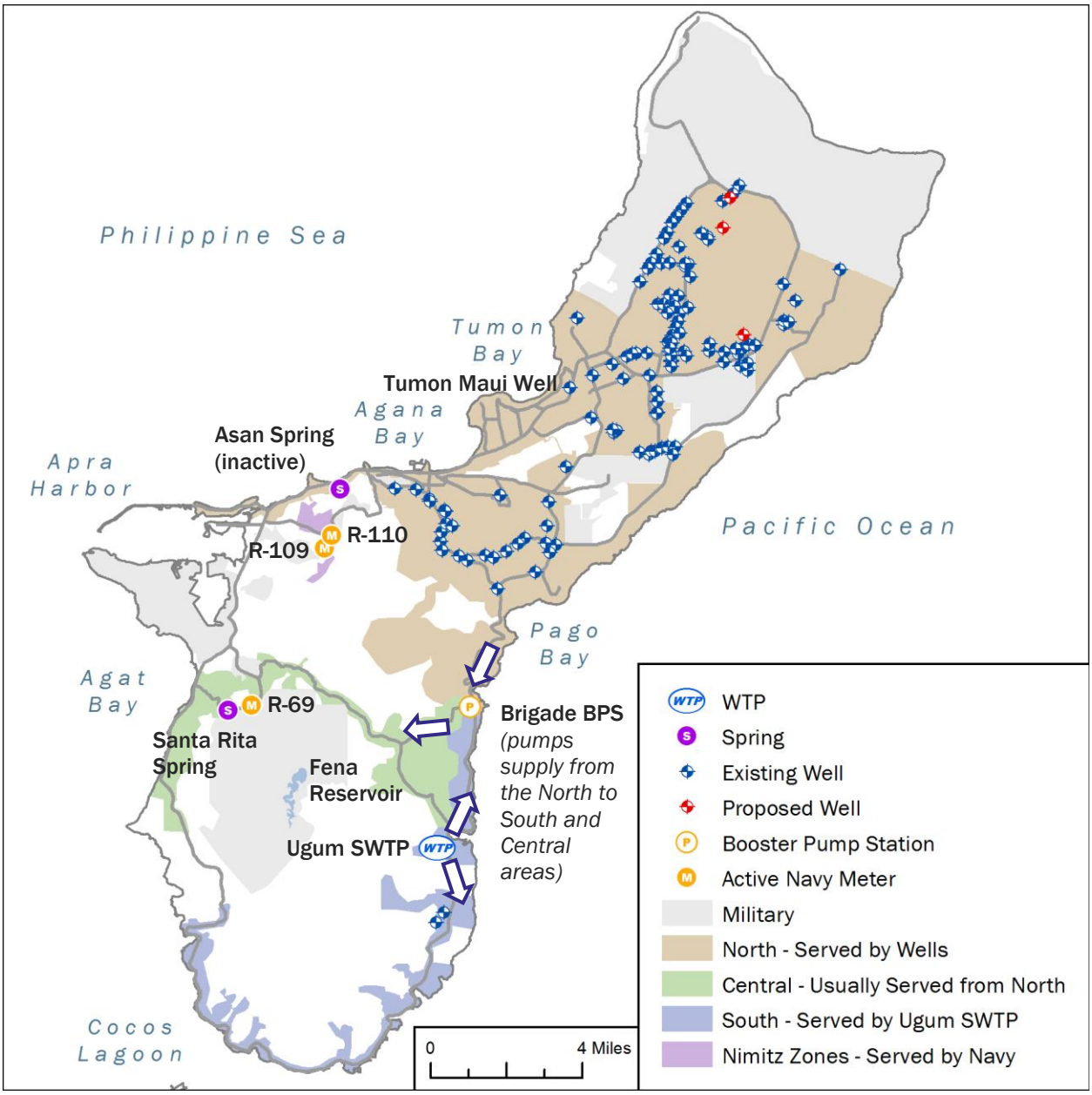

Figure ES-1. Water System Boundaries and Supply Sources

Wastewater System

GWA provides wastewater service to approximately 30,000 wastewater customers including civilian accounts island-wide and Andersen Air Force Base (AFB) and other military installations in northern Guam. GWA's wastewater system facilities include the following:

- **Treatment facilities:** GWA operates seven wastewater treatment plants (WWTPs). GWA's two largest treatment plants (Hagåtña and Northern District) provide chemically enhanced primary treatment and discharge effluent to ocean outfalls. The other treatment plants have original design capacities less than 1 mgd and were designed to provide secondary treatment. An overview of the GWA's seven WWTPs is presented in Table ES-1.

- **Piping:** GWA's wastewater collection system consists of approximately 290 miles of gravity pipe and 27 miles of force main pipe, constructed from a variety of materials and ranging in diameter from 3 to 48 inches.
- **Lift stations:** the wastewater collection system includes approximately 82 lift stations operated by GWA. Additional private lift stations also connect to GWA's system.
- **Sewer basins:** the wastewater system consists of seven wastewater basins: Agat-Santa Rita, Baza Gardens, Hagåtña, Inarajan, Northern District, Tumon, and Umatac-Merizo. These seven sewer basins flow to six of the WWTPs. The seventh WWTP, Pago Socio, serves a small area of the island. Figure ES-2 delineates the major wastewater basins.

Table ES-1. GWA Wastewater Treatment Facilities

WWTP	Design Capacity Average Daily Flow (mgd)	Type of Treatment, Process	Current Status	Effluent Disposal System	Basins Served	Municipalities Served
Northern District	12.0 [a]	Chemically enhanced primary	Upgrade to secondary treatment design in progress	Ocean outfall	Northern District	Dededo, Yigo, Andersen AFB, portions of Barrigada, Mangilao
					Tumon	Portions of Tamuning (including Tumon)
Hagåtña (Agana)	12.0	Chemically enhanced primary	Active	Ocean outfall	Hagåtña	Hagåtña, Agana Heights, Asan, Chalan Pago Ordot, Mongmong Toto Maite, Piti, Sinajana, portions of Barrigada, Mangilao, Tamuning, Yona
Agat–Santa Rita	0.75	Secondary: contact stabilization	Expansion and upgrade to secondary treatment in progress	Ocean outfall	Agat-Santa Rita	Agat, Santa Rita
Baza Gardens	0.60	Secondary: extended aeration	Construction of new facilities to close WWTP in progress	Togcha River	Baza Gardens	Talofofo, portions of Yona
Umatac–Merizo	0.39	Secondary: aerated lagoon/ overland flow	WWTP upgrade design in progress	Dry weather: evapo-transpiration and percolation Wet weather: Toguan River	Umatac-Merizo	Umatac, Merizo
Inarajan	0.19	Secondary: aerated lagoon	Active	Percolation	Inarajan	Inarajan
Pago Socio	0.025	Secondary: packaged aeration treatment system	Active	Percolation	Serves a few homes	A very small area in Chalan Pago Ordot

a. The 2011 Court Order limits average daily flow to 6 mgd, but allows for conditional increases to 9 mgd.

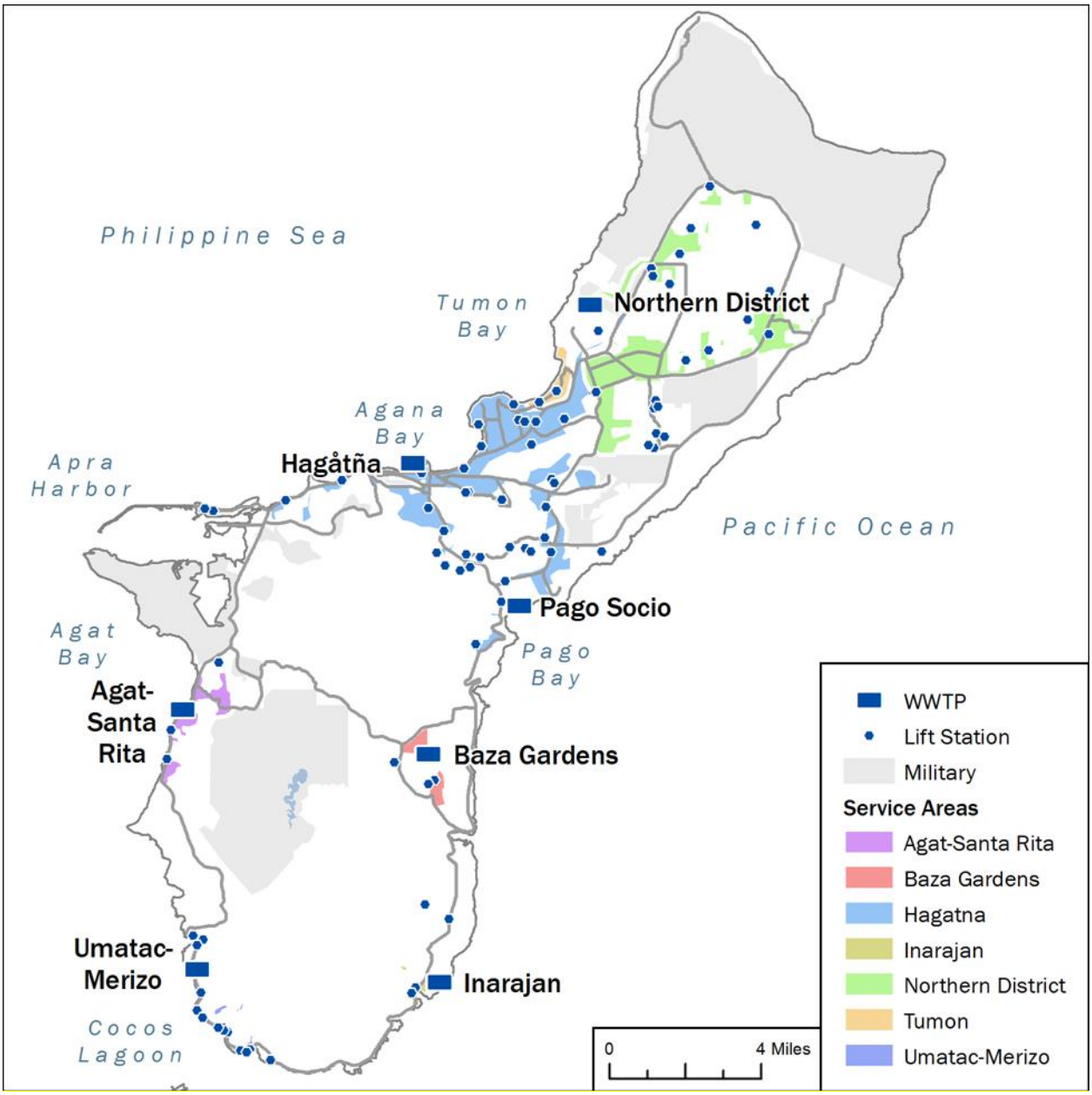

Figure ES-2. GWA Wastewater Basin Boundaries

Existing Utility System Condition and Performance

GWA has made significant progress since the 2006 WRMP, however, there are still many areas where improvements are necessary as described below.

Water System

The overall condition of equipment in the water system varies depending primarily on its age. The condition of some production wells and booster pump stations is poor, with significant corrosion evident in some areas. In addition, non-revenue water (NRW) represents one of the most significant issues facing GWA. NRW is defined by the American Waterworks Association (AWWA) as "unbilled authorized consumption (water for firefighting, flushing, etc.) plus apparent losses (customer meter inaccuracies, unauthorized consumption and systematic data handling errors) plus real losses (system leakage and storage tank overflows)" (American Water Works Association (AWWA), 2012).

Aging water storage tanks and dividing the water system into appropriate pressure zones are also an issue. GWA is in the process of repairing or replacing storage tanks with the program anticipated to be complete in 2021. A program to properly separate the GWA water system into pressure zones is also in progress.

Wastewater System

Significant rehabilitation is underway at many of GWA's treatment plants to expand capacity and consistently meet discharge permit requirements. At the time of this WRMPU, major modifications are in progress at the Umatac-Merizo and Baza Gardens facilities to meet the requirements of the 2011 Court Order and the plants' National Pollutant Discharge Elimination System (NPDES) permits by 2018. The new Agat-Santa Rita WWTP is partially complete and currently treating Agat-Santa Rita wastewater flows. The design to upgrade the Northern District WWTP to secondary treatment standards is also in progress as one of the Military Build-up projects.

The overall condition of equipment at many of the wastewater pumping stations is poor and must be addressed. Computer modelling indicated capacity problems in various segments of the collection system in the Hagåtña basin and throughout Northern Guam. Like the water system, significant improvements have occurred and issues are being addressed at key locations through rehabilitation contracts.

Pipe rehabilitation projects are currently in progress in Baza Gardens, Agat, and Santa Rita. Additional projects are in the design stage that will upgrade sections of piping in Agat, Asan, Hagåtña, Dededo, and other areas.

Source Water

Surface water provides the predominant source of potable water in southern Guam. In the North, groundwater supplies drinking water for Guam's residents and visitors, primarily from the Northern Guam Lens Aquifer (NGLA). GWA is committed to long-term sustainable management of the NGLA and has implemented a source water CIP program, which includes both the redevelopment of existing well sites and the completion of new wells. Data is being collected in the NGLA Database and the monitoring program will undergo a significant expansion as part of the pending Military Build-up. The NGLA is being studied and monitored extensively, with the goal of sustainably managing the resource now and into the future.

As GWA takes an active role in sustainable management of the water resources of Guam, formalization of GWA water resource policy is necessary to guide water resource development, use, and management by GWA into the future. Developing source water-related policy will create a roadmap for critical water supply decisions to be made over the next 20 years and beyond. Specific recommendations to protect the supply and quality of Guam's limited surface and groundwater resources are outlined in Volume 1, Section 5.

Planning Considerations

The master plan considered service levels, changes in population and land use, regulations, and asset conditions. Additional service-specific considerations were included in the planning for the water and wastewater systems.

Service Levels

In 2006, GWA developed four level of service (LOS) criteria that represent fundamental services routinely provided by water and wastewater utilities, which are limited to regulatory requirements of the water and wastewater treatment plants and severe service issues related to water service interruptions and sewage spills. These criteria remain important in GWA's current regulatory enforcement environment.

The GWA management team is now focusing on far more than the minimum LOS targeted in 2006. Significant additions include more pronounced attention to customer-oriented LOS including customer wait times, field service request response times, septic tank elimination, and integration with the OneGuam initiative. The introduction of additional mission-related measures further expands the 2016 LOS including goals related to distribution system pressure, asset reliability, and the delivery of the capital improvement plan. A LOS related to GWA employees' safety and employment satisfaction has also been added.

The GWA management team developed the following 15 strategic LOS categories during two workshops conducted in April 2016:

- Drinking water quality
- Reliability of water supply
- Wastewater effluent discharges
- Wastewater system spills
- Ensure financial capacity to meet operational needs
- Improve customer wait times to register issues/concerns at GWA offices
- Ensure adequate pressures in the distribution system
- CIP execution schedule
- Ensure a safe work environment
- Customer complaint response
- Distribution system integrity
- Critical asset reliability (water and wastewater plants, pump stations, wells)
- Septic tank elimination (sewer hookup program)
- Integration of GWA and Department of Defense (DoD) systems, OneGuam
- Employee satisfaction and pride

Improvements identified as part of this master plan are focused on improving performance on these essential measures. Additional information is presented in Volume 1, Section 3.

Population and Land Use Forecasts

The population of Guam is expected to grow from approximately 159,000 in 2010 to 212,000 in 2050. Guam's population fluctuates with world economic factors. As such, the development of population projections was based on 2010 U.S. Census Bureau data and tied to the combined effect of economic growth (tourism, military buildup, and other construction and economic development activity), labor market conditions, and geopolitical factors.

This growth can be attributed to the following key areas:

- **Military Buildup:** in 2014, approximately 6,000 active duty military personnel were based on Guam. By 2026, an additional 5,000 Marines and 1,300 dependents will be transferred to the island from Okinawa, Japan, increasing the military population by nearly 50 percent over 2014 levels. In addition to the increase in active duty military and dependents, Guam's population is expected to fluctuate due to construction activity related to the military buildup and civilian jobs created by buildup activities.
- **Planned Developments:** there are many new developments planned for Guam. Some of these are large commercial developments such as new hotels or additions to hotels and others are residential subdivisions. In addition, several Chamorro Land Trust tracts are planned for development, with some uncertainty as to how these areas will be serviced. The WRMPU evaluated the requirements for supply of water and sewer services to proposed developments known at the time of this report as well as the general increase in population.

Regulatory Issues

GWA must comply with territorial and federal regulations for both water and wastewater treatment and services. Water standards are based on the requirements established by the Safe Drinking Water Act (SDWA), while wastewater treatment and disposal is governed by the Clean Water Act (CWA). The U.S. Environmental Protection Agency (USEPA) issues NPDES permits for GWA facilities when required and is responsible for monitoring compliance. Guam Environmental Protection Agency (EPA) is the territorial agency in charge of monitoring GWA operations and monitoring for SDWA compliance.

Physical and Cyber Security Issues

Physical and cyber security issues require consideration in the unpredictable natural and geopolitical environment to develop resilience to natural disasters, accidents, and malevolent threats. Specific recommendations for security measures are presented in Volume 1, Section 6.3.

Capital Improvement Program

A major component of this WRMPU is to propose specific Capital Improvement Projects (CIP) for implementation between 2018 and 2037. GWA's CIP needs are organized into three key areas: water system, wastewater system, and general facilities/equipment (including supervisory control and data acquisition system [SCADA] and electrical). A summary of the number of projects and total estimated cost for each category are listed in Table ES-2. Additional detail is provided in Volume 1 for projects related to the overall organization and assets, Volume 2 for water projects, and Volume 3 for wastewater projects. A project sheet was developed for each proposed project, which includes a description, justification, anticipated schedule, and estimated budget. These project sheets can be used by GWA to develop specific 5-year CIP.

Table ES-2. CIP Summary				
Project Category	Number of New Projects	Estimated Cost WRMPU Proposed Projects	Number of Ongoing Projects [a]	Estimated Cost of Ongoing Projects
Water System Improvements				
Pipeline Projects	17	$204,402,000	2	$2,500,000
Storage Tank and BPS Projects	30	$120,082,000	5	$30,808,000
Water Production Projects	10	$123,216,000	3	$8,667,000
Other Water System Projects/Studies	5	$14,449,000	4	$5,500,000
Total Water System Improvements	62	$462,149,000	14	$47,475,000
Wastewater System Improvements				
Gravity Sewer Projects	27	$250,247,000	7	$69,230,000
Force main Projects	4	$22,498,000		
Lift Station Projects	3	$68,156,000	2	$4,293,000
Wastewater Treatment Facilities	9	$71,238,000	3	$151,946,000
Other Wastewater System Projects/Studies	5	$10,978,000		
Total Wastewater System Improvements	48	$423,117,000	12	$225,469,000
General Systems Improvements				
General Facilities / Equipment Improvements	10	$59,800,000	1	
SCADA / Electrical	4	$37,176,000	2	$5,175,000
Total General System Improvements	14	96,976,000	3	$5,175,000
Total (rounded)	124	$982,242,000	29	$278,119,000

a. Projects currently in progress by GWA with available funding

A workshop was conducted in April 2016 with GWA personnel and management to establish a relative ranking system for non-economic factors important to GWA when considering project priority. Based on this non-economic prioritization, project timing (as determined by the population projections, condition assessments and hydraulic modeling), and project cost estimates, a base CIP program was developed for the 20-year planning period. The CIP improvement plan is outlined in Volume 1, Section 11.

Water System Improvements

Recommendations for improvements to GWA's water system and related facilities are summarized below, including water treatment, supply, and distribution facilities. Detailed information can be found in Volume 2.

Water Treatment

Capital improvements and general operations and maintenance (O&M) improvements are necessary to provide continued reliable operation of the Ugum SWTP. Recommended improvements include the following:

- **Intake cleaning** to remove sediment accumulation in the river at and just upstream of the intake.
- **Raw water intake upgrade** to allow GWA efficient extraction of Ugum River water even during high turbidity periods and operate at low river conditions.
- **Reliability improvements** to refurbish and upgrade existing equipment and systems at the Ugum SWTP that need repair, replacement, or modification to improve plant capacity and maintain plant operability.
- **Routine equipment overhaul program** including scheduled replacement of the treatment membranes and removal and refurbishment of major plant equipment such as raw water pumps, blowers, compressors, finished water pumps, centrifuge, control system and other components.
- **General recommendations:** Additional training is recommended to provide operations staff with the skills required to manage plant operations.

Wells

Several projects are recommended for GWA to improve the capacity, reliability, and safety of the water system with respect to existing or proposed production wells.

- **New wells:** GWA should plan for approximately 13 new wells between 2020 and 2037. A well exploration and development project is recommended to plan the location of the future wells.
- **Existing wells:** Each of the 120 system wells can be expected to require a significant rehabilitation project every 15–20 years. Two types of projects are recommended for the existing wells:
  - An annual project to address relatively minor issues that can affect production wells, such as flow meter replacement, modifications for improved motor cooling, and minor improvements based on deficiencies identified during condition assessment.
  - Extensive well overhaul projects to address significant issues and equipment replacement, new borehole development, and similar major rehabilitation requirements.
- **Wellhead Protection Plan (WHPP) implementation:** The recommendations of the 2014 WHPP should be implemented, including limiting land use within wellhead protection zones, development of a water supply contingency plan, and well abandonment practices.

Storage Tanks

All storage tanks should be inspected every five years. Based on the condition of the tanks, some tanks may need more frequent inspections, such as the existing steel tanks.

GWA will inspect some of the existing storage tanks in the next few years. Plans for new storage may change depending on the results of those tank inspections. Some storage tanks believed to be repairable may need replacement instead of repair.

Booster Pump Stations

GWA operations staff have rehabilitated some BPSs, but full rehabilitation is recommended to address all outstanding issues. BPSs recommended for rehabilitation or replacement that are not currently underway include Gayinero, Geus, Mataguac, Nimitz Hill Upper, Nimitz Hill Lower, Santa Ana, Santa Rita Spring, Toguan, Umatac 1, and Umatac 2. In addition, surge issues observed at startup or shutdown of pumps should be addressed, especially at BPSs with high suction pressures.

Distribution System

The following improvement projects are recommended for piping, PRV, and isolation valves to address capacity and condition issues and to realign existing pressure zones.

- **Piping condition improvements:** The 2006 WRMP documented the need to remove smaller diameter (less than 6 inches) and asbestos cement water lines. Annual projects are proposed to replace all 2-inch and AC piping.
- **Pressure reducing valves:** For the pressure zone realignment, existing PRVs need to be rehabilitated and new PRVs installed. New master meters should be added to each new or rehabilitated PRV. The number of PRVs anticipated to serve each pressure zone are listed in Volume 2, Section 8.
- **Valve exercise and maintenance:** To ensure all valves necessary for operations, maintenance, and isolation are functional, GWA should implement a valve exercise program. Broken valves should be documented as they are located and then repaired or replaced.

Water Loss Control

The 2006 WRMP outlined recommendations for water loss reduction and measures taken by GWA through the ongoing leak detection program. Additional tasks that should be implemented to further reduce water losses include the following:

- **Leak detection and repair:** GWA should continue with the plans to have two leak detection crews to record the estimated leak rate and location of each verified leak so that water loss and repair location data can be uploaded into the computerized maintenance management system (CMMS) and geographic information system (GIS). A prioritization schedule for leak detection should be established and GWA should set up a multi-year professional services contract for leak detection if assistance is required.
- **Line locating crew:** GWA should consider forming a dedicated line locating crew. GWA should procure the appropriate line locating equipment, train the crew in field line locating procedures, and update the existing Work Plan, protocols, and standard operating procedures (SOPs) from the original leak detection program.
- **Meter calibration:**
  - **GWA water production and master meters:** all well and master meters should be inspected annually. Based on the inspections, the meters should be repaired or calibrated as needed, with priority given to deep wells.
  - **GWA residential/commercial meters:** GWA should work toward reviewing and testing/calibrating all meters in the system.
- **Other recommendations:** GWA should continue installing master meters. A study should be performed to review the planned master meter locations. The master meters should be implemented in conjunction with an island-wide system being developed by the Guam Power Authority (GPA) with their “Smart Meter” program.

Fire Hydrants

The GWA water system was estimated to include 410 fire hydrants that have failed or are close to being in a non-usable condition and 1,548 hydrants that are close to failure. GWA has identified 300 of these 410 fire hydrants for replacement in the next five years; however, a more aggressive schedule is recommended:

- Replace the hydrants in extremely poor overall condition (score of 5 in the condition assessment) within the next five years, then begin repair or replacement of hydrants in poor overall condition (score of 4 in the condition assessment).
- Form a fire hydrant repair and replacement crew to evaluate all fire hydrants and issue work orders, perform preventive maintenance, and perform corrective maintenance including repair and replacement of the hydrants.
- Other recommendations include standardizing on two or three hydrant manufacturers to reduce parts, tools, and increase efficiency of repairs, and developing a unique ID and color-coding scheme for each fire hydrant.
- Coordinate regularly with the Guam Fire Department (GFD). GWA can share GIS and CMMS information while GFD can assist with future assessments and hydrant flow volumes.

General Water System Recommendations

- **The OneGuam** framework would potentially integrate DoD and GWA water resources and water system facilities. Recommendations to support the OneGuam framework over the planning horizon include the following:
  - Conduct a feasibility study to determine the potential for a singular, unified water utility.
  - Model the proposed combined water system to properly analyze the water systems and identify locations where piping could be shared.
  - Complete a rate study and develop a strategic plan for moving to a combined water utility.
- A **South Guam Water Supply Study** is needed to analyze options to provide adequate and reliable water supply for South Guam (including maximizing output from the Ugum SWTP).

Wastewater System Improvements

Recommendations for improvements to GWA's wastewater collection and treatment systems are summarized below.

Gravity Piping

Recommended improvements for GWA's gravity sewer system include the following:

- **Piping Improvements:** An annual program should be established to inspect, rehabilitate, and replace gravity piping based on the condition assessment risk analysis. New piping should be sized to handle future planned peak wet weather flows. Larger diameter piping, piping near reported sanitary sewer overflows (SSOs), and piping with overlapping capacity and condition improvements are prioritized for rehabilitation/replacement. This risk analysis should be updated periodically (every five years at a minimum) using the latest data.
- **Manholes:** GWA should implement a manhole rehabilitation program to fix issues as they are found, including raising manholes, cutting down brush, maintaining easements, and rehabilitating or replacing manholes. Major manhole issues should be grouped into projects and put out to bid to be repaired by a qualified contractor.

- **Septic/Cesspool System:** Actions should be implemented to connect houses on septic/cesspool systems to the collection system according to the prioritization matrix included in Volume 1, Section 5.2.
- **CCTV:** Closed Circuit Television (CCTV) data should be collected, organized, and stored in a single centralized location on a GWA server. This information will be utilized in the piping improvements risk analysis.

Force Mains

Recommended piping projects to address identified capacity and condition issues for force mains include the following:

- **Force main rehabilitation/replacement program:** An annual program should be established to perform condition assessment and rehabilitate and replace force main piping based on the results of the condition assessment. The force mains should be inspected according to the prioritization in Volume 3, Section 5.
- **Priority Replacement Projects:** Priority force main replacement projects include the Yigo Lift Station Force Main, Route 1 Asan Force Main rehabilitation/replacement, and the Hagåtña WWTP Force Main rehabilitation/replacement.

Lift Stations

The following improvements are recommended for lift stations:

- Lift stations should be rehabilitated and replaced based on the priorities listed in Volume 3, Section 6.
- GWA should review the study recently conducted for the Fujita lift station and force main and select an option for implementation.
- A preventive maintenance program should be implemented to address operational issues at lift stations, including grease and rag build-up that clogs the pumps.

Wastewater Treatment

Recommended improvements to GWA's wastewater treatment systems are summarized below.

- **Umatac-Merizo WWTP:** The Umatac-Merizo WWTP is undergoing major modifications to meet the 2011 Court Order, which will increase the plant's capacity to be adequate through 2037 flows. The WWTP upgrade will be complete in 2018 and will require typical regular maintenance, but no additional improvement projects are expected in the near future.
- **Baza Gardens:** The Baza Gardens WWTP is undergoing major modifications to meet the 2011 Court Order, which will transform the plant into an equalization basin and pump station equipped with preliminary treatment. As part of this project, a cross-island pipeline will be constructed to transfer Baza Gardens flows to the Agat-Santa Rita WWTP for further treatment and disposal, providing adequate capacity through 2037 flows. The redesigned Baza Gardens wastewater system will require regular maintenance of the pump stations and preliminary treatment, but no other improvement projects are expected over the planning horizon.
- **Agat-Santa Rita WWTP:** The new Agat-Santa Rita WWTP will replace the existing plant and will be fully operational in 2018. The new plant will require regular maintenance, but no improvement projects are expected in the near future. A WWTP rehabilitation project is recommended after 15 years of operation to include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, rehabilitation of electrical equipment and control systems, and rehabilitation of the backup generator.

- **Inarajan WWTP:** Routine improvement projects are necessary to maintain the plant in sound operating condition, including rehabilitation of concrete structures, installation of new electrical and control systems, installation of new floating mechanical aerators, rehabilitation or replacement of valves and pipe appurtenances, installation of a new headworks with automatic screens and influent flow meter, and implementation of sludge removal. It is also recommended that a flow measurement and monitoring program be implemented to provide long-term assessment of the system capacity and to help dictate the timeline for future expansions.
- **Pago-Socio WWTP:** GWA plans to convert the existing Pago-Socio WWTP into a pump station. Wastewater flows will be conveyed into an existing nearby wastewater transmission line and ultimately to the Hagåtña WWTP for treatment and disposal.
- **Northern District WWTP:** A detailed design is underway to upgrade the Northern District WWTP to meet the NPDES permit's secondary treatment requirements. After the new WWTP is complete, it will require regular maintenance, but no major improvement projects are expected in the near future. A WWTP rehabilitation project is recommended after 15 years of operation to include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, and rehabilitation of electrical equipment and control systems.
- **Hagåtña WWTP:** The Hagåtña WWTP was upgraded in 2014 to an enhanced primary treatment process. The plant will require a future rehabilitation project which is recommended in 2027. The project should include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, and rehabilitation of electrical equipment and control systems. The design of a complete upgrade to the HWWTP to meet secondary treatment requirements is planned to begin in 2037.

Solids Management

The recommended approach for GWA's solids management is to continue disposal of dewatered sludge at the Layon landfill. GWA faces considerable challenges implementing system-wide court-ordered improvements and secondary treatment upgrades at the two largest WWTPs; therefore, attempting to add an optional biosolids recycling program to GWA's priority list is not currently advised.

In the future, GWA could choose to recycle a portion of wastewater solids by converting the dewatered sludge to a Class A biosolids product with new options for disposal or reuse. GWA should continue to discuss opportunities with other agencies and consider jointly participating in projects if opportunities arise. Two potential opportunities include:

- **Future Composting.** A portion of GWA's dewatered solids could potentially be composted, which would divert green waste and dewatered sludge from the landfill, increasing capacity. A Class A biosolids product with improved characteristics would be produced and marketed primarily for landscaping purposes. The local compost market should be evaluated in more detail to determine the potential production capacity.
- **Future Indirect Drying.** GPA is proposing to construct a new power generation facility adjacent to the Northern District WWTP. Waste heat from the GPA facility could potentially be used to dry dewatered solids to reduce landfill tip fee expenses or create a fuel for a future waste-to-energy facility (if developed). If the solids are dried to greater than 90 percent solids content, the product will qualify as Class A biosolids and could potentially be marketed for landscaping or land application purposes. GWA should continue to discuss opportunities with GPA as the power generation facility concept is developed.

General Facilities/Equipment Improvements

Recommendations for improvements to GWA's asset management program, GIS, and SCADA/electrical systems are summarized below.

Asset Management

GWA has made significant progress in implementing many features of an asset management (AM) program. Building upon the work to date, recommendations for future progress are outlined in Volume 1 Section 7. These efforts will further define the program, ensuring the AM program is known and understood by staff and all involved stakeholders, driving the maintenance management plan to improve preventive maintenance/corrective maintenance (PM/CM) ratios in each work group from year to year, and collecting up-to-date data on assets and maintenance costs to enable improved CIP decision making.

GIS Program

Proposed improvements to the GWA GIS program include staffing, training, and hardware and software upgrades. Refining customer meter locations and the integration of GIS-based field data collection and CMMS software are also recommended. Additional detail can be found in Volume 1, Section 8.

SCADA/Electrical Improvements

Recommended improvements to GWA's SCADA system include:

- Continued implementation of the 2014 SCADA Master Plan
- Repair or replacement of control instrumentation as required at all sites and plants
- Specialized workforce development and training
- Standardization of programming language, equipment, and wiring
- Use of the GPA wireless network
- Additional physical and cyber-security measures

Financial Plan

GWA's proposed Master Plan capital improvements plan outlines a viable schedule for improvements that effectively balances system investment needs with financial impacts on GWA ratepayers.

Capital Program Expenditures

The GWA Master Plan capital program calls for approximately $1.61 billion of capital spending ($1.26 billion in current year dollars) over the 2018–2037 forecast period as shown in Figure ES-3. Of this amount, approximately $424 million has already been raised or is anticipated to be externally funded, requiring GWA to finance as much as $1.19 billion in capital project spending over the forecast period. The next four years of the program are expected to be the most capital-intensive years of the program primarily due to the overlap of the completion of court ordered projects and projects required for the military buildup.

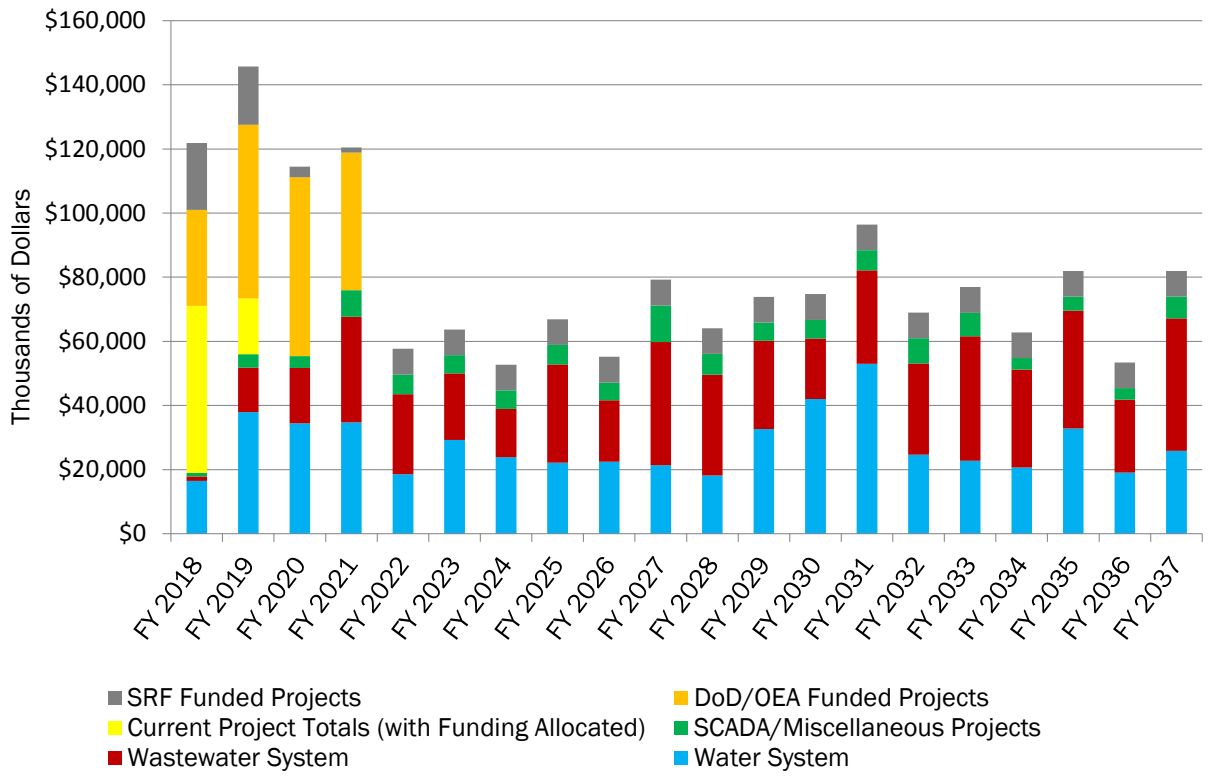

Figure ES-3. GWA Master Plan Capital Program Expenditures, FY 2018–2037

Debt Service Requirements

This capital program will require incurrence of substantial debt on a regular basis throughout the forecast period. Debt service requirements are projected to increase 2.55 times during the forecast period, from under $31.7 million per annum to $80.9 million per annum by FY 2037. Similarly, service revenues (to support these debt issuances) are projected to increase substantially over the forecast period, from approximately $112 million in FY 2018 to over $247.6 million in FY 2037.

The base case analysis assumes that GWA will issue revenue bond debt in four of the next five years and every third year thereafter. Continuing its historical practice, GWA will obtain SRF grants of $8 million per annum, and will increase current revenue funding of capital to almost $50 million by the end of the forecast period as shown in Figure ES-4.

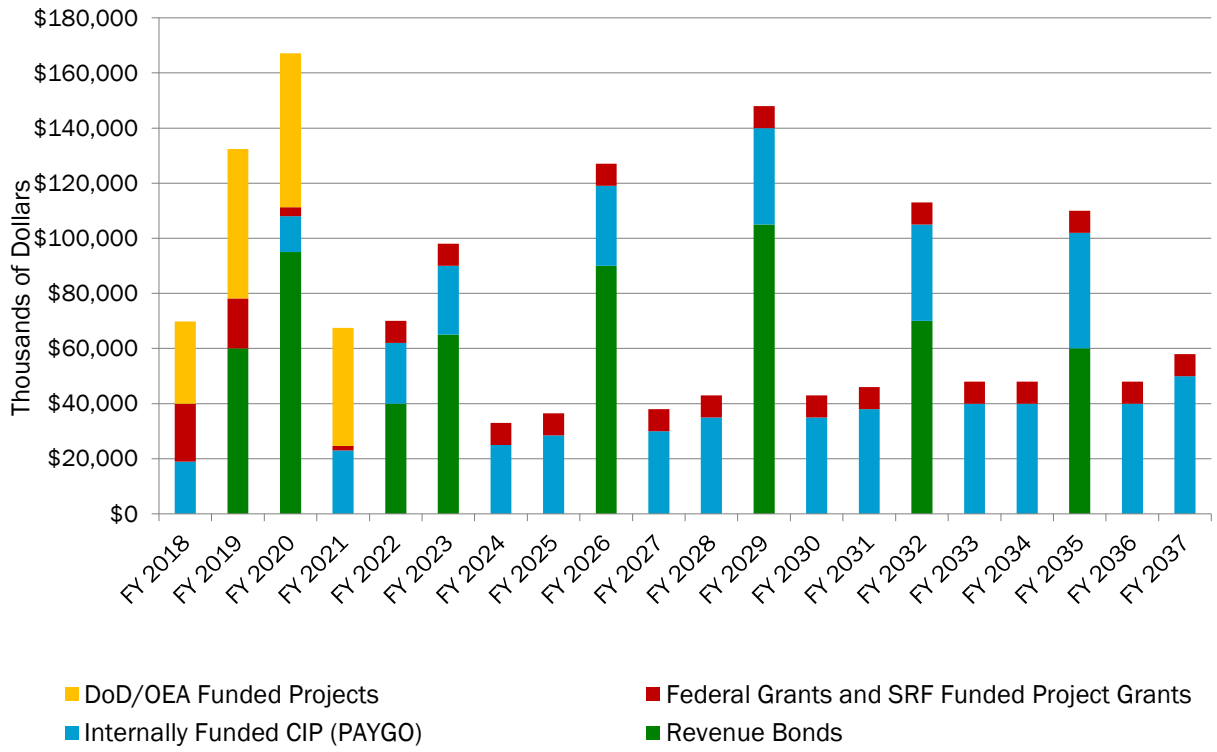

Figure ES-4. GWA Capital Program Funding Sources, FY 2018–2037

The financial plan also assumes that GWA's revenue bonds are issued under GWA's current, relatively less advantageous, borrowing terms (5 percent annual interest, 6.00 percent funded bond reserve, no insurance) that reflect its relatively low credit ratings. Given the forecasted need to issue $585 million over the 20-year planning period, GWA would be well served by improvements to the credit ratings under which it issues municipal debt obligations. Over the long term, GWA's actions to enhance its credit rating will be particularly important.

Water Affordability

Financing the Master Plan capital program will result in substantial increases in debt service obligations and increases in annual service revenues. Debt service requirements are projected to represent approximately 33 percent of service revenues by the end of the Master Plan forecast period; pay-as-you-go funding of capital expenditures will reach approximately $50 million.

The base case rate increase pattern, as shown in Figure ES-5, results from an effort to smooth rate increases while building financing capacity for annual spending levels in the range of $50–80 million. This will also position GWA to finance additional capital investments beyond the forecast period, potentially including secondary treatment upgrades at the Hagåtña WWTP or projects deferred due to atypical cost escalation.

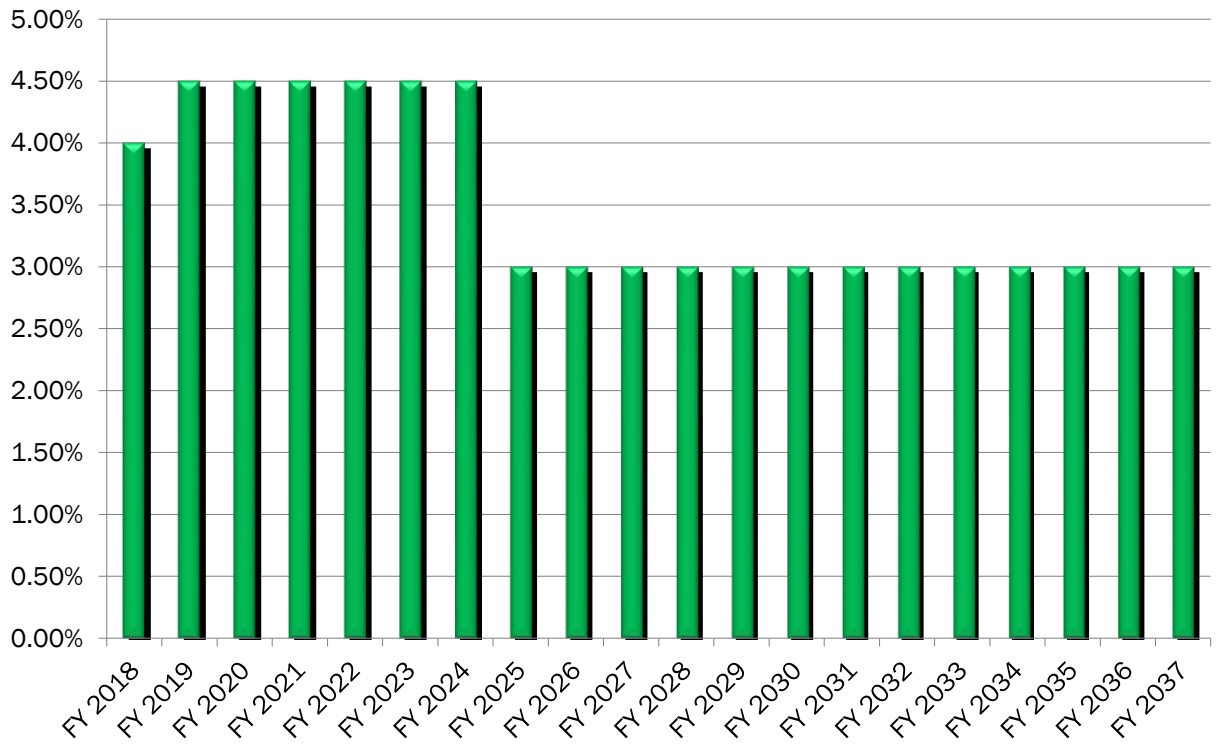

Figure ES-5. GWA Projected Water and Wastewater Service Rate Increases, FY 2018-2037

The Master Plan program may be viewed as presenting a significant yet manageable financial burden for the GWA residential population in general under the regular rate increases projected. Residential water and wastewater customers with typical water usage of 7,500 gallons per month currently pay $1,081 annually, or approximately 2.38 percent of estimated median household income (MHI). Projected systemwide rate increases, based on currently identified Master Plan projects, will drive water and wastewater bills to just over 3.5 percent of MHI over the forecast period.

Low-income residential customers currently pay approximately 5.2 percent of their incomes for water and wastewater services, and that amount rises to just under 7.0 percent over the forecast period, based on currently identified Master Plan projects. To address the anticipated impact on low-income residential customers, the Master Plan recommends that GWA review options to address low-income water affordability.

Public Outreach

A public outreach campaign was completed following the production of the WRMPU draft. The intent of the public outreach campaign was to provide information on the purpose, content and recommendations included in the WRMPU and to solicit feedback for incorporation into the final report. The public outreach campaign used a variety of methods for communication with the public and government agencies throughout Guam including mailing flyers, website access, printed reports

and public meetings. Public meetings were held at ten locations and comments were recorded and incorporated into the final WRMPU as required.

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