GUAM WATERWORKS AUTHORITY

Engineering Division

Potable Water Production Enhancement Plan

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Introduction

GWA has not developed a new well since the 1990's, and many of the current operating wells were drilled in the 1960's. Depending on the quality of the installation and assuming that proper maintenance is performed, the expected life of a well in this corrosive environment is about 50 years. Adding to the challenges GWA faces with existing operating wells is the fact that well construction prior to 1978 is not well documented.

Although, the permitted GWA water supply production rate is 44.1 million gallons per day (MGD), the actual water production rate as of March 2010 is 38.5 MGD. This is due to a number of wells being "down-hard" or off-line because the wells require major rehabilitation, such as re-drilling of the well. The current demand on the GWA system is 43 MGD; GWA currently meets this demand by purchasing 4.5 MGD from the Navy. The Navy is reluctant to provide GWA with more than 3.5 MGD on an average day, but is assisting GWA with its current production issues. The current production to demand ratio is 0.977 (42/43) with Navy water purchases assuming the 3.5 MGD Navy requirement. Table A provides a list of water supply sources and their current MGDs. Ultimately, GWA would want to operate the system without Navy water purchases due to the price of Navy water.

Table A: GWA Current Production

Source	Production MGD
Wells	36.2
Ugum Treatment Plan	2.3
Springs	0
Navy	3.5
Total	42

Problem Statement

The current production issue can be divided into supply side and demand side pressures. The supply side pressure or reduction of sources water is three fold. First, the Navy has notified GWA that the supply will be reduced. Second, the Guam Environmental Protection Agency (GEPA) requirement regarding the reduction of chlorides in specific wells will result in a loss of supply. Third, the loss of production due to specific wells at the end of their life cycle or specific wells going down due to unforeseen failures. The demand side pressures or increasing demands are two fold: the demand for water has been increasing due to new service connections over the years; and the water loss due to unaccounted water causes a demand pressure on the system.

The new external pressures that affect the current production issue are as follows. GEPA's Water Resources Management Program (WRMP) is responsible for the protection of the aquifer. The Guam aquifer has a fresh water lens that rests on salt water. An early warning indicator of the stress on the fresh water lens is the chloride levels which measure the amount of sea water in the lens. Base on GEPA 2009 Annual Production Well Inspection Report, 13 of GWA's wells were required to decrease production due to the chloride levels; and 16 wells were approaching the chloride limit. One approach to supplementing the water supply due to the decrease in production of these 13 wells is to maximize the use of GWA's surface water and ground water. It is estimated that an increase in production of 2 MGD is needed to offset this loss in production. In June 24, 2008 and December 15, 2009 the Navy notified GWA that GWA adhered to the allocation of 3.5 MGD. In the most recent letter however, GWA's water purchase of 4.1 MGD cannot be continued by the Navy this dry season.

Solution

The long term solution for supply is to establish and maintain a supply verse demand factor of 1.2 or a "1.2 Supply to Demand Factor." The 1.2 Supply to Demand Factor will provide the operational flexibility and emergency preparedness to adequately ensure pressure and supply to GWA customers. Additionally a 1.2 Supply to Demand Factor or a 20% excess of supply to demand will assist GWA in basic maintenance and operational needs. Performing periodic maintenance on the Ugum treatment plant is an example of the need of excess sources water requirement. With excess capacity Ugum can be taken off line for needed repairs and maintenance. An operational example is the optimization of water quality by shutting down or ramping down individual wells that are experiencing an increase in chloride levels. With the establishment of a standard of 1.2 Supply to Demand Factor the solution to the current production issues can be put into long term context.

To address the current production issues, the solution must align with the long term solution of implementing the 1.2 Supply to Demand Factor which includes both supply side and demand side strategies. With this in mind, the solution should be as broad as possible. On the supply side, production can be increased by the refurbishment of "down-hard" wells, refurbishment of springs and full utilization of the Ugum Treatment Plant water. These supply side solutions are capital intensive and time intensive requiring project planning, project or program procurement, project design and project construction. On the demand side is the current focus of the meter program, leak detection program, local water auditing, and island-wide water auditing system. The island-wide water auditing will use the bubble map zone as an analytical tool combined with master metering to measure field data.

GWA Water Operations Department plays a vital role in the accomplishment of this program. For example, Water Operations assistance in the evaluation of down-hard wells to determine the low cost solution for getting these wells up and running and operations will get down hard wells up and running on a temporary basis to meet the

current demands. The current wells targeted for reduction due to GEPA's chloride requirements will have to be reevaluated in terms of time of implementation. The water system cannot adequately meet the demand with the loss of supply from these high chloride wells without supplemental supply. In some instances there may be an immediate need to adjust some high chloride wells. Therefore, GWA's Deep-Well Chloride Action Plan must be revised to accommodate today's operational challenges with respect to water production.

Supply Side Solutions

The supply side solution can be divided into three categories: increase production by well projects; increase production by springs; and full utilization of the Ugum Water Treatment Plant water. The following Capital Improvement Projects can accomplish GWA's supply side production needs.

Well Production

The "down hard" wells will be evaluated to determine if the well can be rehabilitated, re-drilled or abandoned. "Down hard" wells are the most cost effective approach to increase production because the existing "down-hard" sites already are GWA property, with existing back-up generators and buildings. The CIPs for down-hard wells are divided into two projects for funding reasons.

- *CIP PW 05-13, Deep Well Rehabilitation*: This project will provide rehabilitation of "down-hard" wells to increase supply. This project will require a feasibility study to determine the specific approach to each well and the cost estimate for each well site.
- *CIP PW 05-14 New Deep Wells at Down Hard Well Sites*: This project will include new source water by drilling new well adjacent to the existing wells. This cost of these new well will include casing and the transmission line to tie the well into the system. This project will require a feasibility study to determine the specific approach to each well and produce a cost estimate for each well site.

Development of new water wells shall be addressed by the following.

- *CIP PW 09-02 Water Wells.* This CIP will construct approximately 16 new production wells to produce an additional 7 MGD. Because the aquifer withdrawal rate is nearing the estimated maximum sustainable yield, it is imperative that the identification of the site locations and well development are addressed with the understanding of the aquifer as a whole.

Fully Utilize the Ugum Treatment Plant Water

The upgraded plant capacity at Ugum Treatment Plant is 4 MGD. In the dry season, the production is limited to 2.5 MGD to maintain minimum stream flow. Two CIP projects are required to fully utilize this supply.

- *CIP PW 09-01 Ugum Water Treatment Plant Intake Modifications:* this project includes an alternative analysis and a design concept report to refine the extent and cost of this critical project. This project will improve the intake structure of the Ugum Water Treatment Plant to minimize siltation and provide more reliable raw water supply during low river flow conditions. The current capacity of the intake pumps is estimated at 3.0 MGD but to fully utilize the treatment plant the intake pumps must be upgraded.
- *CIP PW 05-12 Brigade II (Ugum Lift) BPS Upgrade.* A new Brigade II booster pump station is required to fully utilize the surface supply from the south or the Ugum Treatment Plant. The new pump station, located at the Brigade II BPS site, will serve both the Windward Hills Reservoir and the Pulantat Reservoir. To provide this operational flexibility the new pump station shall be located on the downstream side of the Ugum Reservoir and able to overcome the pipe head loss plus the elevation difference (139 feet) between the Pulantat Reservoir and the Ugum Reservoir. Approximately 1,100 feet of pipe is required in addition to the pump station. Additionally, the Brigade and Windward Hills booster pump stations will be upgraded to increase reliability and energy savings.

Springs

Two spring projects are being considered to increase production.

- *CIP PW 05-03 Santa Rita Springs Booster Pump Rehabilitation, Phase II.* Phase I of the project has completed the Route 5 Transmission Line and a portion of the Santa Rita Booster Station. Phase II will include additional improvements to the booster station, specifically the impound reservoir.
- *CIP PW 05-18 Rehabilitation of Asan Springs Ground Reservoir.* This project will include the reservoir rehabilitation and treatment and chlorination facilities upgrade.

Demand Side Solutions

The demand side solution is focused on reducing GWA loss rate. The current projects that reduce the loss rate are the meter program and leak detection program. The leak detection program demonstrated approximately 5 MGD in pipe leaks. Future efforts to reduce water losses are water auditing efforts using the bubble map, master metering and partial based mapping audits for individual customer meters. Additionally, efforts on enhancing GWA's Conservation Program are underway which will subsequently reduce the supply side requirement.

CIP PW 05-16 Master Metering: This project involves the design and installation of water meters, meter vaults, and SCADA at major GWA facilities and pressure zones designed to fully account for water consumption. It is anticipated that the project will greatly aid in analyzing and forming a more accurate picture related to leak detection. The Leak Detection Contractor will make recommendations on key pressure zone locations. Although, the designer will validate and make determinations on sites, the project has been divided to accommodate SRF funding availability on its annual allotment. It is planned that this project will take approximately six years to complete the entire island based on 102 sites which includes 84 sites on the water transmission/distribution system and 18 wastewater potable water sites. The project is needed to perform water audits on water service areas (WSA) as required by US EPA. Furthermore, this project will greatly enhance the data from the current leak detection contract.

CIP EE 09-06 SCADA Improvements Phase 1: Phase 1 of this project involves the development of a SCADA Master Plan, design and construction standards and installation of a SCADA Master Station and SCADA System at selected Critical Water Wells and Critical Wastewater Pumping Stations along with the Critical Chlorination System Wells. The SCADA System will convey SCADA data and status information to a GWA Central Dispatch Center where digital text messaging would be directed to key personnel. This component will assist in managing the demand side by increasing the amount of information and decreasing the time to receive the information. Including in the management of the demand side, the SCADA system is required to optimize the system operations, as well as, vastly reduce the existing human capital that currently gathers information.

CIP PW 09-03 Water Distribution System Pipe Replacement: This project will fund the pipe replacement projects identified through the leak detection program; identify pressure problems and the hydraulic modeling. A priority ranking system will be developed to rank the pipe replacement based on age of pipe, type of pipe, number of leaks per 1,000 feet, quantity of leaks per 1,000 feet and identified pressure problem. This project is more of a program because of the pipe replacement addresses leaks, failures and age issues. CIP PW 09-05 Northern System Water Distribution System 2005 Improvements, CIP PW 09-06 Central Water Distribution System 2005 Improvements, and CIP PW 09-07 Southern Water Distribution System 2005 Improvements can also be used for line replacement projects.

Implementation Strategy

The supply side and demand side projects recommended above are categorized as either short term implementation strategy or medium term implementation strategy. These projects have been ranked in priority from Priority 1 to Priority 4 as shown in Table B. Projects ranked as Priority 3 and Priority 4 are determined outside the Short Term Implementation strategy in terms of project construction. However in order to accelerate these medium term projects, the planning and design phases of Priority 3

and 4 projects should be considered part of the short term implementation strategy. Where the procurement of design services for Priority 3 projects should begin before Priority 4 projects.

Table B: Recommended Project Priority

CIP #	Name	Priority	Implementation Strategy
N/A	Water Operations support for site evaluation an site clean up	Priority 1	Short Term
PW 05-03	Santa Rita Springs Booster Pump Rehabilitation, Phase II	Priority 1	Short Term
PW 05-12	Brigade II (Ugum Lift) BPS Upgrade	Priority 3	Medium Term
PW 05-13	Deep Well Rehabilitation	Priority 1	Short Term
PW 05-14	New Deep Wells at Down Hard Well Sites	Priority 1	Short Term
PW 09-01	Ugum Water Treatment Plant Intake Modifications	Priority 3	Medium Term
PW 09-02	Water Wells	Priority 4	Medium Term
PW 05-16	Master Metering	Priority 3	Medium Term
PW 05-18	Rehabilitation of Asan Spring Ground Reservoir	Priority 2	Short Term
EE 09-06	SCADA Improvements Phase 1	Priority 3	Medium Term
PW 09-03	Water Distribution System Pipe Replacement	Priority 4	Short Term

Funding

Table C provides the "Short Term" total project cost estimates for CIPs and planning and design of "Medium Term" projects. The preliminary cost estimate will improve as projects progress in the planning and design process. One example of improved project cost is when GWA receives the cost data from the drilling of the Airport Wells. As shown in Table C, the cost estimate, the existing funding sources, and funding shortfalls are listed. The funding short fall for "Short Term" plan is $5,950,000. Of the total $5,950,000, approximately $450,000 can be reimbursed from the 2010 Bond proceeds.

Table D provides the "Medium Term" construction cost estimates and funding short falls. The funding for the planning and design for theses medium term projects in the Short Term see Table C. The funding short fall for "Medium Term" plan is $15,560,000. In conclusion $21,510,000 ($5,950,000 + $15,560,000) is required to implement the short term and medium term projects.

Table C: "Short Term" Planning Level Cost Estimate

CIP #	Name	Funding	Cost Estimate	Funding Shortfall
	Water Operations support for site evaluation and site clean up	N/A		$225,000
PW 05-03	Santa Rita Springs Booster Pump Rehabilitation, Phase II	2005 Bond	$264,000	0
PW 05-12	Brigade II (Ugum Lift) BPS Upgrade (Planning & Design Only)	None	$120,000	$120,000
PW 05-13	Deep Well Rehabilitation (4)	None	$548,000	$548,000
PW 05-14	New Deep Wells at Down Hard Well Sites (8)	None	$3,773,000	$3,773,000
PW 09-01	Ugum Water Treatment Plant Intake Modifications(Planning & Design Only)	2010 Bond Partial	$200,000	200,000
PW 09-02	Water Wells (Planning & Design Only)	2010 Bond Partial	$1,800,000	0
PW 05-16	Master Metering (Planning & Design Only)	None	$200,000	$200,000
PW 05-18	Rehabilitation of Asan Spring Ground Reservoir	None	$634,000	$634,000
EE 09-06	SCADA Improvements Phase 1	2010 Bond	$250,000	250,000
PW 09-03	Water Distribution System Pipe Replacement	2010 Bond	$14,300,000	0
Required Funding Estimate				$5,950,000

Table D: "Medium Term" Planning Level Cost Estimate

CIP #	Name	Exiting Funding	Construction Estimate	Funding Shortfall
PW 05-12	Brigade II (Ugum Lift) BPS Upgrade (Construction Only)	None	$1,080,000	$1,080,000
PW 09-01	Ugum Water Treatment Plant Intake Modifications(Construction Only)	2010 Bond Partial	$1,800,000	$1,180,000
PW 09-02	Water Wells (Construction Only)	2010 Bond Partial	$13,000,000	$11,500,000
PW 05-16	Master Metering (Construction Only)	None	$1,800,000	$1,800,000
Required Funding Estimate				$15,560,000

"Short Term" Projected Production Increase

The purpose of this section is to evaluate the increase in quantity of water if the "Short-Term" projects listed in Table B are implemented.

Table E: Short Term Supply Side Strategies

Sources	Site	Notes	gpm
Down Hard well	A-7	Pump stuck in well head	113
Down Hard well	D-3	Pump stuck in well head	189
Down Hard well	D-17	Collapsed screen	199
Down Hard well	D-18	Collapsed screen	180
Down Hard well	A-1	Pumping air	216
Down Hard well	A-2	Pumping air	241
Down Hard well	A-3	Pumping air	180
Down Hard well	D-22	Pumping air	200
Down Hard well	M-9	Pumping air	148
Down Hard well	M-17A	High tributary	202
Down Hard well	A-28	PCE contamination	223
Down Hard well	D-13	High chloride	0
Down Hard well	M-14	Chlordane Contamination	239
Down Hard well	Y-7	pump motor stuck in well	300
Spring	Santa Rita		165
Spring	Asan		298
Total Estimated Production			3,093

The total wet season estimated production from Table E is 3,093 gallons-per-minute (gpm) or 4.4 MGD. The projected production from the implementation of these well and spring short term projects would increase from 36.2 to 40.6 MGD (36.2 + 4.4 = 40.6). This is summarized in Table F, along with the increase in Supply to Demand Factor form 0.98 to 1.08 (46.4 / 43 = 1.08).

Table F: GWA Project Production

Source	Current Production	Projected Production
Wells & Springs	36.2 MGD	40.6 MGD
Ugum Treatment Plant	2.3 MGD	2.3 MGD
Navy	3.5 MGD	3.5 MGD
Total	42 MGD	46.4 MGD
Supply to Demand Factor	0.98	1.08

To reiterate, the long term solution for supply is to establish and maintain a "1.2 Supply to Demand Factor." The 1.2 Supply to Demand Factor will provide the operational flexibility and emergency preparedness to adequately ensure pressure and supply to GWA customers. The projected production with the implementation of this plan is the first step to achieving the long term objective. Further evaluation of the system should

be made on the Supply and Demand Factor after the completion of the Short Term projects and during the implementation of the medium term projects.

An additional observation is the 3.5 MGD of Navy water that makes up for 0.08 (3.5/ 42) of the Supply to Demand Factor. GWA should have the goal of increasing production in order to decrease purchases of Navy water, except in emergency situations. This is due to the high price of purchasing Navy water as compared to GWA production cost. But, it may not be cost effective for GWA to build a water distribution system to get completely off Navy water, but minimizing Navy Water purchases must be a goal of GWA.

"Medium Term" Analysis

The "Medium Term" Analysis is performed to evaluate the "1.2 Supply to Demand Factor" after the implementation of the "Short Term" and "Medium Term" projects. This section answers the question: is the developments of the "Short Term" and "Medium Term" projects provide too much supply? The "Medium Term" Analysis is a best case scenario assuming no military build-up, GWA existing well infrastructure is dependable, and no reduction in well capacity due to GEPA chloride requirements. Both of these assumptions are not likely, but are valid assumptions for understanding the impact of implementing the Supply Side and Demand Side projects in this report.

Funding Example

CIP PW 09-02 Water Wells is listed on both the short term and medium projects. The project includes $1,800,000 for design listed in Table C and $13,000,000 listed in Table D for construction at a total cost of $14,800,00, with $3,300,000 of the funding identified in the 2010 Bond. Therefore, in order to fully implement this project an additional $11,500,000 is required as listed in Table D.

Demand Side Improvements

The 2009 leak detection program demonstrated approximately 5 MGD in pipe leaks. With the implementation of *CIP PW 09-03 Water Distribution System Pipe Replacement*: pipes identified through the leak detection program will be replaced. GWA could possible see a reduction in the leak rate 50%, assuming an aggressive line replacement program. Thus, the pipe replacement program could yield 2.5 MGD savings (0.50 X 5 MGD = 2.5 MGD). This demand side water savings is a decrease in production requirements of 2.5MGD, subtracting the current production of 43 MGD with the 2.5 MGD saving yields a decrease in required production of 40.5 MGD.

"Medium Term" Projected Demand Increase

Demand increases proportionately as population increases. Using a conservative population increase of 2% per year the demand will increase 10.4% in the next five years (1.02^5). So the demand in 2015 could be estimated at 43 MGD X 1.104 = 47.5 MGD or 40.5 MGD X 1.104 = 44.7 MGD with an aggressive pipe replacement program.

Projected Production Increase

The quantity of some source water is dependent on the season. The wet season has the maximum production and the end of the dry season experiences the minimum production. The end of the dry season also is expected to have the highest water demand. Therefore, "1.2 Supply to Demand Factor" is the Average Year Supply to Demand Factor for the Dry Season and Wet Season. However, to understand the worst case scenario GWA must evaluate the Dry Season Supply and Demand Factor.

The production of water from the wells and springs is reduced during the dry session. The Santa Rita Spring, Asan Spring, and Well D22 decrease in the dry season from 663 gpm to approximately 332 gpm or a reduction of 0.5 MGD. This reduces the dry session supply from Table D to 41.1 MGD. The upgraded plant capacity at Ugum Treatment Plant is 4 MGD. In the dry season, the production is limited to 2.5 MGD to maintain minimum stream flow. Table F presents the Dry Season and Wet Season production with corresponding "Supply to Demand Factors." Table G also compares the "Supply to Demand Factors" with the reduction of demand side by an aggressive pipe replacement program.

"Mid-Term" Analysis

Assuming a population growth of 2% annually and water system leaks reduced by 50% by an aggressive pipe replacement program, the "1.2 Supply to Demand Factor" is not maintained after 2016 and new source water will have to be developed. The "Supply to Demand Factor" was calculated using the base number of 40.5 MGD demand at year 2010 with a wet season supply of 54.9 MGD and a dry season supply of 52.9 MGD. A breakdown of the "Supply to Demand Factor" by year is provided in Table H.

The "Medium Term" Analysis is a best case scenario assuming no military build-up, GWA existing well infrastructure is dependable, and no reduction in well capacity due to GEPA chloride requirements.

Table G: Best Case Scenario Projected Production

Source	Wet Season Production	Dry Season Production
Wells & Springs	40.6 MGD	41.1 MGD
New Wells	7 MGD	7 MGD
Ugum Treatment Plant	4 MGD	2.5 MGD
Navy	3.5 MGD	3.5 MGD
Total Supply	55.1 MGD	53.1MGD
2015 demand	47.5 MGD	47.5 MGD
Supply to Demand Factor	1.16	1.12
2015 demand w/ pipe replacement	44.7 MGD	44.7 MGD
2015 Supply to Demand Factor w/ pipe replacement	1.23	1.19

Table H: Best Case Scenario "Supply to Demand Factor" (SD Factor)

Years	Year	Growth factor	Estimated demand	Wet Season SD Factor	Dry Season SD Factor	SD Factor
4	2014	1.082	43.8 MGD	1.258	1.212	1.24
5	2015	1.104	44.7 MGD	1.233	1.187	1.21
6	2016	1.126	45.6 MGD	1.208	1.165	1.19
7	2017	1.148	46.5 MGD	1.185	1.142	1.16
10	2020	1.219	49.4 MGD	1.115	1.075	1.10

Military Build-Up

The current water supply to demand ratio and the projected water supply to demand ratio demonstrate that GWA must require any Department of Defense related projects to provided source water at the 1.2 supply to demand ratio level as a requirement of permitting. Further any and all major development must provide source related at the 1.2 supply to demand ratio level during the permitting process. Small developments and residential permits contribute to the source water under the System Development Charges.

Recommendations

Increasing the production of water in GWA system must be made the highest priority of the utility in order to keep our customers with tap water and maintain adequate pressure in the water distribution system. The following recommendation would keep this project on the critical path and enhance the information to make better discussions in the future.

- As soon as possible work on advertizing professional services contracts that are critical path to planning and design.
- Define the funding sources for the Short Term Projects.
- GWA's Deep-Well Chloride Action Plan must be revised to accommodate current operational challenges with respect to production of water. Specifically update the schedule for the well plan implementation.
- Provide an assessment the new well project including which sites have GWA drilled test well, which site has GWA acquired property. Develop targeted areas on Guam where GWA can drill the most productive and reliable wells.

Implementation Status (Post Script)

Water Operations is responsible for the operations and maintenance of GWA's well field. Along with the day by day challenges water operation team has been focused on providing support for site evaluation repairing down hard wells. This June "Down Hard" Well Y-7 was repaired to add an additional flow of approximately 340 gpm.

Figure A: Typical Well Site