CHAPTER 7 – WATER REUSE

7.1 Introduction

The reuse of treated wastewater has become increasingly popular in the United States over the past decade. Both the general decrease in potable water sources and the advancements in wastewater treatment technologies have contributed to the increasing spectrum of reuse opportunities. Water reuse has proven vital to some communities in supplementing a potable water supply to a growing consumer base. In addition to this primary benefit, the reuse of treated wastewater can reduce pollutant loading to surface waters and can potentially postpone, and sometimes eliminate, costly investments in developing new water sources and supplies.

The current potable water demand from residential, tourism, agricultural and golf course irrigation uses are projected to increase on Guam over the course of the planning horizon of this WRMP through 2026. Because Guam currently does not have established regulations governing recycled water reuse, Hawaii and California regulations are used as the basis for the recommendations provided in this chapter. Those regulations and associated guidelines, which are summarized in the attached Appendix 3E – Summary of Hawaii and California Water Reuse Regulations, should be used as a template for developing reuse criteria specific to potential beneficial reuses on Guam.

7.2 Regulations for Beneficial Wastewater Reuse

Currently, 27 states including California, Oregon and Hawaii have regulations for Unrestricted Urban Reuse. Regulations and guidelines vary from one state to another, depending on the various types of application. Regulations refer to actual rules that have been enacted and are enforceable by state agencies. Conversely, guidelines are not enforceable but can be used in the planning and development of reuse alternatives and programs. Additionally, monitoring requirements vary significantly from one state to another and from one type of reuse to another. Figure 7-1, EPA Suggested Water Recycling Treatment and Uses, was extracted from the document, "Water Recycling and Reuse: The Environmental Benefits" by EPA Region IX, and it depicts the recommended treatment processes, together with the associated beneficial use alternatives.

Figure 7-1 – EPA Suggested Water Recycling Treatment and Uses

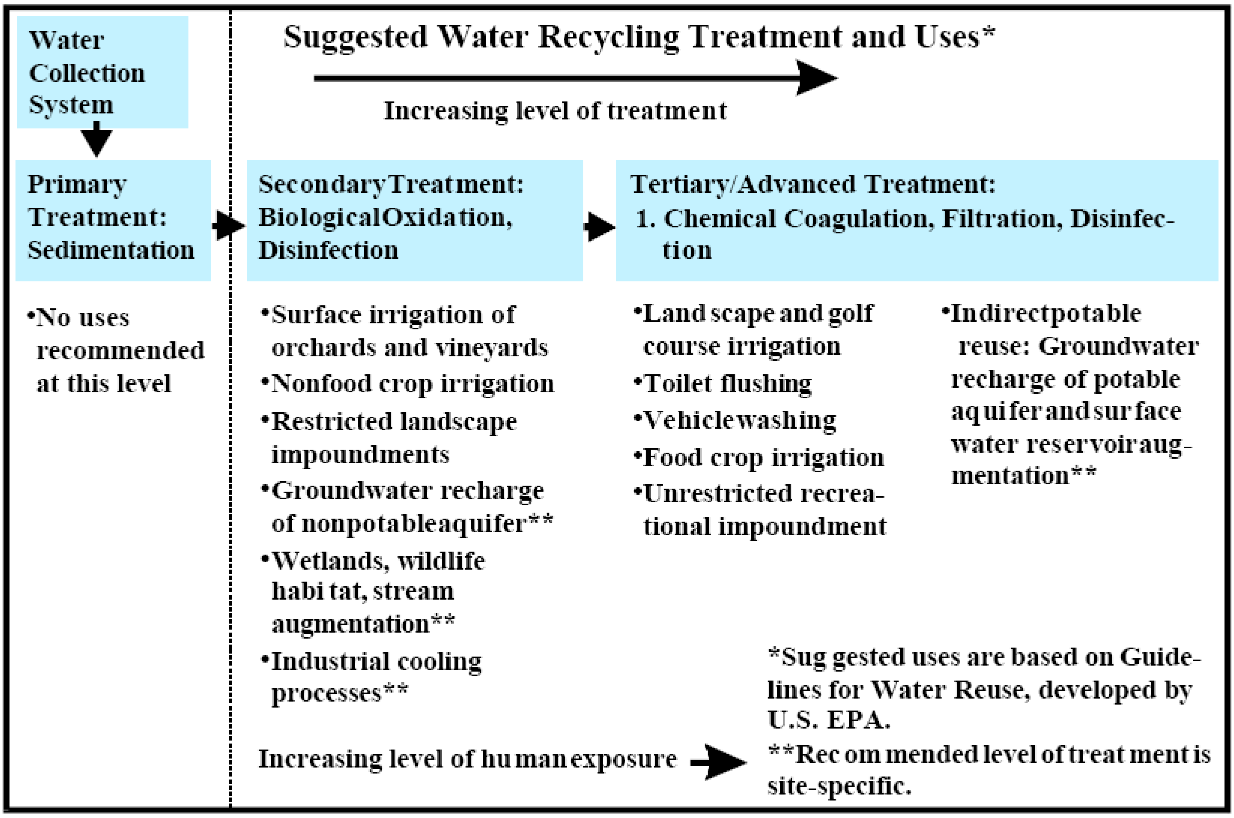


Figure 7-1 also provides a generalized flow diagram of treatment levels compared with beneficial reuse alternatives. As previously mentioned, the required treatment levels vary from one state to another for various beneficial reuse alternatives, deviating from EPA's recommendations shown above. Even though the treatment processes and levels may change from one state to another, the EPA definitions for the various beneficial reuse alternatives remain constant. The following section defines and summarizes these common reuse categories.

7.2.1 Common Types of Wastewater Reuse Applications

The EPA has separated potential beneficial reuse categories into Groundwater Recharge, Industrial Reuse, Environmental Reuse, Restricted Recreational Reuse, Unrestricted Recreational Reuse, Agricultural Reuse on Non-Food Crops, Agricultural Reuse on Food Crops, Indirect Potable Reuse, Unrestricted Urban Reuse and Restricted Urban Reuse (EPA, 2004). For each of these reuse categories, the EPA suggests various treatment options for achieving required minimum standards, which are summarized below. Some of the minimum standards specific to Hawaii and California deviate from the EPA suggested minimums, as discussed in the following subsections.

7.2.1.1 Groundwater Recharge

Most states require a relatively low level of treatment for groundwater recharge, which typically includes a minimum of secondary treatment with disinfection. However, most potable water supplies are protected by a requirement for minimum separation between the point of recharge and the potable water supply wells. The separation distance, soil characteristics, hydrogeology and residence time all govern the quality and quantity of recycled water recharge into groundwater aquifers through various means such as filtration basins, percolation ponds or direct injection wells. Because of the many variables involved, most states do not have specific regulations or guidelines, but instead they determine required treatment processes on a case-by-case basis. Geothermal injection is another form of wastewater reuse in terms of recharging groundwater aquifers.

7.2.1.2 Industrial Reuse

The regulation and guidelines for industrial reuse vary significantly from one state to another. The potential for human exposure is the basis for the required level of treatment, and the primary reuse for industrial facilities includes system cooling, boiler-feed water, process water and general washdown.

7.2.1.3 Environmental Reuse

Only Florida, South Dakota and Washington currently have guidelines or regulations that govern the reuse of recycled wastewater for various environmental reuses, such as wetland creation, natural wetland enhancement or to sustain or augment stream flows. The level of treatment required for reuse varies significantly, and it is based on the degree of potential public access to the recycled water. The most common reuse application is actually found in tertiary wastewater treatment processes involving enhancement of marshes or wetlands.

7.2.1.4 Unrestricted Urban Reuse

Unrestricted urban reuse is defined as recycled water that can be used for applications where public exposure is likely, thereby requiring a high level of treatment. Some of the more common examples of beneficial reuse are irrigation of parks, golf courses, playgrounds, school yards and residential landscaping. Other examples include toilet flushing, air conditioning, fire protection, construction, ornamental fountains, street cleaning and aesthetic impoundments. Treatment processes vary from one state to another; however, the minimum level of treatment typically includes tertiary treatment followed by disinfection. Additional levels of treatment, such as removal of nutrients, heavy metals and salts, may be required as well.

7.2.1.5 Restricted Urban Reuse

Restricted urban reuse is defined as recycled water that can be used for applications where public exposure is controlled, resulting in lower treatment requirements than that for unrestricted urban reuse. One of the more common beneficial reuses includes aboveground irrigation of areas such as highway medians or subsurface irrigation. Treatment processes vary from one state to another; however, the minimum level of treatment typically includes secondary or biological treatment, followed by disinfection. Additional levels of treatment, such as filtration, may be required.

7.2.1.6 Restricted Recreational Reuse

Similar to restricted urban reuse, restricted recreational reuse involves the reuse of recycled wastewater where public exposure is controlled, thus requiring a less stringent level of treatment compared with unrestricted recreation reuse treatment levels. An example of restricted recreational reuse is an impoundment of water in which recreation is limited to fishing, boating, and other non-contact recreational activities. Secondary treatment with disinfection is the typical minimum level of treatment.

7.2.1.7 Unrestricted Recreational Reuse

Much like unrestricted urban reuse, unrestricted recreational reuse involves the use of recycled water where public exposure is likely and therefore requires a high level of treatment. An example of unrestricted recreational reuse is an impoundment of water in which no limitations are imposed on body-contact water recreational activities. Only seven states in the U.S. have regulations or guidelines for unrestricted recreational reuse applications. Treatment processes vary among these states; however, the minimum level of treatment is secondary treatment followed by disinfection. Additional levels involve oxidation, coagulation and filtration.

7.2.1.8 Agricultural Reuse on Non-Food Crops

Agricultural reuse of recycled water for non-food crops reduces the potential of human exposure, in turn requiring a lower level of treatment compared with recycled irrigation water for edible food crops. Some examples include the irrigation of fodder, seed crops, pasture land, commercial nurseries, and sod farms. Treatment processes vary from one state to another; however, the minimum level typically includes secondary treatment followed by disinfection. Additional levels of treatment, such as oxidation and filtration, are commonly required.

7.2.1.9 Agricultural Reuse on Food Crops

Agricultural reuse on food crops is simply the use of recycled water for irrigation purposes on food crops that are intended for direct human consumption. Several states prohibit the use of recycled water for irrigation of food crops, whereas others allow it only if the food crop is to be processed and not eaten raw. Treatment processes vary significantly from one state to another. However, much like the treatment level for unrestricted urban reuse, secondary treatment along with disinfection is typically the minimum level. Additional levels of treatment, such as oxidation, coagulation and filtration, are commonly required.

7.2.1.10 Indirect Potable Reuse

Indirect potable water reuse is best defined as the use of recycled water to augment surface or groundwater sources that are used for a source of potable water. The minimum treatment processes range significantly from one state to another. Much like groundwater recharge, there are many factors involved that ultimately require a very high level of treatment and are typically determined on a case-by-case basis.

7.2.2 Comparison of Hawaii's and California's Standards for Beneficial Uses

Appendix 3E was developed to present the regulations and guidelines that govern the more common beneficial reuse alternatives in Hawaii and California. Table 7-1 lists the Hawaii and California minimum standard reuse categories for the more common beneficial uses. Some of these alternatives would also likely be more feasible for Guam to implement in the planning horizon.

Table 7-1 – Comparison of Beneficial Uses and Associated Reuse Categories for Hawaii and California

Beneficial Use	Minimum Standards	
	Hawaii	California
Surface Irrigation of Unrestricted Access Golf Courses	R-1	Tertiary
Surface Irrigation of Parks and Playgrounds	R-1	Tertiary
Irrigation of Food Crops (recycled water comes into contact with edible portion of crop)	R-1	Tertiary
Toilet and Urinal Flushing	R-1	Tertiary
Landscape Impoundments and Decorative Fountains	R-1	Tertiary
Commercial and Public Laundries	R-1	Tertiary
Industrial Processes with Exposure to Workers	R-1	Tertiary
Air Conditioning Systems with a Tower, Evaporative Condenser, or other Water-Emitting Features	R-1	Tertiary
Restricted Recreational Impoundments	R-1	Secondary-2.2
Surface Irrigation of Restricted Access Golf Courses	R-2	Secondary-23
Subsurface Irrigation for Landscape and Turf at Parks, Playgrounds, Golf Courses	R-2	NA
Irrigation of Cemeteries and Road Sides/Medians	R-2	Secondary-23
Structural Firefighting	R-2	Tertiary
Non-structural Firefighting	R-2	Secondary-23
Air Conditioning Systems without Tower, Evaporative Condenser, or Other Water-Emitting Features	R-2	Secondary-23
Industrial Processes without Exposure to Workers	R-2	Secondary-23
Irrigation for Fodder Crops and Fiber Crops	R-3	Undisinfected Sec.
Irrigation of Food Crops (recycled water does not come into contact with edible portion, orchards/vineyards)	R-3	Undisinfected Sec.
Irrigation of Non-Food-Bearing Trees	R-3	Undisinfected Sec.

NA – Regulations for subsurface irrigation for landscape and turf at parks, playgrounds, and golf courses are not stated by California in Title 22

The differences in standards between Hawaii and California are subtle; however, both sets should be reviewed in depth prior to adopting or developing regulations and requirements specific to Guam.

7.3 Current Wastewater Production, Treatment, and Reuse Opportunities

Potential beneficial reuse opportunities within the serviceable vicinity of each STP on Guam were identified and are discussed below. Some of the more feasible reuse alternatives that could potentially be implemented in this planning horizon include landscape irrigation, golf course irrigation and agricultural land irrigation, in addition to toilet flushing. Landscape irrigation and toilet flushing alternatives were assumed to be viable alternatives only for future planned developments, which would likely include private homes, hotels, and condominiums. Implementing separate transmission lines to distribute recycled water to these proposed developments would only be feasible under new development circumstances; however, implementing a new distribution system to service existing housing and hotel facilities would not be cost-effective because of the high cost to retrofit an existing building for dual plumbing. Because most of the new developments identified in Volume 1, Chapter 6 – Population and Land Use Forecast, and discussed below are in the early planning phases, quantifying the recycled water demand would be both difficult and inherently inaccurate.

Conversely, irrigation demand from existing golf courses and agricultural lands offers a much greater potential for reuse. A survey of seven golf courses on the island included specific questions pertaining to each facility's current irrigation use and its potential interest in converting to irrigation with recycled water. The survey did not yield statistically significant results, nor was the determination of a specific dedicated user made. The results of the survey are summarized in Table 7-2. However, if dedicated users are identified in the future and water reuse regulations are developed, the determination of capital costs associated with STP upgrades and implementation of distribution networks, compared with the return from the dedicated user, should be evaluated.

Table 7-2 – Golf Course Survey Results (Private Courses)

No.	Golf Course	Village	No. of Holes	Comments	Closest STP	Approximate Distance (miles)
1	Guam International Country Club	Dededo	18	No written response-conveyed interest over phone call (3/13/06 & 3/27/06)	Northern District	2.5
2	LeoPalace Resort Country Club	Yona	4 courses/9 holes each	No response	Hagatna	3.2
3	Mangilao Golf Course	Mangilao	18/120 acres	Written response-interested (3/20/06)	Northern District & Hagatna	5.5 6.3
4	Country Club of the Pacific	Ipan/Talofofo	18	Written response-not interested (3/22/06)	Baza Gardens	1.4
5	Starts Guam Golf Resort Inc.	Dededo	27	No written response-conveyed interest over phone call (3/13/06)	Northern District	4.0
6	Onward	Talofofo	18	Golf course closed-could not make contact	Baza Gardens	0.7
7	Windward Hills Country Club	Talofofo	18	No response	Baza Gardens	1.1

A detailed facility plan would need to be developed for determining the most suitable system for a pre-determined, dedicated reuse market, and it would ultimately replace the conceptual developmental suggestions presented below. Figures 7-2 and 7-3 delineate the proximity of the private golf courses surveyed to the nearest STPs. The approximate distances to the plants are listed in Table 7-2.

Figure 7-2 – Northern Region Golf Courses Proximity to STPs

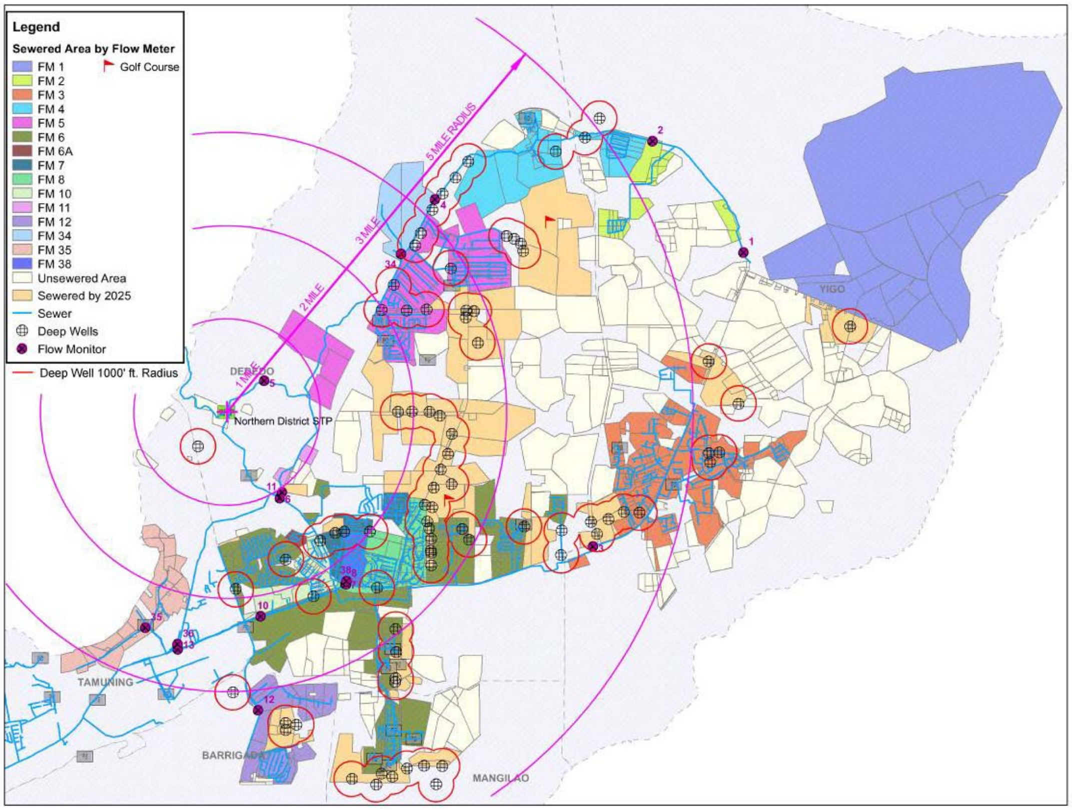
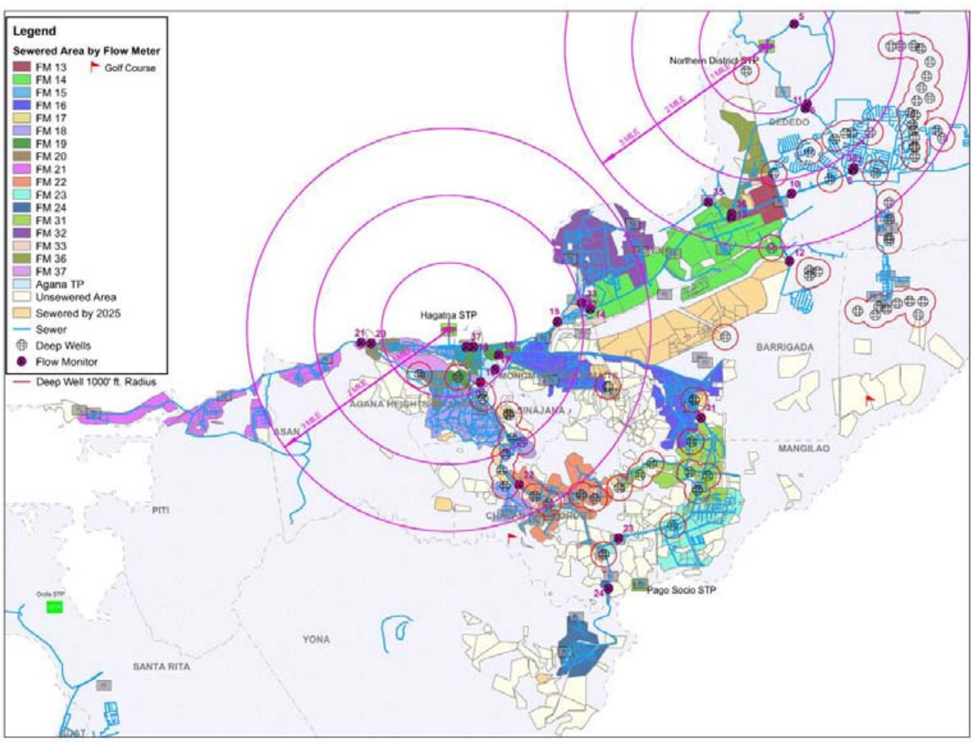


Figure 7-3 – Central Region Golf Courses Proximity to STPs



Although reuse can be beneficial in reducing water demands and in providing a means for disposal of the effluent, there can be potential conflicts between the utility and the end user. For example, if reuse is the only method of disposal (discharge) of the effluent then sufficient storage capacity must be developed to hold the effluent during the rainy season and at times when the end user does not need to irrigate. The utility also needs to have a long-term contract with the end user to ensure that this disposal option remains viable. In general, it is recommend that the utility own the area being irrigated and then lease it to an operator instead of entering into a lease with the landowner. This will, in the long term, be less expensive for the utility and will ensure that the area is available for use whenever needed.

Some of the main issues that need to be considered when completing a detailed facilities plan for a specific treatment plant are listed below:

- Identify all of the potential parcels of land that could be used for reuse.
- Determine the level of treatment required for each potential end user.
- Determine whether alternative disposal methods, such as a direct discharge, are needed for each potential end user or combination of end users.
- Determine the infrastructure needs to develop each potential end user site(s). This would include pump station(s), pipelines and possibly storage facilities.
- Develop opinions of the probable costs for construction, operation, maintenance, easements and possible land acquisitions for each potential end user.
- Determine the interest in water reuse by current property owners.
- Compare monetary and non-monetary factors of each reuse alternative with the non reuse alternative.
- Summarize findings in a written report.

In addition to identifying potential reuse opportunities within the serviceable vicinity of each STP, current STP effluent quality was compared with the potential beneficial reuse alternative standards. These reuse alternative standards are based on both Hawaii and California minimum standards; whereas the current effluent quality and NPDES permit limitations for each STP were adapted from Chapter 8, Biosolids Management of this volume.

7.3.1 Reuse Opportunities in the Agat-Santa Rita STP Vicinity

Based on the population and land use forecast for Guam between 2015 and 2020 (see Volume 1, Chapter 6), potential reuse opportunities in the planning horizon could include using the Agat-Santa Rita STP's effluent for toilet flushing and landscape irrigation for the planned Nomura Resort Hotel, Agat Hilltop Gardens, S&R Hotel and the Corps of SDA Hotel. These proposed private developments are all within a serviceable distance from the Agat-Santa Rita STP. This alternative would require either upgrading the Agat-Santa Rita STP processes or constructing a satellite tertiary treatment plant to meet the potential beneficial reuse water quality standards of either Hawaii's R-1 or California's disinfected tertiary levels. Additionally, adequate storage and a distribution network would have to be implemented to service the reuse market.

This alternative would only be economically viable if the cost of the recycled water to the dedicated user was proven to return the capital cost of the system within its design life. Because there are no current identifiable irrigation demands for golf courses or agricultural lands within the serviceable range of the Agat-Santa Rita STP, future water reuse will be confined solely to new development demand. Furthermore, under current operating conditions, the Agat-Santa Rita STP's NPDES permit limitations for average monthly 5-day biochemical oxygen demand (BOD_5), average monthly total suspended solids (TSS), and average monthly fecal coliforms are all currently being exceeded, as indicated in Table 7-3.

Table 7-3 – Agat-Santa Rita STP Effluent Characteristics
(Including Hawaii and California Minimum Standards)

			Beneficial Reuse Categories and Minimum Standards						
			Hawaii			California			
Agat-Santa Rita STP (Secondary Treatment – Ocean Outfall)		NPDES Limitation	R-1	R-2	R-3	Tertiary	Secondary -2.2	Secondary-23	Undisinfected Secondary
Average Monthly BOD_5 (mg/L)	84.3	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly TSS (mg/L)	63.4	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly Fecal Coliform (CFU/100mL)	24,192	200	2.2	23	NS	2.2	2.2	23	NS
Maximum Daily Fecal Coliform (CFU/100mL)	NA	NA	23	200	NS	23	23	240	NS
Average Monthly Turbidity (NTU)	NA	NA	2	NR	NS	2	NR	NR	NS
Average Daily Maximum Influent Flow (mgd)	NA	None	NR	NR	NR	NR	NR	NR	NR
Average Daily Influent Flow (mgd)	1.9	None	NR	NR	NR	NR	NR	NR	NR

NS - Not Specified by the State of Hawaii or California regulations.
NA - Information Not Available.
NR - Not Regulated by the State of Hawaii or California.
The BOD_5 and TSS concentrations in the effluent from a STP are based on the arithmetic average of the results of the analyses of composite samples.

Based on this existing effluent quality, there are no beneficial reuse options currently available for the effluent that would meet the minimum standards for Hawaii or California reuse categories.

7.3.2 Reuse Opportunities in the Hagatna STP Vicinity

One potentially viable reuse opportunity based on population projections for 2015-2020, would use Hagatna STP treated effluent for toilet flushing and landscape irrigation in the proposed Lonfit New Town development. This would require upgrading the Hagatna STP from its primary treatment level or constructing a separate treatment facility to meet beneficial reuse water quality standards potentially set forth by the GEPA. Currently, the Hagatna STP's NPDES permit limitations for average monthly BOD_5 and average monthly TSS are being exceeded, as shown in Table 7-4. There are two golf courses near the Hagatna STP: LeoPalace Resort Country Club, a distance of 3.2 miles from the plant; and Mangilao Golf Course, 6.32 miles from the plant (see Figure 7-3 for locations).

Table 7-4 – Hagatna STP Effluent Characteristics
(Including Hawaii and California Minimum Standards)

			Beneficial Reuse Categories and Minimum Standards						
			Hawaii			California			
HAGATNA STP (Primary Treatment – Ocean Outfall)		NPDES Limitation	R-1	R-2	R-3	Tertiary	Secondary -2.2	Secondary-23	Undisinfected Secondary
Average Monthly BOD_5 (mg/L)	85.4	80	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly TSS (mg/L)	63.4	60	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly Fecal Coliform (CFU/100mL)	NA	NA	2.2	23	NS	2.2	2.2	23	NS
Maximum Daily Fecal Coliform (CFU/100mL)	NA	NA	23	200	NS	23	23	240	NS
Average Monthly Turbidity (NTU)	NA	NA	2	NR	NS	2	NR	NR	NS
Average Daily Maximum Influent Flow (mgd)	10.8	12	NR	NR	NR	NR	NR	NR	NR
Average Daily Influent Flow (mgd)	8.7	None	NR	NR	NR	NR	NR	NR	NR

NA - Information Not Available.
NS - Not Specified by the State of Hawaii or California Regulations.
NR - Not Regulated by the State of Hawaii or California.
The BOD_5 and TSS concentrations in the effluent from a STP are based on the arithmetic average of the results of the analyses of composite samples.

Further evaluation of the potential reuse options would require extensive analysis of the associated treatment upgrades, storage and distribution systems. Because of the anticipated high capital cost associated with upgrading a treatment facility of this magnitude, coupled with the lack of an identified dedicated high-capacity user, water recycling at the Hagatna STP is not considered to be economically viable in the planning horizon.

7.3.3 Reuse Opportunities in the Baza Gardens STP Vicinity

Compared with the regions surrounding the other STPs, the vicinity around the Baza Garden STP has a high density of golf courses and large contiguous areas of agricultural land. As shown in Figure 7-4, the Country Club of the Pacific (1.4 miles from the STP), Onward (0.7 mile from STP) and Windward Hills Country Club (1.1 miles from the STP) are all located relatively close to the STP. This proximity provides opportunities for reuse of recycled water treated at the Baza Garden STP. Furthermore, the relatively small capacity of the Baza Garden STP (0.5 mgd) is also desirable for balancing the volume of the treated effluent with the potential market demand. Unlike the Agat-Santa Rita, Hagatna and Northern District STPs' discharges via ocean outfalls, the Baza Garden STP discharges into the Togcha River and has a limited assimilation capacity relative to the ocean. Under current operating conditions, the NPDES permit limitations for average monthly BOD_5, average monthly fecal coliforms, and maximum daily fecal coliforms are all currently being exceeded, as shown in Table 7-5. However, the average monthly TSS limitation is not currently being exceeded.

Figure 7-4 – Southern Region Golf Courses Proximity to STPs

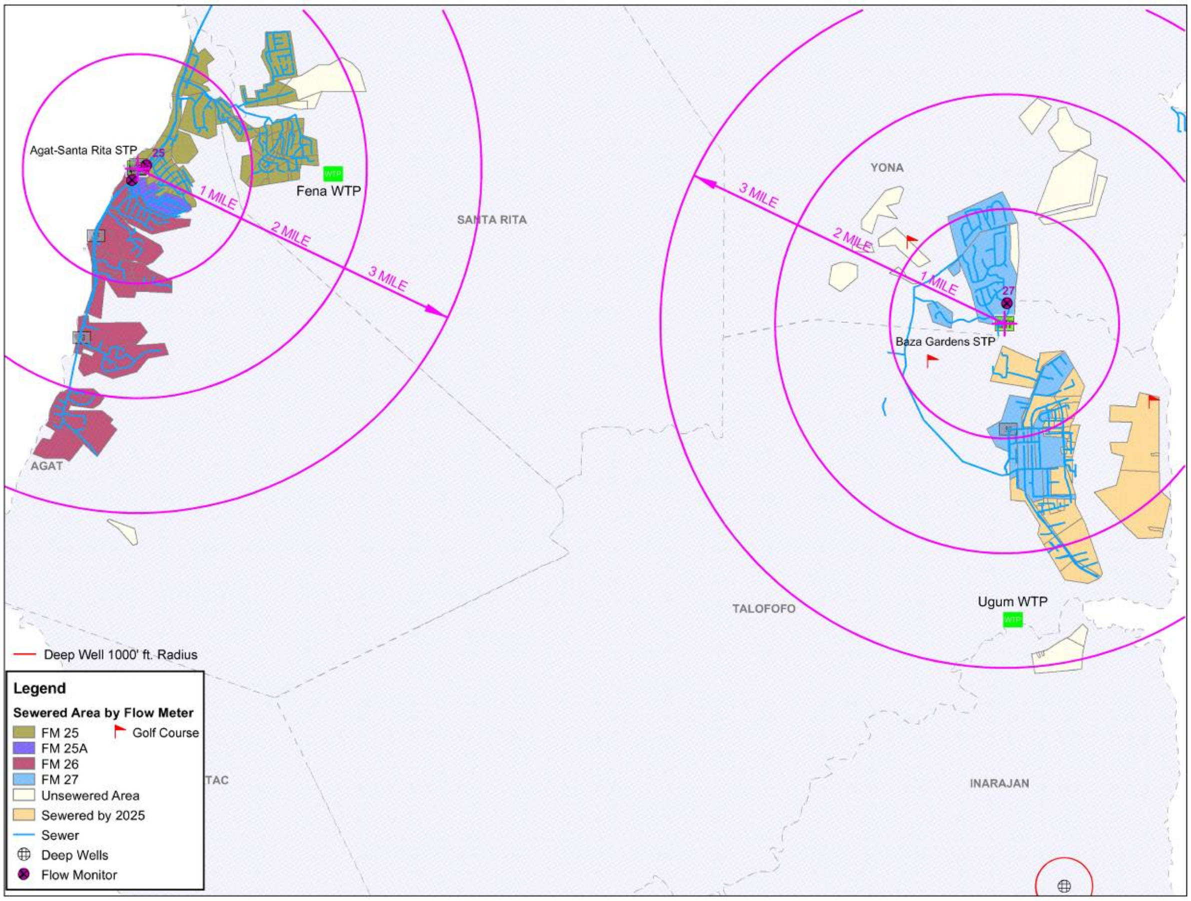


Table 7-5 – Baza Gardens STP Effluent Characteristics
(Including Hawaii and California Minimum Standards)

BAZA GARDENS STP (Secondary Treatment – Stream Outfall)		NPDES Limitation	Beneficial Reuse Categories and Minimum Standards: Hawaii R-1	Hawaii R-2	Hawaii R-3	California Tertiary	California Secondary -2.2	California Secondary-23	California Undisinfected Secondary
Average Monthly BOD_5 (mg/L)	53.4	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly TSS (mg/L)	16.7	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly Fecal Coliform (CFU/100mL)	19,477 (E. coli)	126 (E. coli)	2.2	23	NS	2.2	2.2	23	NS
Maximum Daily Fecal Coliform (CFU/100mL)	24,192 (E. coli)	406 (E. coli)	23	200	NS	23	23	240	NS
Average Monthly Turbidity (NTU)	NA	NA	2	NR	NS	2	NR	NR	NS
Average Daily Maximum Influent Flow (mgd)	NA	None	NR	NR	NR	NR	NR	NR	NR
Average Daily Influent Flow (mgd)	0.499	None	NR	NR	NR	NR	NR	NR	NR

NS - Not Specified by the State of Hawaii or California regulations.
NA - Information Not Available.
NR - Not Regulated by the State of Hawaii or California.
The BOD_5 and TSS concentrations in the effluent from a STP are based on the arithmetic average of the results of the analyses of composite samples.

Currently, there are no beneficial reuse options available for the effluent that would meet the minimum standards of Hawaii or California reuse categories. However, future upgrades to the STP may be warranted if the potential reuse markets discussed below become interested.

There are three 18-hole golf courses within serviceable range of the Baza Garden STP: Windward Hills, Country Club of the Pacific and Onward. However, no projections regarding the number of new golf courses planned for development within the planning horizon could be made from the available information. In predicting the irrigation demand for golf courses in similar climatic conditions of Guam, two application rates were assumed: 1,000 gpd per hole for greens alone, and 6,000 gpd per acre. Each of these application rates was used to generate an expected range of demands for the three Talofofo Village golf courses that are currently in operation and in close proximity to the Baza Garden STP (Table 7-6).

Table 7-6 – Estimated Irrigation Demand from Golf Courses Located in the Talofofo Village

Golf Course	Irrigation of Greens Only (1,000 gpd/hole)	Irrigation of Entire Golf Course Grounds (6,000 gpd/acre)
Windward Hills (18 holes, approximately 100 acres)	18,000	600,000
Country Club of the Pacific (18 holes, approximately 100 acres)	18,000	600,000
Onward (18 holes, approximately 100 acres)	18,000	600,000
Total	54,000 gpd[1]	1,800,000 gpd[1]

[1] - The irrigation demands quantified above are considered to be estimates and are provided to illustrate a range of demands from a potential viable reuse market.

In comparing the range of estimated irrigation demands above to the average daily operating capacity of the Baza Garden STP (0.5 mgd), the balance of irrigation demand with treated effluent supply is favorable. However, fluctuations in seasonal climatic conditions would require supplemental storage and an auxiliary outfall or, potentially, another reuse market to supply. If Guam adopts California or Hawaii reuse standards, public access restrictions at each golf course would dictate the water quality requirements for irrigation use. As explained in Appendix 3E, either Hawaii's R-2 standards or California's secondary-23 standards would be the minimum required treatment level and access restrictions would be required in addition to monitoring requirements.

In addition to using treated effluent for golf course irrigation, agricultural land irrigation is also a potential reuse opportunity near the Baza Garden STP. Approximately 650 acres of irrigable agricultural land exist in the Talofofo Village and within serviceable range of the STP. Irrigation water management practices change with crop type, soil texture and seasonal climatic conditions, so an estimated 1,000 gpd per acre was an assumed application rate. Using this rate, an estimated 650,000 gpd for irrigation demand would be required. This additional demand further reinforces the potential need for irrigation opportunities. Crop type and irrigation management practices would dictate the quality of effluent required to comply with the standards presented in Appendix 3E.

In addition to potential reuse markets such as golf course and agricultural land irrigation, the population and land use forecast for Guam between 2015 and 2020 (see Volume 1, Chapter 6) identified the proposed Manengon Hills development as being within an effective serviceable distance of the Baza Garden STP. Incorporating transmission lines for toilet flushing and landscape irrigation practices into the proposed private development's new infrastructure may be viable in the planning horizon.

This facility has a number of end users that could practice water reuse. A detailed feasibility plan would be required to evaluate these reuse alternatives and the associated STP upgrades, it is recommended that that this be completed as a next step.

7.3.4 Reuse Opportunities in the Umatac-Merizo STP Vicinity

Even though the region surrounding the Umatac-Merizo STP consists of agricultural land with reuse opportunities associated with irrigation, the Umatac-Merizo STP currently uses overland flow processes to dispose of treated effluent. Because of this type of disposal and the fact that there are no current NPDES permit limitations on the Umatac-Merizo STP effluent, reuse opportunities were not explored in the serviceable vicinity of the STP (Table 7-7).

Table 7-7 – Umatac-Merizo STP Effluent Characteristics
(Including Hawaii and California Minimum Standards)

			Beneficial Reuse Categories and Minimum Standards						
			Hawaii			California			
UMATAC-MERIZO STP (Secondary Treatment – Percolation)		NPDES Limitation	R-1	R-2	R-3	Tertiary	Secondary -2.2	Secondary-23	Undisinfected Secondary
Average Monthly BOD_5 (mg/L)	NA	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly TSS (mg/L)	NA	30	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly Fecal Coliform (CFU/100mL)	NA	126 (E. coli)	2.2	23	NS	2.2	2.2	23	NS
Maximum Daily Fecal Coliform (CFU/100mL)	NA	406 (E. coli)	23	200	NS	23	23	240	NS
Average Monthly Turbidity (NTU)	NA	NA	2	NR	NS	2	NR	NR	NS
Average Daily Maximum Influent Flow (mgd)	0.67	None	NR	NR	NR	NR	NR	NR	NR
Average Daily Influent Flow (mgd)	0.398	None	NR	NR	NR	NR	NR	NR	NR

NA - Information Not Available.
NS - Not Specified by the State of Hawaii or California Regulations.
NR - Not Regulated by the State of Hawaii or California.
The BOD_5 and TSS concentrations in the effluent from a STP are based on the arithmetic average of the results of the analyses of composite samples.

7.3.5 Reuse Opportunities in the Northern District STP Vicinity

Similar in size and treatment level to the Hagatna STP, the NDSTP is confronted with the same constraints for developing viable reuse opportunities. Because of the relatively large, primary effluent flow and the fact there are only two current identifiable users within serviceable range of the STP, the development of water reuse is impractical in the near planning horizon for this area. However, two potential users are the Starts Golf Course Inc. (a 27-hole golf course located 4.0 miles from the STP), and the Guam International Country Club (an 18-hole golf course 2.5 miles from the STP). Also, Mangilao Golf Course is approximately 5.5 miles from the STP. Figure 7-2 shows the golf course locations. Even though residential developments are being proposed in the vicinity of the NDSTP between 2015 and 2020, the estimated reuse demand from both golf courses and the proposed developments would be magnitudes lower than the current STP effluent yield. Furthermore, the potential for contamination of the northern groundwater lens should be a major consideration in the planning and development of water reuse in the northern region of the island. Under current operating conditions, the NPDES permit limitations for both average monthly BOD_5 and average monthly TSS are currently being exceeded, as shown in Table 7-8.

Table 7-8 – Northern District STP Effluent Characteristics
(Including Hawaii and California Minimum Standards)

			Beneficial Reuse Categories and Minimum Standards						
			Hawaii			California			
NORTHERN DISTRICT STP (Primary Treatment – Ocean Outfall))		NPDES Limitation	R-1	R-2	R-3	Tertiary	Secondary -2.2	Secondary-23	Undisinfected Secondary
Average Monthly BOD_5 (mg/L)	85.7	85	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly TSS (mg/L)	62.6	50	30	30	30	≤ 30	≤ 30	≤ 30	≤ 30
Average Monthly Fecal Coliform (CFU/100mL)	NA	NA	2.2	23	NS	2.2	2.2	23	NS
Maximum Daily Fecal Coliform (CFU/100mL)	NA	NA	23	200	NS	23	23	240	NS
Average Monthly Turbidity (NTU)	NA	NA	2	NR	NS	2	NR	NR	NS
Average Daily Maximum Influent Flow (mgd)	9.6	6	NR	NR	NR	NR	NR	NR	NR
Average Daily Influent Flow (mgd)	9.3	None	NR	NR	NR	NR	NR	NR	NR

NA - Information Not Available.
NS - Not Specified by the State of Hawaii or California regulations.
NR - Not Regulated by the State of Hawaii or California.
The BOD_5 and TSS concentrations in the effluent from a STP are based on the arithmetic average of the results of the analyses of composite samples.

7.3.6 Reuse Opportunities in the Inarajan STP Vicinity

The population and land use forecast for Guam between 2015 and 2020 (see Volume 1, Chapter 6) has projected the largest proposed residential development on Guam (Dandan Estates), and it would be within a serviceable range of the Inarajan STP. In addition to the proposed Dandan Estates, the projected increasing size of the Ija subdivision may provide potential beneficial reuse opportunities, such as toilet flushing and landscape irrigation, to be incorporated into the new development infrastructure. Currently, there are no viable reuse opportunities that involve irrigation of golf courses or agricultural land. A potential beneficial reuse table for the Inarajan STP was not developed because effluent disposal is through percolation basins that do not require NPDES Permit Limitations. Because there are no current limitations and monitoring records are unavailable, providing conceptual reuse recommendations for current and future reuse opportunities is difficult.

7.3.7 Reuse Opportunities in the Pago Socio STP Vicinity

The population and land use forecast for Guam between 2015 and 2020 (see Volume 1, Chapter 6) did not identify any proposed developments within the vicinity of the Pago Socio STP, nor are there any current recognizable dedicated users; therefore, water reuse in the planning horizon is not practical. Similar to the Inarajan STP, a potential benefit reuse table was not developed for the Pago Socio STP because effluent disposal is through percolation basins which, as mentioned above, do not require NPDES permit limitations. Because the effluent volume is unknown, and considering that there are no current monitoring records with which to evaluate treatment performance, providing reuse recommendations for the near and distant future is difficult. Furthermore, the recommendation is made in Chapter 5, Wastewater Treatment Facilities in this volume, to convert this plant site to a pump station and deliver collected flow to the Hagatna STP.

7.4 Summary of Reuse Alternatives Proposed in Previous Plans

Because a majority of Guam's STPs have inoperable liquid stream treatment components and capacity measuring devices, knowing the specifics in terms of quality and quantity of wastewater effluent to date is difficult, as indicated above. Furthermore, the minimal land base on Guam limits the reuse opportunities to only a few feasible alternatives that have been previously discussed or have been suggested in prior studies. Many reuse alternatives that would typically be suitable for other geographical locations are not necessarily applicable on Guam. Some of these alternatives include the use of recycled water for industrial purposes, wetland enhancement and firefighting. Reuse alternatives that have been briefly discussed and proposed in previous studies are re-introduced below for discussion purposes only.

7.4.1 Reuse Alternatives Proposed in Guam Islandwide Wastewater Facilities Plan

The Guam Island-wide Wastewater Facilities Plan, developed by Duenas & Associates and CH2M HILL in 1994, discussed several alternatives for reuse. Reuse alternatives that were found to be impractical for Guam included aquaculture and direct groundwater injection. Because of the undeveloped technology associated with aquaculture, the large footprint resulting from constructing lagoons, and the high degree of operator experience required, this alternative was deemed impractical. The reuse of wastewater through direct groundwater injection requires a highly treated effluent, which far exceeds the effluent quality currently being generated. Because of the associated high cost of upgrading the existing treatment processes to produce effluent of this quality, this alternative was also deemed impractical and was not further pursued in the Island-wide Plan.

Reuse alternatives that were found to be practical in the Island-wide Plan included rapid infiltration, constructed wetlands, and irrigation. Rapid infiltration involves the application of treated effluent onto spreading basins where shallow infiltration can occur. Rapid infiltration requires highly permeable soils, such as loamy sands, which primarily exist in the northern regions of the island. A similar percolation practice is currently being used at the Inarajan and Pago Socio STPs. Constructed wetlands can be used for secondary or tertiary treatment processes and are commonly designed for wildlife enhancement. Such wetlands are typically implemented where natural wetlands do not occur and as a component to advance treatment processes. The Island-wide Plan also briefly discussed the potential for irrigation with recycled wastewater, as previously discussed in this chapter.

7.4.2 Reuse Alternatives Proposed in Guam Water Facilities Master Plan Update

Similar to the 1994 Guam Island-wide Wastewater Facilities Plan, the 1992 Guam Water Facilities Master Plan update prepared by the Barrett Consulting Group also recommended similar beneficial reuse alternatives. These included golf course and agricultural irrigation in addition to groundwater recharge. Additionally, the 1992 Master Plan suggested implementing separate transmission lines to convey recycled water from an STP to the point of use. The same document recommended that EPA establish a set of criteria to regulate water reuse similar to those of the Hawaii Department of Health.

7.5 Potential Funding Sources

The implementation of reuse systems, including treatment facility upgrades, storage and transmission networks, typically entails a significant capital cost. Because of this associated high cost, obtaining funds through long-term water and wastewater revenue bonds, which spread the cost over multiple decades, can alleviate initial financing problems. Creating a totally self-supporting reuse program that would be financed by recycled water user fees only is virtually impossible. Supplemental funding through bonds, grants and developers is generally essential for capital cost financing.

7.6 Conclusion

The continued population growth, coupled with a projected increased usage of the limited potable water sources, will eventually force GWA into exploring alternative water supplies. The accelerating technology of wastewater treatment has increased beneficial reuse opportunities. These reuse opportunities are governed by EPA regulations, which are adopted in general and then tailored to each state's public and environmental health laws. The adoption of wastewater reuse regulations is an essential component in ensuring the sustainability and protection of human and environmental health on Guam. These regulations will provide the basis for protecting sensitive water resources, in addition to providing the planning foundation for future water reuse on the island of Guam.

7.7 Recommendations

- It is strongly recommended that GEPA establish a set of criteria regulating water reuse similar to Hawaii and California regulations and requirements summarized in this chapter. The regulations should focus on the more feasible and potential beneficial reuse alternatives specific to Guam, such as golf course irrigation, landscape irrigation, agricultural irrigation and toilet flushing.

- In comparing potential beneficial reuses and the associated required upgrades from one STP vicinity to another, the region surrounding the Baza Garden STP has the greatest potential for reuse. Once regulations regarding wastewater reuse have been adopted, a focused feasibility study is recommended, which would analyze the cost-benefits of the treatment upgrades and the associated specific reuse markets. Some specific elements of this study are listed in Section 7.2. Because of their proximity to the Baza Garden STP, golf course irrigation and agricultural irrigation are the two most viable reuse markets identifiable in this planning horizon. Since the irrigation demand would have seasonal fluctuations, an auxiliary outfall would have to be considered, in addition to on- or off-site storage.

- It should also be noted that various types of sensitive golf course turfs do not tolerate high levels of sodium or total dissolved solids that can occur if appropriate treatment processes have not been carried out on the recycled water. Additional considerations for golf course irrigation include site topography, proximity to residential dwellings, depth of groundwater, climatic data, detailed information of the physical and chemical soil properties and required reservoir storage to balance irrigation demand against the amount of inflow from the STP. Identification and evaluation of alternative reuse markets, such as the proposed Manengon Hills development for landscape irrigation and toilet flushing, should also be included in the feasibility study.

- Treated wastewater is not the sole source of potential recyclable water for augmenting supplies on the island. Because of Guam's high annual precipitation, implementing components for stormwater collection, detention/storage, treatment and distribution to supplement current potable water supplies should also be further investigated. GWA does not have jurisdiction over stormwater management on the island of Guam; however, the Guam Department of Public Works does. Therefore, any exploration into beneficial reuses of recycled stormwater should be coordinated with the recommendations provided in this 2006 GWA WRMP.
- Using stormwater as an alternative water source became a point of discussion at village meetings in the Tamuning and Hagatna areas during 2004. Because of this public interest, further investigation into the feasibility of future development should be considered. Ideally, a stormwater feasibility plan would focus not only on stormwater reuse, but also on floodwater prevention in urbanized areas such as Agat, where localized flooding becomes a problem during intense durations of rainfall. An additional feasibility plan would be needed and should focus on these two primary topics: storm drainage improvements in urbanized areas of Guam; and development of stormwater collection, treatment and conveyance systems in the southern areas of Guam. The urban areas would benefit from improvements made to existing storm drainage infrastructure, whereas development of surface water collection and storage for supplementing water for future demands should be pursued as technology becomes more advanced. As an interim measure, and to further protect potable water resources from polluted storm water contamination on Guam, the best management practices outlined in the Horsley Witten Group draft report titled "*CNMI and Guam Stormwater Management Criteria Draft Report, March 4, 2004"* should be followed.

7.8 CIP Impacts

The WRMP does not recommend any CIP projects at this time; however, the groundwork is laid for consideration in the future when regulations are adopted and more firm projects can be identified.