CHAPTER 6 – SEPTIC SYSTEMS & UNSEWERED AREAS

6.1 Introduction/Background

Septic systems are currently in use throughout Guam for wastewater collection and disposal in the areas not sewered. It is estimated that 41% of the island residents utilize these individual wastewater disposal systems (IWDS) as reflected in GWA's customer count list. A large portion of Guam residents have septic systems and these vary in quality and consistency of design and construction. Figures 6-1A through 6-1D display existing sewer collection systems and wells located in unsewered areas. Also shown are wellhead protection zones of 1,000-foot radius. The potential negative impact that these systems have on the water quality of the aquifer makes quantifying this wastewater disposal practice a crucial first step to developing a program to sewer these areas.

Septic system refers to a system that receives and disposes of wastewater originating from building(s) and consists of a septic tank and leaching field (or seepage pit). Figure 6-2, Septic System Typical Layout, illustrates a plan view of a typical septic system and design guidelines. The wastewater influent makes its way to the buried septic tank from the building thru gravity sewer piping. The solids settle in the tank and a sludge layer forms on the bottom and contains about 60% of the solids in the raw sewage. A scum layer, consisting of oils and soap, forms on the surface. The septic tank discharges the settled wastewater for further treatment and disposal to a leaching field. Seepage pits (cesspools) can combine both of these steps into one bottomless tank, where the untreated sewer is deposited directly into the surrounding soil.

This chapter is organized with a discussion of septic system regulations on Guam, then presents existing septic system locations and their impacts, and, finally, outlines possible mitigation methods.

6.1.1 Regulatory Environment

Septic systems fall under the jurisdiction of the GEPA who reviews the design and construction of septic systems, making sure that the systems meet current regulations.

6.1.1.1 IWDS Enabling Legislation

GEPA is authorized by Section 45106 of Chapter 45, Title 10 Guam Code Annotated to develop the policies needed to carry out the provisions of Title 10, Chapter 48, Toilet Facilities and Sewage Disposal.

6.1.1.2 GEPA Regulations

GEPA has developed the Onsite Wastewater Treatment and Disposal System Regulations for Residential Septic Tank and Leaching System and Temporary Toilet Facilities (Septic System and Leaching Field Regulations) (adopted July 2, 1987) to establish the rules and regulations as required by Chapter 48, Title 10. The purpose of GEPA's septic system policy is to safeguard the environment and the people of Guam from damaging exposure to untreated wastewater.

Figure 6-1A – Sewers and Unsewered Properties in the North District Area

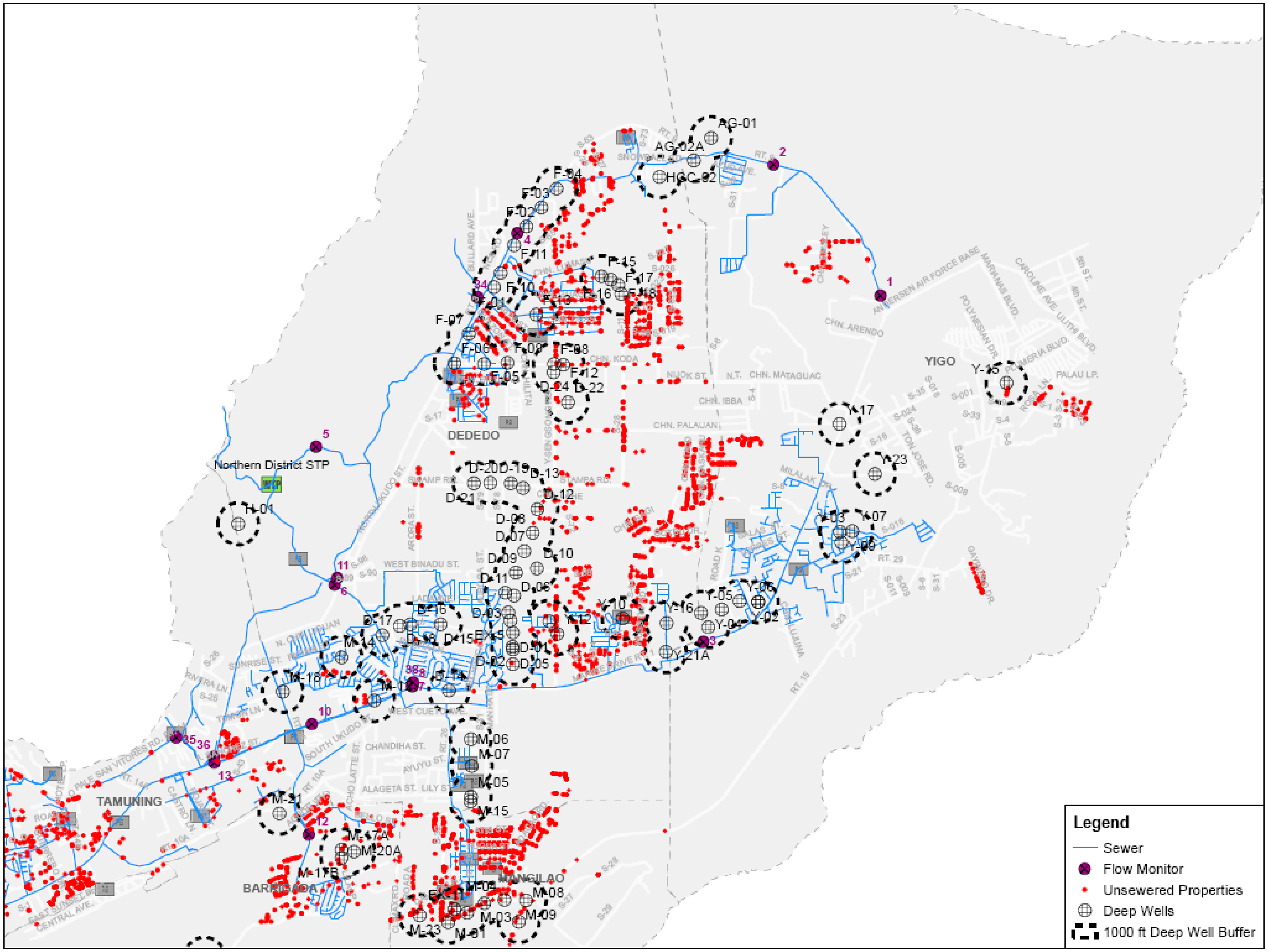


Figure 6-1B – Sewers and Unsewered Properties in the Hagatna Area

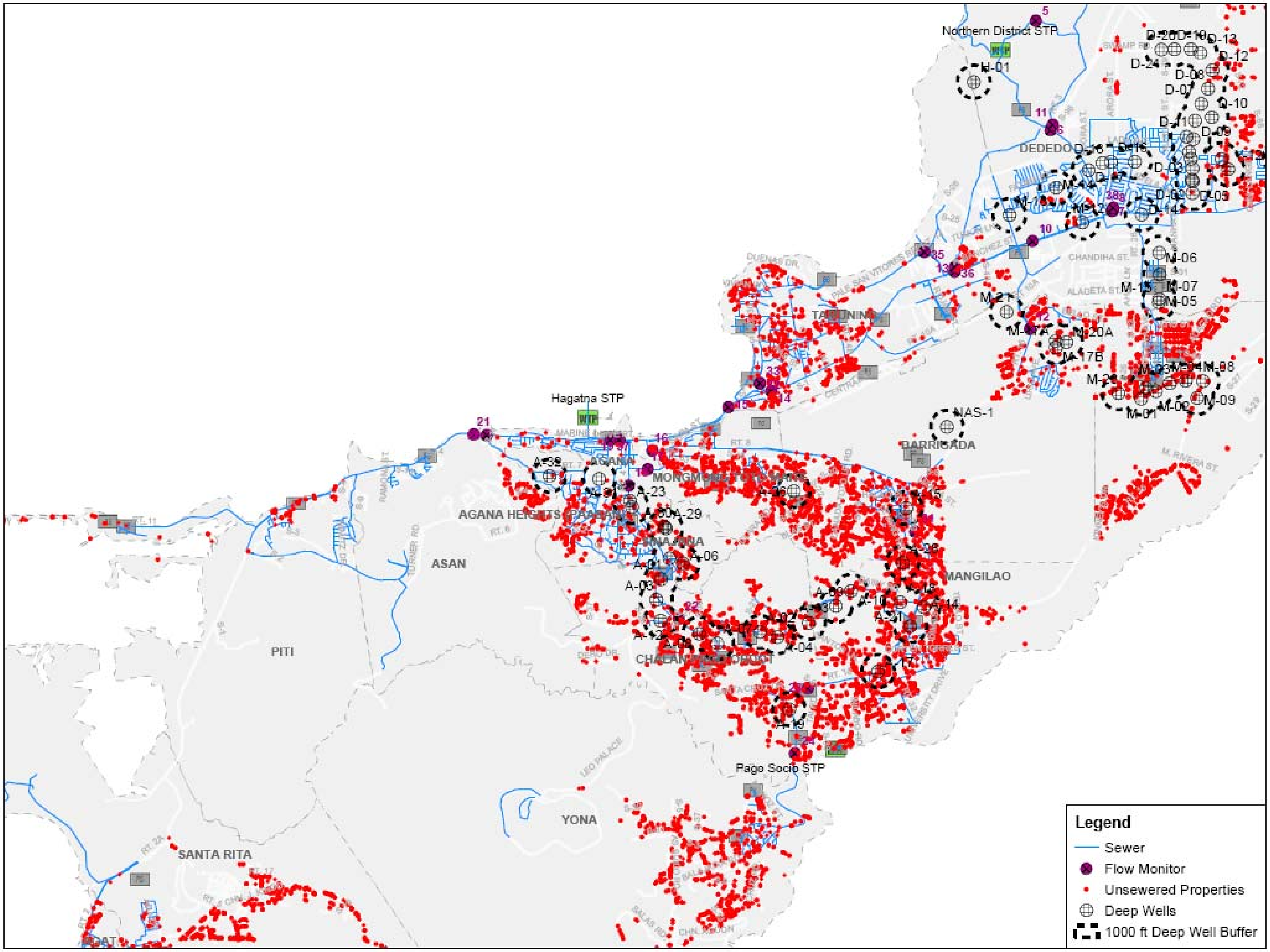


Figure 6-1C – Sewers and Unsewered Properties in the Baza Gardens and Agat-Santa Rita Areas

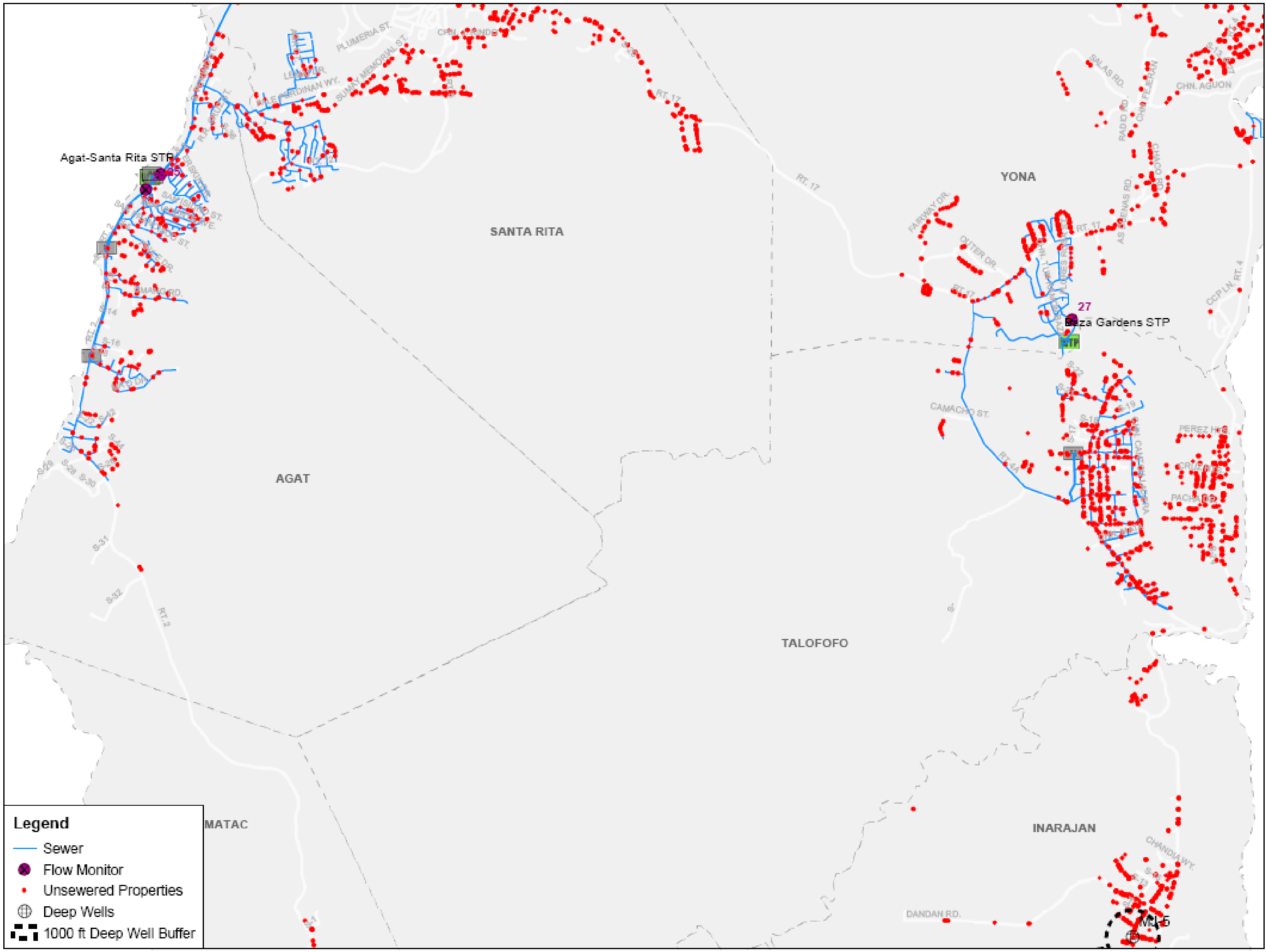


Figure 6-1D – Sewers and Unsewered Properties in the Umatac-Merizo and Inarajan Areas

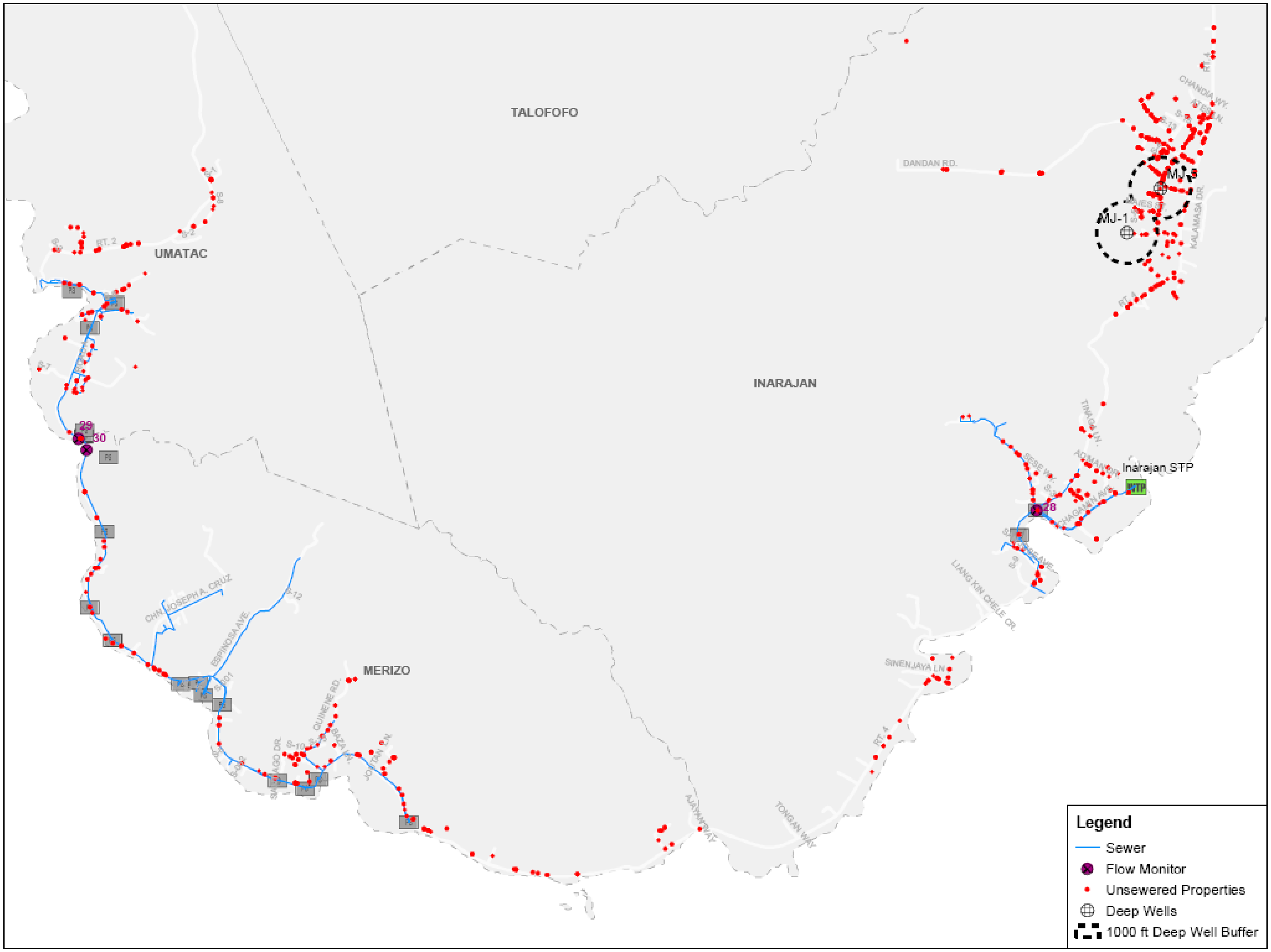


Figure 6-2 – Septic System Typical Layout

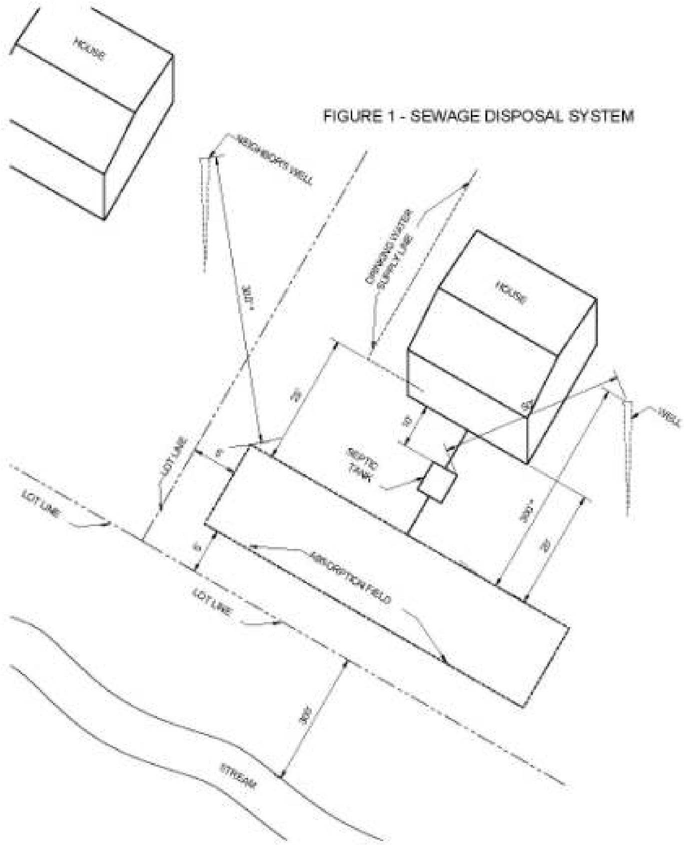


TABLE 1
GUIDELINES FOR CONSTRUCTION OF SEPTIC TANK
(LIQUID CAPACITY)

NUMBER OF BEDROOMS	RECOMMENDED SEWAGE FLOW * (GALLONS) GPD	RECOMMENDED MINIMUM TANK CAPACITY (GALLONS)	RECOMMENDED MINIMUM INSIDE TANK DIMENSION L.W.D.
2	480	750	6' x 4' x 6'
3	720	1,080	7'-6" x 4' x 6'
4	960	1,440	7' x 6' x 6'
5	1,200	1,800	7' x 7' x 6'
6	1,440	2,160	8.5' x 7' x 6'

SOURCE: GEPA, RURAL ISLANDWIDE FACILITIES PLAN, TABLE 5-2, PAGE 5-17.

MANUAL OF SEPTIC TANK PRACTICE - U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE.

PUBLIC HEALTH SERVICE PUBLICATION #526

SECTION VIII - LOCATION AND INSTALLATION OF SEWAGE DISPOSAL SYSTEM

A. NO PART OF THE SYSTEM SHALL BE LOCATED SO THAT IT IS NEARER TO ANY WATER SUPPLY THAN OUTLINED IN FIGURE 1 AND TABLE II, OR SO THAT SURFACE DRAINAGE FROM ITS LOCATION MAY REACH ANY DOMESTIC WATER SUPPLY. THE DISTANCES GIVEN IN FIGURE 1 AND TABLE 1 ARE THE MINIMUM DISTANCES TO ANY WATER OF THE TERRITORY, PROPERTY LINES, DWELLING, SCHOOL, PUBLIC BUILDING, OR A BUILDING USED FOR COMMERCIAL, OR INDUSTRIAL PURPOSES OR AS A PLACE OF ASSEMBLY.

B. SUGGESTED LOCATION OF TANK AND DISPOSAL FIELD ON VARYING GROUND SLOPES (FIGURE 2)

SOURCE: GEPA, JULY 2, 1987. ONSITE WASTEWATER TREATMENT AND DISPOSAL SYSTEM REGULATIONS FOR RESIDENTIAL SEPTIC TANK AND LEACHING SYSTEM AND TEMPORARY TOILET FACILITIES.

Septic System
Typical Layout

As required by GEPA, any single-family residence or duplex located within 200 feet of public sewer availability shall connect to the public sewer system. If public sewer is not available, toilet facilities shall be constructed as a Type 2 facility, defined as a toilet flushed with water and connected to a septic tank and leaching system. The design requirements established by the Septic System and Leaching Field Regulations are only applicable for systems serving a four-plex dwelling or less.

GEPA requires that all lots serviced by a Type 2 facility maintain an area with capacity of replacing 100% of the leach field system. Minimum safe horizontal distance requirements are also established by GEPA and are listed below in Table 6-1.

Table 6-1 - Minimum Safe Horizontal Distances in Feet[1]

From	To		
	Privy	Septic Tank	Absorption Bed/Field
Any water of the Territory		300’	300’
Any dwelling, school, public building, or a building used for commercial or industrial purposes	20’	10’	20’
Property boundary lines		5’	5’
Water lines		10’	
Wells		300’	300’

[1] GEPA, Onsite Wastewater Treatment and Disposal System Regulations for Residential Septic Tank and Leaching System and Temporary Toilet Facilities, Table I

The septic systems must be inspected and approved by GEPA, meet all minimum distance requirements detailed in Table 6-1, be accessible for inspection, emptying and cleaning, and have an acceptable cover. Additionally, the septic tank must be constructed a distance of 10 feet away from the drinking water supply line (the leaching field must be 25 feet away and the seepage pit 50 feet away).

GEPA has also adopted Guam’s Wellhead Protection (WHP) Program (March 4, 1993). The WHP program establishes a “wellhead protection area” for public drinking water wells. A radius of 1,000 feet has been established around each well as the protected zone where no septic systems/leaching field should be constructed. There is an apparent conflict between the 1,000 feet protection zone established by the WHP Program and the 300 feet protection zone established by the Septic Tank and Leaching Field Regulations. According to the WHP Program, the 1,000 feet minimum radius was adopted in October 1990 (three years after the adoption of the current Septic Tank and Leaching System Regulations). Revision of the Septic Tank and Leaching System Regulations are needed, as recognized by GEPA. GEPA anticipates that the 1,000-feet revision will be made to the regulations this year, and implemented in 2007.

As a part of the WHP Program, GEPA began investigating illegal individual wastewater systems (i.e. cesspools) within the 1,000-feet proximity of public drinking water wells. The survey started in March 2004 with results yet to be determined.

The goal of this initiative is to locate the possible sources of pollution to Guam's drinking water. Upon completion of the study, GEPA will locate and address the areas in need of remediation. GEPA is currently unable to provide any numbers or locations of illegal cesspools on island.

Once public sewer has been made available to buildings that utilize septic systems, the owners have five years to connect to the public system. Exceptions to the five-year-rule include situations where the existing septic systems are inadequate and areas of the Groundwater Protection Zone, where the number of septic systems is greater than four per acre. In these situations, the building owners must connect to the public system within a maximum period of six months from time of notification.

6.1.1.3 Zoning & Land Use

Zoning and land use are discussed in detail in Volume 1, Chapter 6 – Population and Land Use Forecast. The majority of Guam is zoned as agriculture and much of the agriculture zoning is developed as rural residential areas, constituting 8.16 percent of the total land use. The majority of residential single dwelling and multiple dwellings are located in the northern and central areas of the island. Military/federal land use, the largest category of generalized land use, constitutes 29.58% of the total island acreage.

Based on the active customer count provided by GWA, the Dededo/Yigo area has approximately 13,199 active GWA customers; 35.7% of GWA's active customers are located in this area. These two villages are located in the northern part of Guam over the main source of potable water for the island.

Because the groundwater source in northern Guam is considered the principal water supply for the island, the GEPA asserted a policy that residential development on lots of 9,600 square feet or less, depending on the zoning standard, should be connected to the nearest sewer line. If unsewered, the minimum lot area should be 19,200 square feet. Many rural areas in northern Guam are not sewered. Numerous single-family residential units are located in rural areas, so septic tanks and leaching fields are the primary means of sewage disposal. Consequently, local environmental officials suspect that high concentrations of nitrate may be making their way to the aquifer.

6.1.1.4 Building Permit Zoning Requirements for Residential Development

Certain measures have been taken to lessen the density of septic systems in a given area over time, in turn lessening the impacts to the groundwater. As established by the Department of Land Management and Planning Division (DLMPD), a residential lot within the groundwater protection zone must be a minimum of ½ acre to be allowed to utilize a septic tank system (where no public sewer is available). The exception is a minimum of ¼ acre requirement for Parental lots, lots that are subdivided and deeded by the original landowners to their heirs. The lot requirements have been in place since 1995.

The DLMPD ½ acre requirement currently regulates the density of development. However, a more conservative zoning regulation was proposed by the Public Utility

Agency of Guam's (PUAG) Rural Islandwide Wastewater Facilities Plan, October 1982, which recommended "In order to keep nitrate concentrations within acceptable Public Health limits, it is recommended that all areas designated as a critical recharge areas limit single family dwelling units utilizing on-site wastewater disposal to a minimum lot size of one house per acre (Guam acre = 40,000 square feet.). Any subdivision with densities greater than one house per acre (Guam acre) located in the designated critical aquifer recharge area should be required to provide a collection system with wastewater transport out of the recharge area for treatment and ultimate disposal."

Guam has consistently seen development outpace the needed infrastructure improvements. This "catching-up" practice has allowed subdivisions to be constructed and inhabited before adequate wastewater collection systems have been put in place. A glaring example of subdivision development without adequate infrastructure has recently (January 2006) been in the local news. The Gill Baza subdivision was able to sell ¼ acre, unsewered lots in an area that requires ½ acre-sized lots for the use of septic systems. This subdivision apparently slipped through the cracks of the governmental permitting process without the required agencies conducting thorough plan reviews or inspections. It should be noted that if these practices continue, similar problems will likely occur in the future.

6.1.1.5 Ground Water Under the Direct Influence of Surface Water (GWUDI)

This topic is addressed in detail in Volume 2, Chapter 2, Sections 2.4 and 2.5 identifying areas most affected and alternatives for addressing the challenges. Key concepts from this chapter are repeated here because of their importance for potential regulatory impacts on unsewered areas in the Northern System, even though they are not in force at the present time.

Wastewater pump station overflows that mimic significant rainfall in the area of some A-series wells have affected water quality rapidly as well. This information as well as other data being gathered by GEPA and GWA will be used to determine if the Northern System might be considered groundwater under the direct influence of surface water. Land development standards are not currently protecting the EPA "Sole Source Aquifer" designation of the area though GWUDI designation has not been made by GEPA at the time of this report, it is under serious review. The lack of significant turbidity readings paralleling significant rainfall shows other issues need resolution.

A GWUDI designation for the Northern System would require that groundwater used for drinking water comply with the surface water treatment rules. The greatest impact associated with this designation would be the cost to filter the groundwater and monitor water quality in the distribution system.

6.1.1.6 Other Considerations

An innovative septic tank effluent disposal study is currently being conducted by GEPA and is funded by a Clean Water Act Section 319 grant. The demonstration project consists of one residential system located in Latte Heights. The project proposal documents indicate that the system was constructed so that the household effluent is initially deposited in a sedimentation tank (also functioning as a septic tank) before it passes through the subsurface flow constructed wetland area (SF CW). The septic tank, constructed as a part of the SF CW system, will need to be pumped more often than a traditional residential septic tank system, due to a "highly efficient bio-filter" utilized on the effluent side of the tank that will increase the amount of solids trapped in the tank. The SF CW was chosen over a free water surface to discourage the presence of pests, such as mosquitoes, and foul odors and does not pose a great health risk to humans that come in contact with the CW. The post SF CW effluent then passes through a sand filter before it is finally deposited in a subsurface leaching bed.

The SF CW provides an additional denitrification step to the septic system process. The sand filter that follows the SF CW removes the majority of residual solids, BOD, and reduces coliform and nutrient levels. During the dry season and beginning stages of operation, the SF CW may require additional water in order to maintain the plants. Certain other operation and maintenance measures are required to keep the system running successfully.

A final project report is currently not available, but will provide the detailed information regarding the study and its results. The study requires some additional sampling before it is completed. Upon completion, GEPA will determine if the constructed wetlands system should be incorporated into their Septic Tank and Leaching System Regulations.

6.2 Geographic Distribution of IWDS

There are parts of Guam that are more sensitive to the affects of septic systems than other parts of the island. The Northern Region and the northern portion of the Central Region are located over an aquifer in an area of limestone formations that provides an environment for the septic-treated wastewater to filter down to the island's groundwater source. For the purpose of this WRMP, the regions of Guam are delineated as defined in the PUAG's Rural Island-wide Wastewater Facilities Plan, October 1982, where the island of Guam is considered as divided into three regions: the Northern, Central and Southern Regions. See Figure 6-3 – Regions of Guam.

6.2.1 Northern & Central Regions

The Northern Region is comprised of Dededo, Yigo and Mangilao. The Central Region encompasses Agana, Sinajana, Mongmong-Toto-Maite, Agana Heights, Tamuning, Barrigada, Chalan Pago-Ordot, Yona, Asan, Piti, and Santa Rita. The Southern Region includes Agat, Inarajan, Talofofo, Umatac and Merizo.

6.2.1.1 GPS Plot of Existing IWDS

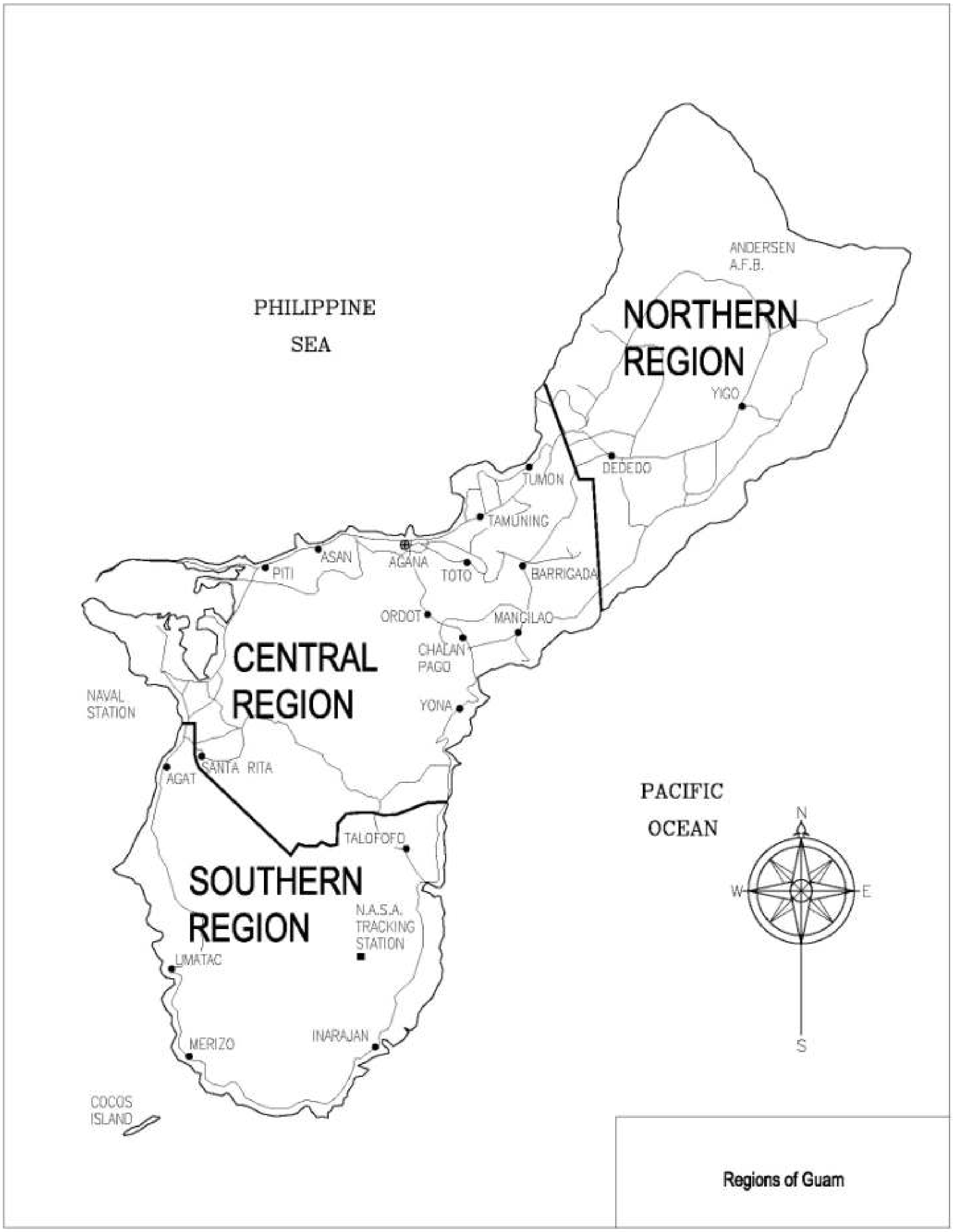
It is known that approximately 42% of all the septic systems on island are located in the Northern Region and approximately 44% are located in the Central Region (GWA customer count). Figures 6-1A and 6-1B show the unsewered areas in these respective regions of Guam. In Figures 6-1A and 6-1B there are shown several population clusters that utilize septic systems within 1,000 feet of public drinking wells, particularly, south Dededo, northern Mangilao, and northern Barrigada.

6.2.1.2 Northern & Central Aquifer Well Fields

The Northern Guam Lens Study (GEPA, 1982) designated a zone of "critical recharge" that includes the Northern and Central Regions that directly affect the quality of Guam's primary potable water source. In this area, rainwater and water from other sources percolates through the limestone aquifer rapidly. Additionally, any pollutants, such as nitrates resulting from septic system wastewater treatment, also eventually make their way to the aquifer.

The growth and development of Guam continues to cause an increase in groundwater use demands. The northern aquifer currently supplies approximately 75% of Guam's potable water (GEPA's Approach for Protecting and Restoring Our Waters, August 16, 1999). "The groundwater in northern Guam was designated as a principal sole source aquifer by the EPA in 1978, under the provisions of Section 1424 (e) of the Federal Safe Drinking Water Act, as amended. (GEPA's Guam's Wellhead Protection Program, March 4, 1993).

Figure 6-3 – Regions of Guam



6.2.1.3 Existing Sewer System

All wastewater flow from Andersen Air Force Base and the public sewer system in the Northern Region is collected and treated at the NDSTP, averaging 7.80 mgd. Wastewater flows from the Central Region are collected and treated at two WWTP's: Hagatna and Pago Socio (Package STP for 15 residences). The second largest STP in the Central Region is Hagatna, receiving an estimated 7.50 mgd from Mongmong-Toto-Maite, Asan, Barrigada, Tumon, Agana, Agana Heights, Sinajana, Tamuning, Mangilao, Chalan Pago-Ordot, and parts of Yona. Flow information for Pago Socio was not available. Figures 6-1A and 6-1B detail the locations of the existing public sewer system. The largest concentrations of sewer connections are located in parts of Dededo, Yigo, Mangilao, and Barrigada. There is a large unsewered area between the Yigo and Dededo service areas over the aquifer recharge area.

6.2.2 Southern Region

The southern region of Guam is not as critical of an area when it comes to protection of potable water sources, which consist mainly of surface water catchments and GWA's Ugum WTP. Although this region is not as densely populated as the rest of the island, the southern part of Guam has poor percolation rates. The Southern Region has percolation rates in the range of one inch per 45 to 60 minutes, in sharp contrast to the one inch per 5 to 15 minutes that is found in the Northern Region. The GEPA Septic System and Leaching Field Regulations requires that the leaching field be sized based on the number of bedrooms and the percolation rates. The slower the percolation, the larger the leaching field. A leaching field in the Southern Region may need to be as much as three times the size of a leaching field in the Northern Region.

6.2.2.1 GPS Plot of Existing IWDS

Approximately 13% of the island's septic systems are located in the southern region of Guam. Although this is a smaller percentage when compared to the Northern and Central Regions, 71.6% of all the residents living in the Southern Region utilize septic systems for their wastewater treatment and disposal. See Figures 6-1C and 6-1D for the unsewered areas in this region. A small northeastern portion of Inarajan (Malojloj) is the only unsewered area of the Southern Region that falls within close proximity to public wells.

6.2.2.2 Surface Water & Ground Water Collection

The vast majority of Guam's potable water supply is provided by the northern aquifer; however, a small aquifer is located near Malojloj, in Inarajan, and it is used from time to time to supplement the Ugum WTP production. Malojloj has two wells: MJ-1 is the primary and MJ-5 is considered backup. In the past, water delivery occurred in the Windward Hills area, but is no longer currently in use.

6.2.2.3 Existing Sewer System

There are four STP's for the Southern Region: Agat-Santa Rita, Baza Gardens, Umatac-Merizo, and Inarajan. Agat-Santa Rita receives an estimated 1.13 mgd from Agat-Santa Rita and Baza Gardens receives an estimated 0.25 mgd from the Talofofo/Yona area. Umatac-Merizo receives an estimated 0.28 mgd from the Umatac and Merizo villages and the Inarajan STP receives an estimated 0.07 mgd from the Inarajan area. The public service lines stay within the villages, which are mainly along the coast.

6.2.3 U.S. Military Property

Andersen Air Force Base wastewater is conveyed to the NDSTP. Additionally, the U.S. Naval Computer and Telecommunications Area Master Station (NCTAMS) and the surrounding housing and the Navy's Nimitz golf facility utilize the NDSTP. The Apra Navy Base has their own STP that handles their needs. However, the Naval Hospital and its surrounded Naval housing wastewater is conveyed to the Hagatna STP. It is unlikely that there are many (if any) septic systems utilized for these facilities; however, that information has not been confirmed by the military.

6.3 Existing Conditions, Impacts on Water Quality of Aquifer

While properly designed and constructed septic systems adequately eliminate the majority of impurities, even a properly functioning septic system may not remove enough nitrogen to maintain an effluent nitrogen level less than the maximum contaminant level (MCL) required for drinking water (EPA's Source Water Protection Practices Bulletin Managing Septic Systems to Prevent Contamination of Drinking Water). The EPA has established a maximum nitrate-nitrogen level of 10 mg/l. Additionally, the nitrogen from septic systems located in the Northern and Central Regions is only reduced by a small amount and the remaining nitrogen converts to nitrates that eventually reach the aquifer. The PUAG's Rural Island-wide Wastewater Facilities Plan, October 1982, states: "It is estimated that existing disposal systems contribute as much as 25% of the nitrate concentration found in some of the production wells in Northern Guam". Nitrates are of concern because of their link to Methemaglobinemia (blue baby), a birth defect resulting from the intake of water that has a nitrogen-nitrate concentration greater than 10 mg/l.

6.3.1 Current Wastewater Flow Rates

Current monthly average flow rates for each treatment plant are discussed in Volume 3, Chapter 8 – Wastewater Treatment Facilities. The average flow rates are as follows (in mgd):

STP	MGD
Agat-Santa Rita	1.13
Hagatna	7.50
Baza Gardens	0.25
Umatac-Merizo	0.28
Northern District	7.80
Inarajan	0.07
Pago Socio	Not Available

GWA provided a customer count that lists the total number of active water customers and the number of active customers connected to public sewer, by village. See Table 6-2 – GWA Active Customer Count as of 03-10-06.

Table 6-2 - GWA Active Customer Count as of 03-10-2006[1]

No.	Village	No. Active Customers	No. Active Customers w/Sewer	No. Active Customers w/Septic
1	Hagatna	159	154	5
2	Agana Heights	611	442	169
3	Agana Heights/Sinajana	154	127	27
4	Agana Heights/Anigua	161	155	6
5	Agat	847	693	154
6	Anigua	79	74	5
7	Asan	332	232	100
8	Barrigada	1,125	459	666
9	Barrigada/Latte Heights	1,743	818	925
10	Barrigada/Mangilao	428	25	403
11	Chalan Pago	1,250	478	772
12	Chalan Pago/Mangilao	214	11	203
13	Dededo	8,185	5,802	2,383
14	East Agana	73	67	6
15	Harmon	1,503	1,211	292
16	Inarajan	215	40	175
17	Ipan	306	1	305
18	Maina	136	15	121
19	Maite	748	618	130
20	Malojloj	467	48	419
21	Mangilao	2,153	1,008	1,145
22	Merizo	461	229	232
23	Mongmong	492	280	212
24	Nimitz/Agat	376	241	135
25	Northern	33	30	3
26	Ordot	409	128	281
27	Piti	494	281	213
28	Santa Rita	943	475	468
29	Sinajana	658	632	26
30	Sinajana/Agana	187	82	105
31	Southern	12	6	6
32	Talofofo	533	93	440
33	Tamuning	3,104	2,718	386
34	Tamuning/Harmon	54	49	5
35	Tamuning/Tumon	29	26	3
36	Toto	432	201	231
37	Tumon	206	162	44
38	Umatac	161	78	83
39	Upper Tamuning	296	254	42
41	Windward Hills	594	285	309
42	Yigo	3,614	1,577	2,037
43	Yigo/Dededo	1,400	738	662
44	Yona	998	353	645
TOTALS		37,022	21,995	15,027

1. Table provided by GWA

It can be assumed that the difference in the Number of Active Customers and the Number of Active Customers with Sewer gives an estimate of the number of GWA customers that utilize a septic tank system (or some other form of individual wastewater system). It is possible that some water customers without sewer accounts are in fact connected to the sewers, but it is not possible to determine from the available information. The northern region of the Guam, particularly in Dededo and Yigo, contains approximately 42% of all the water customers without sewer accounts on the island (a total of 6,230 accounts). Table 6-3, presents each STP and the approximate number of customers they are currently serving. Also listed is the number of customers in the STP servicing area that are currently assumed to utilize septic systems. The information below is estimated from the GWA Active Customer Count as of March 10, 2006 (see Table 6-2). Both Hagatna and NDSTP's would see a 62% increase in customers if all the unsewered areas were connected to the public system.

Table 6-3 - No. of Residents Assumed to Use Septic Systems in STP Service Areas

STP	MGD	No. of Customers on Public Sewer	No. of Customers on Septic
Agat-Santa Rita	1.13	1,690	970
Hagatna	7.50	11,378	7,003
Baza Gardens	0.25	379	1,054
Umatac-Merizo	0.28	313	321
Northern District	7.80	8,147[1]	5,085
Inarajan	0.07	88	594
Pago Socio	Not Available	Not Available	Not Available

1. This number does not include wastewater contributed by Air Force and Naval facilities

6.3.2 Aquifer Yield and Other Potable Water Sources

The northern aquifer is Guam's primary potable water supply. A study in 1982 conducted by GEPA indicated that the groundwater is capable of supplying approximately 60 mgd on a sustained yield basis. According to GEPA, this figure is still considered relatively accurate. GWA has not been consistent in the past, in supplying GEPA with monthly pumping numbers, so it is difficult to establish the aquifer demand. It should also be noted that a portion, estimated to be as high as 50%, of the groundwater pumped by GWA is lost due to leaks in the system and never utilized by the public. Additionally, it is understood that some of the groundwater pumped eventually recharges back into the northern aquifer because of the leaks in the water distribution system.

6.3.3 Measurable Impacts on Water Quality

While Guam's groundwater quality is currently considered to be in good condition, there is concern that the presence of certain water pollutants will adversely affect the future supply. One such source of pollutants is insufficient residential wastewater treatment, causing unacceptable levels of bacteria and nitrates.

GWA monitors the ground water quarterly for all contaminants listed under the Safe Water Drinking Act. Nitrate-nitrogen concentrations are measured annually. A review of GWA's Annual Water Quality Reports from 2000 through 2005 showed that nitrate-nitrogen was found in all GWA wells in 2000. The concentrations ranged from 0.07 to 5.65 mg/L. Well A-26 in Toto and Well M-4 in Mangilao exceeded ½ the MCL of 10 mg/L for nitrate-nitrogen. GEPA samples public drinking water wells only when contamination is suspected, for example, this was the case in January 2006 with the main Tumon water supply well.

The acute MCL for total coliform was violated in June 2000 in the Northern Water System. Positive results for *E. coli* were determined. GEPA issued a NOV and an Stipulated Order of Compliance in August 2000. Chlorine sampling and monitoring procedures were modified.

In July and December 2002, due to problems associated with Typhoon Chata'an in July, and Super Typhoon Pongsona in December, total and fecal coliforms were found in more samples than allowed in the distribution system and these were in violation of the acute Maximum Contaminant Level (MCL) standard for bacteria in drinking water. The contamination was attributed due to lack of disinfectant at the distribution system. Boil Water Notices were issued to the public. The Boil Water Notices were lifted only after additional samples indicated that the bacteriological standards were being met and all distribution systems were adequately chlorinated.

A WERI report was published in September 2002, titled Nitrate-Nitrogen Concentrations in the Northern Guam Lens and Potential Nitrogen Sources. While none of the 147 wells that were monitored as a part of this study had concentrations close to the MCL, 22 wells studied were within 4 - 5 mg/l. The EPA requires an increase in monitoring once the levels reach 5 mg/l (50% of the 10mg/l MCL). Additionally, 39 wells had shown a continuous increase over the last 14 years. As stated in the report, "areas of special concern should include the cluster of GWA wells and Mangilao Golf Course wells in the Mangilao Subbasin". According to this WERI report, the two leading potential sources of nitrogen in the Mangilao Subbasin are septic systems and runoff from a golf course (possibly from fertilizer usage).

6.3.4 Existing Sewer Hook-up Needs

Based on the above discussion, priority areas for extension of the existing sewer system would meet three criteria: 1) where septic systems are near 1,000 feet of existing wells, 2) where septic systems are within 200-ft of existing sewers, and/or 3) where the sewer extension reaches housing clusters at densities greater than one unit per acre over groundwater recharge zones. Figures 6-1A and 6-1B show the first two areas of priority. The third priority areas are shown later in this chapter.

The existing public sewer system may be inadequate (based on plant available capacity information discussed in Section 6.4.3) for handling the current and future developments in the sensitive area of the northern aquifer. The increase in septic system use will continue if the public sewer system is not made available to the growing number of residences in this area, resulting in a continued increase in nitrate-nitrogen pollution of the northern aquifer water supply.

6.4 Future Growth Scenarios

Guam's projected growth will, without a doubt, have an impact on the island's natural resources. A continued increase in the number of septic systems could have a detrimental affect on the public drinking supply.

6.4.1 Population and Housing

It is projected that future growth will continue to follow the current growth patterns, with the largest developments projected in the northern and central areas of Guam. The population projection scenarios in Volume 1, Chapter 6 – Population & Land Use Forecast, forecast the year 2000 population of Guam increasing by 35,894, for a total of 190,699 by 2015, and by an additional 30,752, with a total of 221,451 by 2050. As stated in Section 6.3.1, if the current GWA active customers that are not on public sewer are connected, there would be a 62% increase in the customers served by the Hagatna and NDSTP. The northern region of Guam is also one area where the majority of growth is projected.

6.4.2 Water Demand

As the island population increases, so will water demand. While it is recognized that Guam has the water availability to supply "an estimated 60 mgd on a sustained yield basis" (GEPA Non-Point Source Management Program, 1990), the quality of potable water will likely decrease unless certain measures are taken to protect the supply (monitoring and treatment).

6.4.3 Wastewater System Capacity

The capacity of the existing STP's has a driving affect on which areas and the number of customers that can ideally be added to each plant.

6.4.3.1 GWA STP's

As the island grows and as GWA looks to provide public sewer to areas currently dependent on septic systems, provisions will need to be made to handle the additional wastewater. Current monthly average flow rates for each treatment plant are discussed in Volume 3, Chapter 8 – Wastewater Treatment Facilities. The available capacity at each plant was determined by calculating the difference between design capacity and the current monthly average flow rates (mgd). The results are listed in the table below:

Table 6-4 - GWA STP Capacity

Treatment Plant	Design Capacity from CPE Reports (mgd)	Current Monthly Average Flow Rate (mgd)	Available Capacity (mgd)	Estimated Total Including Unsewered – year 2025 (mgd)
Agat- Santa Rita	0.75	1.13	-0.38	*
Hagatna	12.0	7.50	4.50	9.7
Baza Gardens	0.60	0.25	0.35	*
Umatac-Merizo	0.39	0.28	0.11	*
Northern District	12.0	7.80	4.20	11.9
Inarajan	0.19	0.07	0.12	*
Pago Socio	Not Available	Not Available	NA	*

*Areas outside groundwater protection zone

It appears that the two plants having considerable available capacity are Hagatna (4.50 mgd) and Northern District (4.20 mgd). As discussed in Volume 3, Chapter 8 – Wastewater Treatment Facilities, Hagatna STP would see an estimated Average Dry Weather Flow (ADWF) of 9.7 mgd and NSTP would see an estimated 11.9 mgd ADWF in the year 2025, if unsewered areas are connected to the public system. This estimate includes unsewered areas that are densely populated (over ten people per acre) and/or are near public drinking wells. According to the year 2025 estimate, Northern District STP would be at capacity, while Hagatna STP appears to have the size availability to handle the additional flow. If additional unsewered areas are connected (those in less densely populated areas), GWA would have to conduct a detailed study to determine whether the WWTPs could handle all the wastewater that would result from the new connections. Additionally, design capacity of the existing sewage collection system and pump stations would also require detailed examination before adding more connections.

6.4.3.2 Military STP's

As discussed in Section 6.2.3, Andersen Air Force Base, NCTAMS and the Navy's Nimitz golf course facility send all their wastewater to the NDSTP. The NDSTP has a capacity of 12 mgd and currently sees an average of 7.8 mgd. The main Navy Base has their own STP, Orote STP, which handles their needs (information concerning the design capacity and average flows has not been made available). The Hagatna STP receives flow from the Naval Hospital and its surrounded naval housing. The Hagatna STP has a design capacity of 12 mgd and receives an average flow of 7.5 mgd. Developments in mid-2006 with potential military expansion activities are discussed in Volume 1, Chapter 17.

6.5 Possible Mitigation Methods

The three mitigation options presented in this section include:

- Extending the existing public sewer system to serve customers currently on septic systems
- Implementation of constructed treatment wetlands as individual systems
- Implementation of constructed treatment wetlands to serve a group of residences.

A combination of these approaches could be used effectively for mitigation. It is understood, based on the opinion of GWA's attorney, that GWA is not currently obligated to finance connection of unsewered areas to the existing wastewater collection system. However with the potential for private developers, Government of Guam who is the "developer" for Chamorro Land Trust property, or the possible impact of GWUDI, generating system upgrades to the existing area, it will be necessary to consider the methods described below.

6.5.1 Existing Wastewater Collection System Extension

The assessment of developing a program to connect the unsewered developed areas of Guam is critical to protecting the islands main source of potable water. Analysis of the existing system would be necessary to determine if it is capable of handling the additional flows resulting from the connection of residences previously sewered by septic tanks. The system capacity was assessed as described in Volume 3, Chapter 3 – Wastewater Facilities

Condition Assessment assuming the addition of about 16,500 residents and 3,000 employees in the Northern and Hagatna districts from areas currently without sewers. Sewer upgrades to accommodate that growth as well as growth from existing sewered areas and infiltration/inflow were identified. There are areas within the groundwater protection zone and in close proximity to public drinking wells that should be addressed first.

6.5.2 Alternate Wastewater Treatment Methods

Constructed treatment wetlands are one alternate wastewater treatment method currently under study by GEPA. Constructed treatment wetlands are defined as engineered or constructed wetlands that utilize natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other water source (EPA Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat, October 2000). See Figure 6-6 for a detail of a constructed treatment wetland system. According to the EPA, some benefits of utilizing constructed treatment wetlands include a low construction cost (often costing less than the traditional wastewater treatment options), low operation and maintenance costs and the ability to handle fluctuating water levels. They are also aesthetically pleasing and reduce/eliminate wastewater odors. These systems also need to be combined with sand filtration to polish the effluent.

There are certainly some important considerations that need addressing prior to constructing a treatment wetland. The amount of space must be available to accommodate such a system. Constructed wetlands should not be located in low-lying areas or in a floodplain. An exception to the rule is in areas where the pretreated effluent may be used to recharge systems. Water quality and other possible watershed impacts should also be explored. Planning should include an investigation of soil type, hydrology, vegetation, and the possible presence of endangered species. Additionally, it is imperative that the system be inspected, monitored and maintained on a regular basis in compliance with regulatory requirements. Fluctuations in the effluent quantity and quality also require monitoring. There is also an important issue of insuring that the system has properly trained staff to operate and maintain the system and that a responsible agency is charged with making sure that this happens.

In order for GEPA to allow treatment wetlands as an alternative to septic systems, certain changes to the current legislation would have to be made. The current GEPA treatment wetland study will reveal whether or not this alternative is worth consideration. It may be possible to allow several buildings to connect to one constructed treatment wetland; however, this would require legislation that establishes where and how the treatment wetland should be constructed for servicing multiple private lots. Further, it is vital that a mechanism be developed so that the system can be properly operated and maintained.

Other alternative methods include advanced septic systems for individual units, or small scale mechanical systems (such as membrane bioreactors) serving multiple units and providing the greatest barrier against the transport of pathogens to the groundwater.

6.5.3 Advanced On-Site Treatment

Another approach that could reduce the wastewater load on existing sewers and treatment plant is presented in this section. It will also potentially reduce water supply demands from increased water reuse. However, adequate treatment must be provided to protect public health and groundwater quality from pollutants originating from the on-site disposal. This sub-section discusses two types of on-site treatment systems based on the wastewater source. Wastewater from showers, bathroom sinks, tubs and laundry machines is considered gray water. Gray water may allow for indirect reuse due to its relatively low amount of contaminants. Wastewater from the toilet, kitchen sinks, dishwasher and garbage disposal is considered black water, which generally has lower quality than gray water and therefore higher treatment requirements.

6.5.3.1 On-Site Gray Water Treatment System

A study was done by Brown and Caldwell (Impact of On-Site Systems on Groundwater Quality in Thurston County, Discussion Paper, September 18, 1997) on the impact of gray water on-site treatment system on groundwater quality with focus on pollutants of primary regulatory concerns. These pollutants include nitrogen, phosphorus, bacteria and viruses. The study shows that a properly sited advanced on-site treatment within certain setback distances from water supply sources would adequately remove these pollutants and therefore protect public health.

Gray water system size varies by household size and site considerations. Table 6-5 shows typical components of a gray water system. The primary treatment of a gray water system is the soil matrix underlying the application site. Treatment is generally most efficient in deep unsaturated soils of moderate permeability.

Table 6-5 – Common Gray Water System Components

Component	Purpose
Collection system	Piping for delivery of gray water to surge tank
Surge tank	Temporary storage for large flows from fixtures and appliances such as the laundry machine and bath/shower.
Filter	Removes solids which could clog the irrigation system
Pump	Delivers gray water from the surge tank to the drain field
Distribution system	Delivers gray water to the irrigation site, application may be through a leachfield or drip irrigation system

In most cases, soil treatments of a gray water system provide adequate removal of nitrogen to meet drinking water standard and phosphorus to minimize the risk of euthrophication. Contaminants are exposed to a variety of removal and transformation mechanisms in soil treatments, which may include chemical, physical and biological processes.

Removal of bacteria and particularly viruses requires additional treatments through filtration, sedimentation and inactivation mechanisms provided by setback distances and effective treatment in unsaturated zone. According to EPA (1992), an estimated removal of 99.9% is achieved through an unsaturated zone consisting of a sandy loam with at least three feet of separation between the bottom of the infiltrative surface and the highest ground water mound.

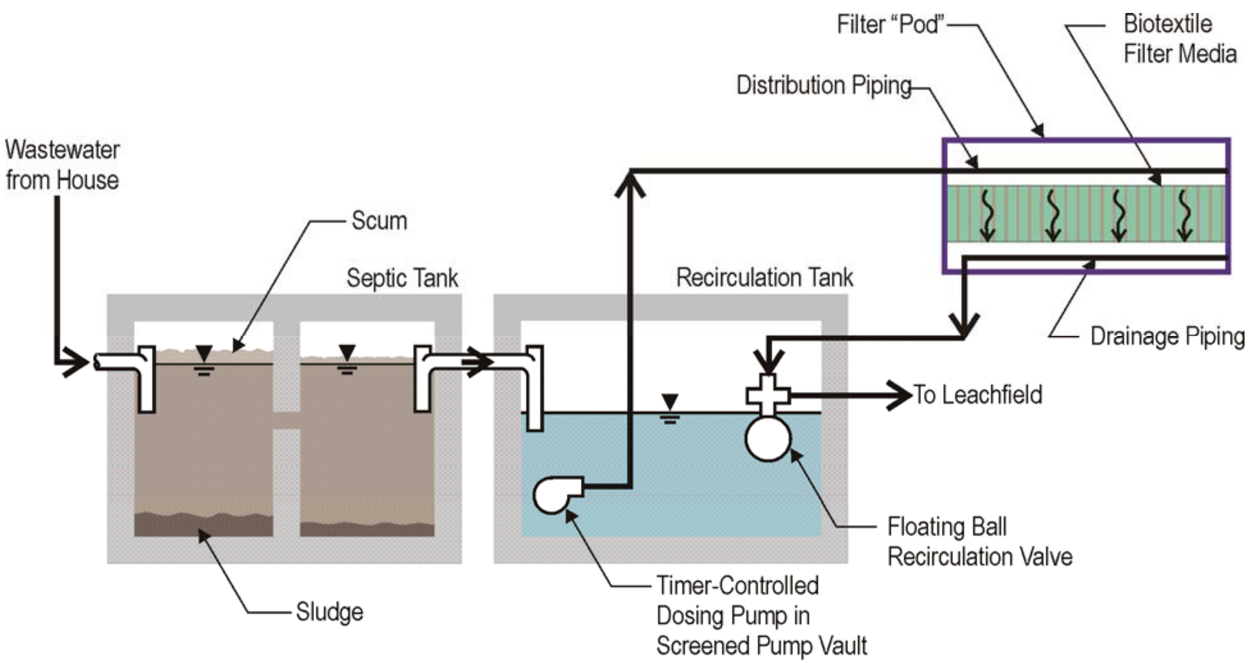
A groundwater model suggests setback distances of 300 to 400 feet between a well and a gray water system to provide sufficient detention time to adequately remove bacteria and viruses to a level that does not pose a significant public health risk. The resulting lot size required to achieve appropriate treatment levels assuming all treatment to be performed within the property line ranges from 2.1 acres to 3.7 acres. Hence, the acceptable density without treatment is about 0.25 unit per acre.

Similar on-site treatments would be required for the unsewered properties in north Guam, as currently the average density in this area is about 1.2 units per acre.

6.5.3.2 On-Site Wastewater System Nitrogen Reduction Upgrade Using Biotextile Filters

The performance of individual onsite wastewater systems can be upgraded using biotextile filter technology. Biotextile filters are a relatively new variation of the proven recirculating packed bed filter technology. Figure 6-4 below is a schematic diagram of an individual onsite wastewater system upgraded with a biotextile filter. As shown in Figure 6-4, wastewater from the house continues to flow into the septic tank, where settleable and floatable solids become sludge and scum, respectively. Septic tank effluent flows into a recirculation tank, where it is pumped to the biotextile filter "pod" and distributed at the top of the filter media. The filter media consists of vertical sheets of non-woven synthetic textile. The wastewater is treated by attached growth micro-organisms as it percolates through the filter media. The wastewater is applied in many small doses throughout the day to increase the hydraulic detention time within the filter media. Drainage piping collects the water at the bottom of the filter and returns it to the recirculation tank. A floating ball recirculation valve automatically controls the return flow back to the recirculation tank or to the leachfield for disposal. The dosing pump timer settings and recirculation tank volume are designed so that wastewater will typically flow through the filter for treatment at least three to five times before being discharged.

Figure 6-4 – Biotextile Filter Schematic



Biotextile filters have proven to produce excellent quality effluent when compared with typical septic tank effluent, as shown in Table 6-6. The table shows that biotextile filter effluent contains significantly less biochemical oxygen demand and total suspended solids than typical septic tank effluent, which reduces solids and organic loading to the leachfield and can enhance or improve soil percolation performance.

Table 6-6 Comparison of Typical Septic Tank and Biotextile Filter Effluents

Parameter	Typical Septic Tank Effluent [a]	Biotextile Filter	
		Effluent [b]	Removal Efficiency [c]
5-Day Biochemical Oxygen Demand (BOD_5)	190 mg/L	<15	>92%
Total Suspended Solids (TSS)	85	<15	>82%
Total Nitrogen	68	35	35%[d] – 50%

[a] Septic tank without effluent filter. Source: Crites and Tchobanoglous (1998)
[b] Source: Crites and Tchobanoglous (1998)
[c] Calculated, except where noted.
[d] Source: Levererenz, et. al. (2000)

Table 6-5 also shows that total nitrogen loading to a leachfield can be reduced between 35 and 50% if a biotextile filter is used. Higher nitrogen removals can be expected in Guam because of the warmer wastewater temperatures, provided that there is sufficient alkalinity in the wastewater. Nitrogen loading is a key issue in the unsewered areas of Guam that are located above key drinking water aquifer. Excessive nitrogen loading by individual onsite wastewater systems located above aquifer can increase the aquifer nitrate concentration above the water quality standard of 10 mg/L (expressed as N).

Upgrading existing individual onsite wastewater systems on Guam with biotextile filter systems will have the effect of reducing the environmental impact each residence has on the underlying aquifer nitrate concentration. Assuming a 35% total nitrogen reduction is achieved by the upgrade, the typical ½ acre residential lot with the upgrade will have the equivalent impact of a ¾ acre residential lot without the upgrade.

Figure 6-5 illustrates a typical residential upgrade using the existing septic tank and leachfield. The recirculation tank and filter pod are both buried adjacent to the existing septic tank. Power for the recirculation pump is obtained from the house circuits.

Figure 6-5 Typical Residential Upgrade

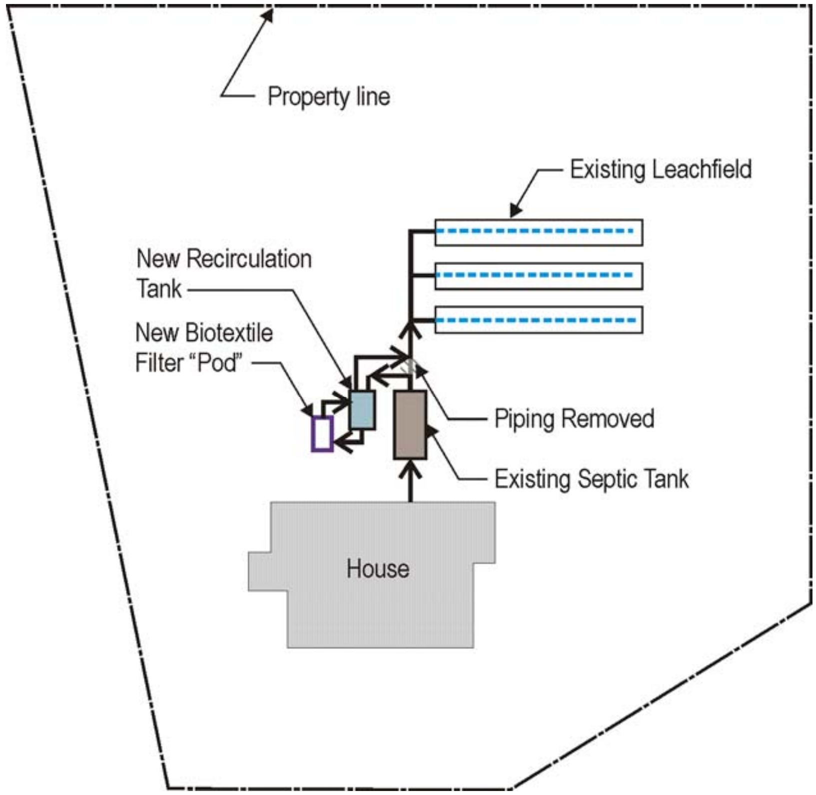


Table 6-7 presents the recirculation tank and biotextile filter needs for residential lots on Guam.

Table 6-7 Biotextile Filter Upgrade Requirements for Residential Lots

Number of Bedrooms	Recirculation Tank Volume (gallons)	Number of Biotextile Filter Pods
1 – 4	500	1
5 – 6	750	2

[a] Advantex AX-20 units manufactured by Orenco Systems, Inc., Sutherlin, Oregon.

6.5.3.3 On-Site Wastewater System Cost and Upgrade Considerations

The estimated cost to upgrade a typical residential lot on Guam (1 to 4 bedrooms) is approximately $16,000. The cost estimate assumes that the existing septic tank and leachfield continue to be used without replacement, and the residence electrical system is sufficient to accommodate the ½ horsepower recirculation pump load.

Operation and maintenance costs for a biotextile filter system are modestly higher than a conventional septic tank system. The recirculation pump system will consume approximately 250 kilowatt-hours of electricity annually. The biotextile filter system should be maintained annually by trained septage haulers or plumbers. Annual maintenance includes hosing accumulated solids off of the biotextile fabric sheets into the recirculation tanks, checking pump and system operation, and checking solids accumulation in the recirculation and septic tanks. The septic tank and/or recirculation tank are pumped out if sufficient solids have accumulated and the septage is disposed at a wastewater treatment plant. The annual maintenance tasks generally take less than one hour to accomplish.

The costs to upgrade a typical residence are significant, therefore a systematic regulatory approach to upgrading unsewered areas of Guam is recommended. A program to provide financial assistance to low-income property owners would possibly be necessary.

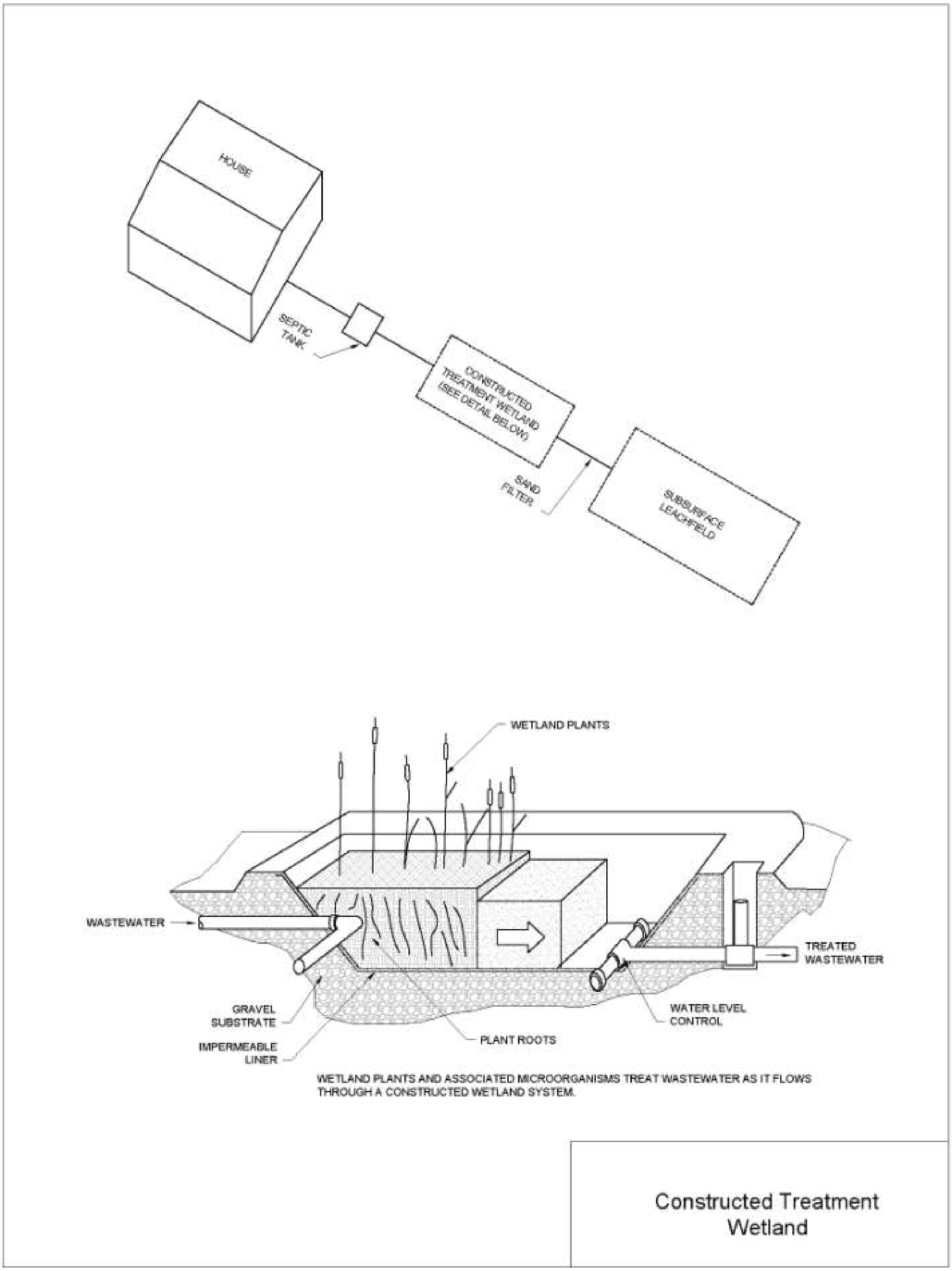
6.5.4 Decentralized Wastewater Collection and Treatment

The possibilities for using a decentralized approach for wastewater treatment and collection are discussed in greater detail in Section 6.5.2 above. While this may be suitable for specific situations, such as isolated locations, it requires additional resources, in terms of staffing to properly operate and maintain these systems. Further, there will be the issue of disposal and those requirements will likely make advanced treatment necessary, requiring even more resources and sophisticated operation. Therefore, we believe that a centralized approach generally represents the most cost effective and efficient method for wastewater treatment and disposal.

6.5.5 Centralized Water Treatment

Groundwater could be collected and treated prior to distribution to customers as discussed in Volume 2, Chapter 2 – Water Regulations, Section 2.4 and 2.5. This alternative would require a system of transmission lines to collect pumped groundwater and convey it to centralized treatment plants. Treatment plants could be located at existing or new reservoir sites. The existing water system in the Northern District relies on the deep wells pumping directly to the distribution system to both feed reservoirs and maintain system pressure at the extremities. Pumping to reservoirs for treatment prior to distribution would result in unacceptably low pressures in portions of the existing network. Additional reservoirs and/or in-line booster pump stations, or new distribution lines from the reservoirs to the location of the deep wells would be required. In the central area, the proposed transmission line system delivering to the Choat reservoir for treatment is feasible. Some adjustment in well pump head capacities may be required, but the Central system would function adequately.

Figure 6-6 – Constructed Treatment Wetland



6.6 Institutional and Administrative Considerations for Mitigation Action

The attorney for GWA states that "GWA is not legally obligated to pay for any costs associated with bringing sewer service to unsewered areas. In fact, under existing law as well as GWA's Rules and Regulations, GWA operates sewer collection lines that are either (1) put in by a developer or the Government of Guam for operation; or (2) receives compensation from a developer to increase sewer sizes to accommodate demand. Many of the unsewered areas involve Chamorro Land Trust Subdivisions or individual properties and the cost of installing sewer service rests with the Guam Legislature and the Governor of Guam, not GWA revenues. In addition, Guam law and the GEPA have approved the use of septic systems which does not involve GWA."

Because the Stipulated Order requires an assessment of septic tank hookups and alternatives as well as an analysis of costs and impacts, the preceding background and the following alternatives and estimated costs have been developed. Institutional changes will be required to fund these requirements, either through GWA rates on water and sewer or through some other governmental mechanism. In Table 14-4, costs that fall in this category are shown with an asterisk.

6.7 Future Actions

Future actions by responsible parties should not only include CIP that bring public sewer to areas without access, but also include the necessary institutional changes to adequately monitor the existing septic systems by Guam's regulatory agencies. GWA would benefit by their increased support. For GWA to exercise any sort of control over the current septic system situation, other governing regulatory agencies must also be a part of the solution. GEPA is the regulatory agency responsible for permitting septic systems and the DLMPD sets zoning requirements that directly affect the placement of septic systems. The institutional changes discussed below were recommended by the PUAG's Rural Island-wide Wastewater Facilities Plan, October 1982, and are still applicable today.

There are additional regulations/requirements that, if implemented, will help the regulatory bodies monitor and identify problems with the existing septic systems. There are steps that may help alleviate some of the nitrate burden on the northern aquifer. Currently, GEPA and the other regulatory agencies in Guam do not have a standard inspection program in place for investigating the performance of existing septic systems. A periodic inspection and pumping program would allow deficient systems to be pin-pointed and corrected, providing some protection of the island's potable water sources. Inspection services could even be contracted out to private firms that pump out septic tanks since they already visit these properties.

- Implement and enforce a septic tank pumping or inspection program for all septic systems to be pumped and/or inspected every three years or when a known problem arises. In addition, require permit renewal for all septic systems every three years, issued only after the septic system owner has the system inspected and repaired accordingly.

Another fix that would aid in the monitoring of existing septic systems is:

- Initiate a septic system record keeping program that includes the type of system constructed, dimensions of the system, year constructed, location, number of people served, inspection dates and results, failures, septage pumping records and any other pertinent information.

At the time this report was written, detailed GEPA records were not available for existing septic systems.

Additionally, changes to the existing GEPA regulations are necessary to update the wellhead protection zone:

- Update the wellhead protection zone from the 300 feet identified in the Septic System and Leaching Field Regulations to the 1,000 feet dictated by the WHP Program.

6.8 Alternative Solutions

The mitigation approaches provided in Section 6.6 are further examined here for recommendation of CIP projects. Three alternatives are examined:

- Sewering of all currently unsewered properties.
- A phased approach concentrating on properties that is near existing sewers or are within the 1,000 feet protection zone of the water supply wells with a long-term program to complete sewering or provide alternative treatment.
- A mixed approach using sewering the areas included in item two above together with the use of transmission lines in the Central area to provide centralized water treatment.

6.8.1 Sewering of all Unsewered Properties

During preparation of the sewer hydraulic model discussed in Section 3 and 4 of this chapter, polygons were constructed surrounding areas of obvious development from available aerial photographs. These were linked to existing sewers to estimate sewered population. The polygons not associated with sewers can be used as a first estimate of the area to be sewered in the future. A total of approximately 15,000 acres in the North and Central areas were not associated with existing sewers. Of this total, approximately 3,000 acres were identified as the most likely to impact water supply wells.

Based on observed sewer density in Guam, it is estimated that 160 feet of 8- to 10-inch sewers will be required per acre to fully sewer an area. In addition, larger trunk sewers or small pump stations will be required to convey the new flows to the existing sewer network for disposal. GWA constructed a new system including 8,150 feet of 8- to 10-inch pipe and an associated pump station in 2003 at a cost of $1,600,000. On a per foot basis upgraded to year 2007, this contract represents a construction cost of $240 per foot of pipe installed. At this average rate and assuming an average of 160 feet of sewer per acre, construction of new sewers in the 15,000 acres identified above would require a budget of $576 million. The most critical 3,000 acres would require a budget of $115 million.

6.8.2 Sewer Properties near Existing Sewers and/or in the 1,000-foot Well Buffer

A total of 12,083 unsewered properties were located via GPS in the WERI study. This is short of the 15,027 identified in Table 6-2. The missing properties may be principally in Yigo and Dededo. Of the 12,083 located, 9,314 are in the northern and central areas. These were located with respect to existing sewers and water supply wells as shown in Table 6-8.

Table 6-8 – Apparent Unsewered Properties Near Wells and Sewers

Service Area	Total Located Unsewered Properties	Within 1,000 feet of Wells	Within 200 feet of Existing Sewers[a]
Northern District	2,667	503	436/131
Hagatna	6,647	903	2137/479
Total	9,314	1406	2573/610

[a] Total number followed by number within 200-feet of existing sewers and within 1tr000-feet of a well

The Stipulated Order requires development of a Sewer Hook-up Revolving Fund to provide service to unsewered properties within 200 feet of existing sewers. Sewering the properties within 200 feet of existing sewers and within 1,000 feet of wells would intercept 3,369 of the located properties in the North and Central areas. Assuming a similar ratio of properties near sewers or wells for the 2,774 missing properties not GPS located (assumed to be in Yigo) would add 1,000 more. Clusters of development in the Northern District at densities greater than one unit per acre were identified where new sewers could intercept approximately 1,200 additional unsewered properties. These areas are shown in Figures 6-7, 6-8 and 6-9.

In a study for the Water Environment Research Foundation[13], Brown and Caldwell gathered information on construction costs for home service laterals on the mainland U.S. The average cost found in this study was $30/foot for installation. For this study, it is assumed Guam costs will be 140% higher than on the mainland, and an average $42/foot for service lateral installation is assumed. Assuming an average of 100 feet of service lateral yields an estimated $4,200 construction cost per new connection. Using the estimates described above results in construction cost estimates to intercept unsewered properties as shown in Tables 6-9, 6-10, and 6-11. Table 6-9 shows costs to meet the GEPA requirements of sewering properties within 1000-feet of deep wells. Table 6-10 presents costs for remaining properties that are within 200-feet of existing sewers but not near wells.

Table 6-9 – Construction Cost Estimate to Intercept Apparent Unsewered Properties near Wells and Existing Sewers

Area	Properties in 1000-ft Well Buffers			Near Existing Sewer Construction Cost $	New Sewer Construction Cost $	Total Construction Cost $
	No. Near Existing Sewers	No. Requiring New Sewers	New Sewer Length, ft			
Hagatna	675	228	21,700	$2,837,736	$ 6,166,524	$9,004,260
North District	168	335	60,300	$ 706,281	$15,880,358	$16,586,639
Total Construction	843	563	82,000	$3,544,017	$22,046,882	$25,590,898
Project Budget[a]				$6,500,000	$40,000,000	$47,000,000

[a] Includes planning level adjustment (50%) plus Engineering (10%), Construction Management (7%), Engineering Services During Construction (5%)

Table 6-10, Construction Cost Estimate to Intercept Apparent Unsewered Properties near Existing Sewers but not near Wells

Area	No. Properties Within 200-ft of Existing Sewers	Service Lateral Construction Cost $
Hagatna	1658	$6,970,320
North District	305	$1,282,236
Total Construction	1963	$8,252,556
Project Budget [a]		$15,100,000

[a] Includes planning level adjustment (50%) plus Engineering (10%), Construction Management (7%), Engineering Services During Construction (5%)

Table 6-11 presents costs for sewering properties in areas with densities greater than one unit per acre as recommended in the 1982 Island-wide Wastewater Facilities Plan but which are not near existing sewers or wells. These should be examined in more detail to develop long term funding mechanisms, and to examine potential alternative approaches. The costs are thus not included in the 20-yr CIP (Volume 2, Chapter 9 and Volume 1, Chapter 15).. The construction costs identified in analyses here are approximately $30,000 per unsewered property intercepted, which can be compared to alternative control methods.

Table 6-11 – Construction Cost Estimate to Intercept Apparent Unsewered Properties in Areas with Density Greater than One Unit per Acre but not near Existing Sewers or Wells

Area	No. Properties	Sewered Area, Ac	New Sewer Length, ft	New Sewer Construction Cost $	Service Lateral Construction Cost $	Total Construction Cost $
Figure 6-7	282	246	24,600	$5,904,000	$1,185,543	$7,089,543
Figure 6-8	446	382	38,200	$9,168,000	$1,875,008	$11,043,008
Figure 6-9	378	115	11,500	$2,760,000	$1,589,132	$4,349,132
Total Construction	1106	743	74,300	$17,832,000	$4,866,400	$22,481,682
Project Budget[a]				$32,600,000	$8,900,000	$41,500,000

[a] Includes planning level adjustment (50%) plus Engineering (10%), Construction Management (7%), Engineering Services During Construction (5%)

Figure 6-7 – Additional Properties Intercepted Near F Series Wells

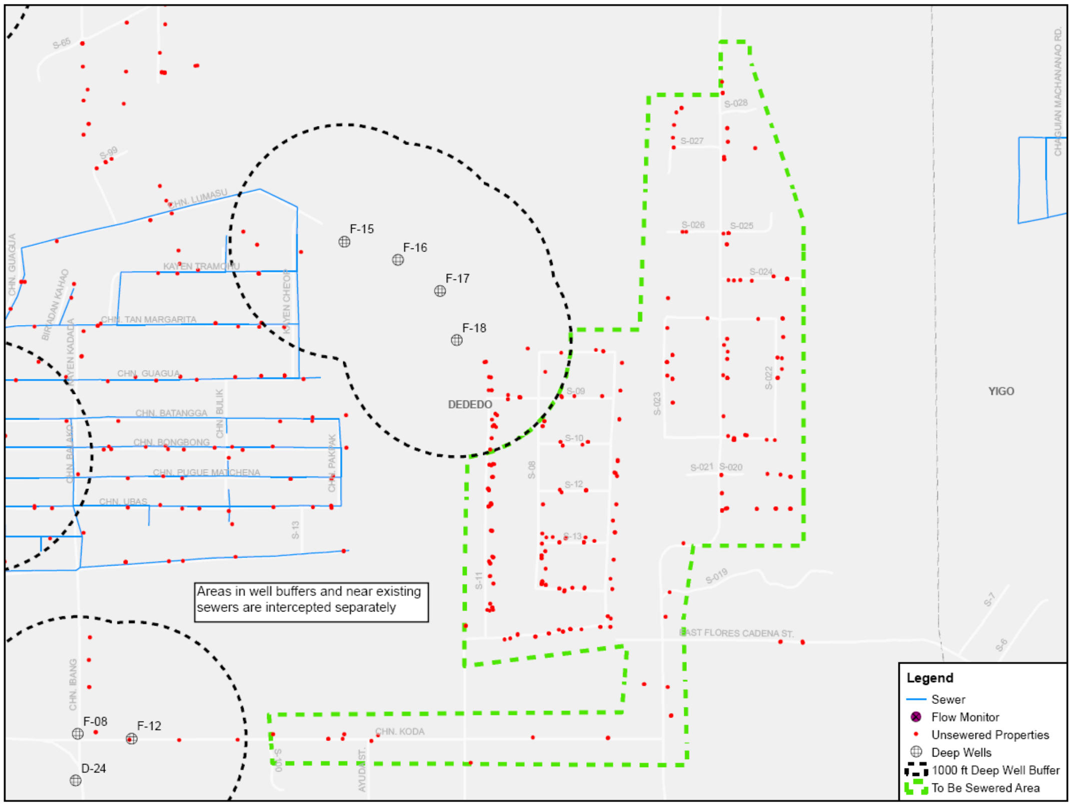


Figure 6-8 – Additional Properties Intercepted Near Y and D Series Wells

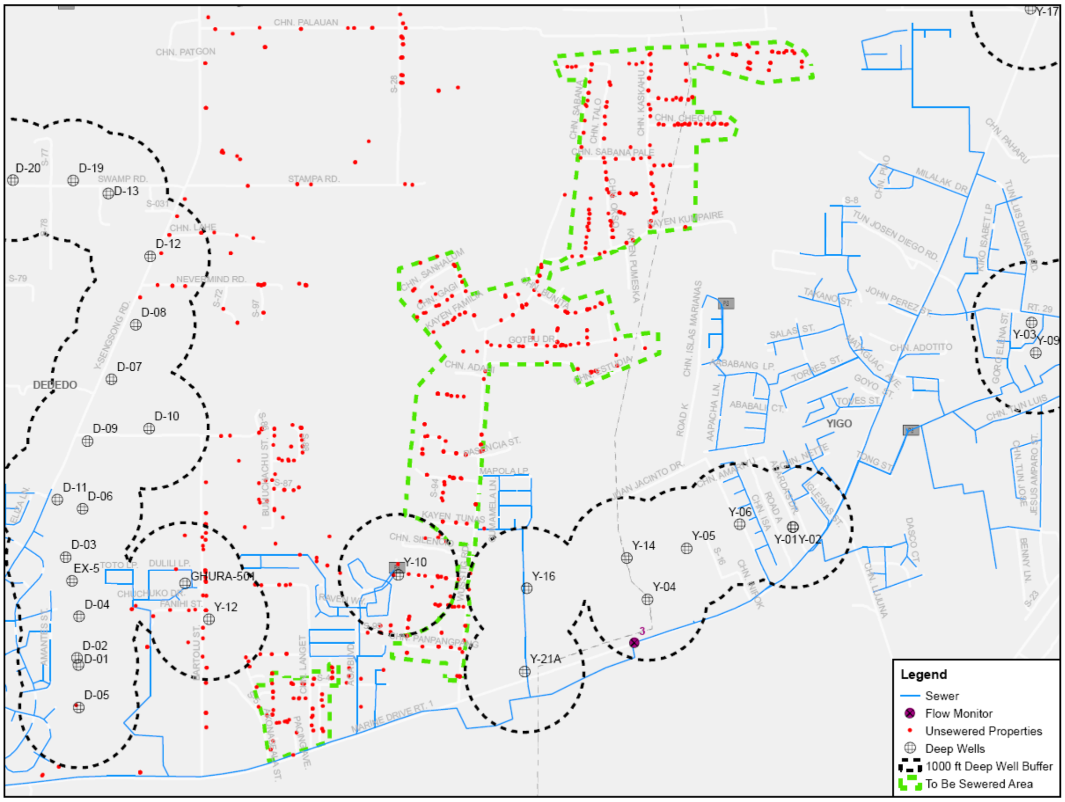
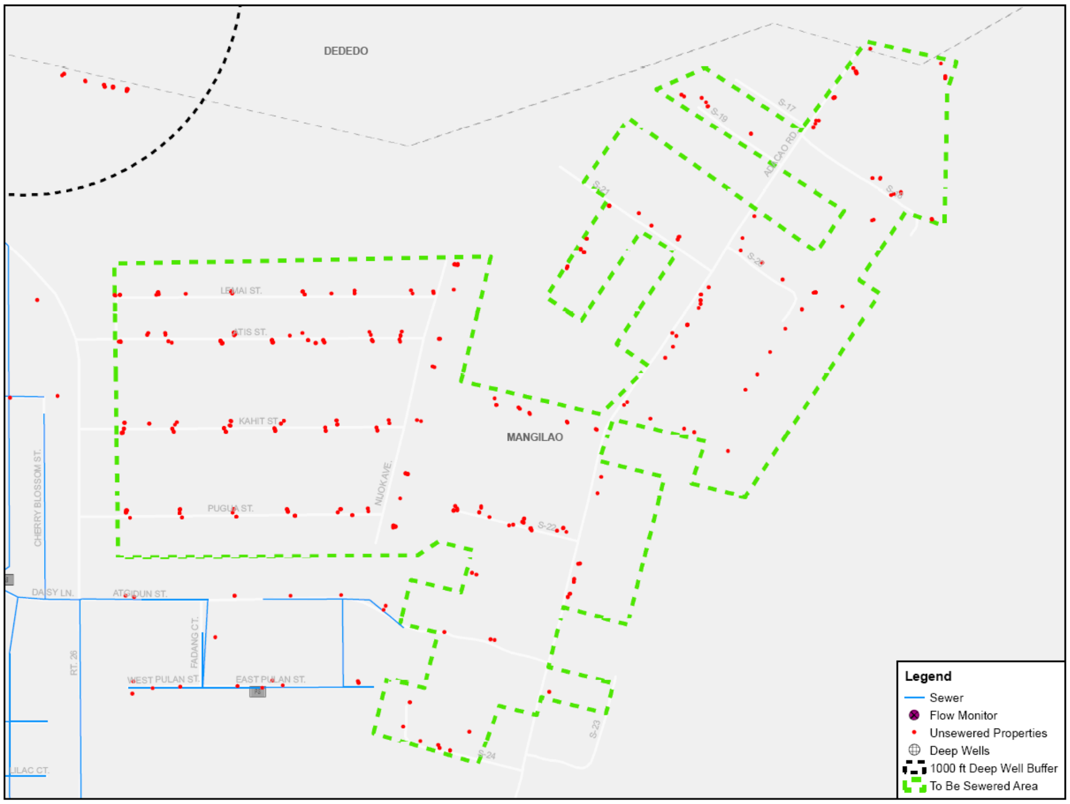


Figure 6-9 – Additional Properties Intercepted Near M Series Wells



6.8.3 Centralized Water Treatment

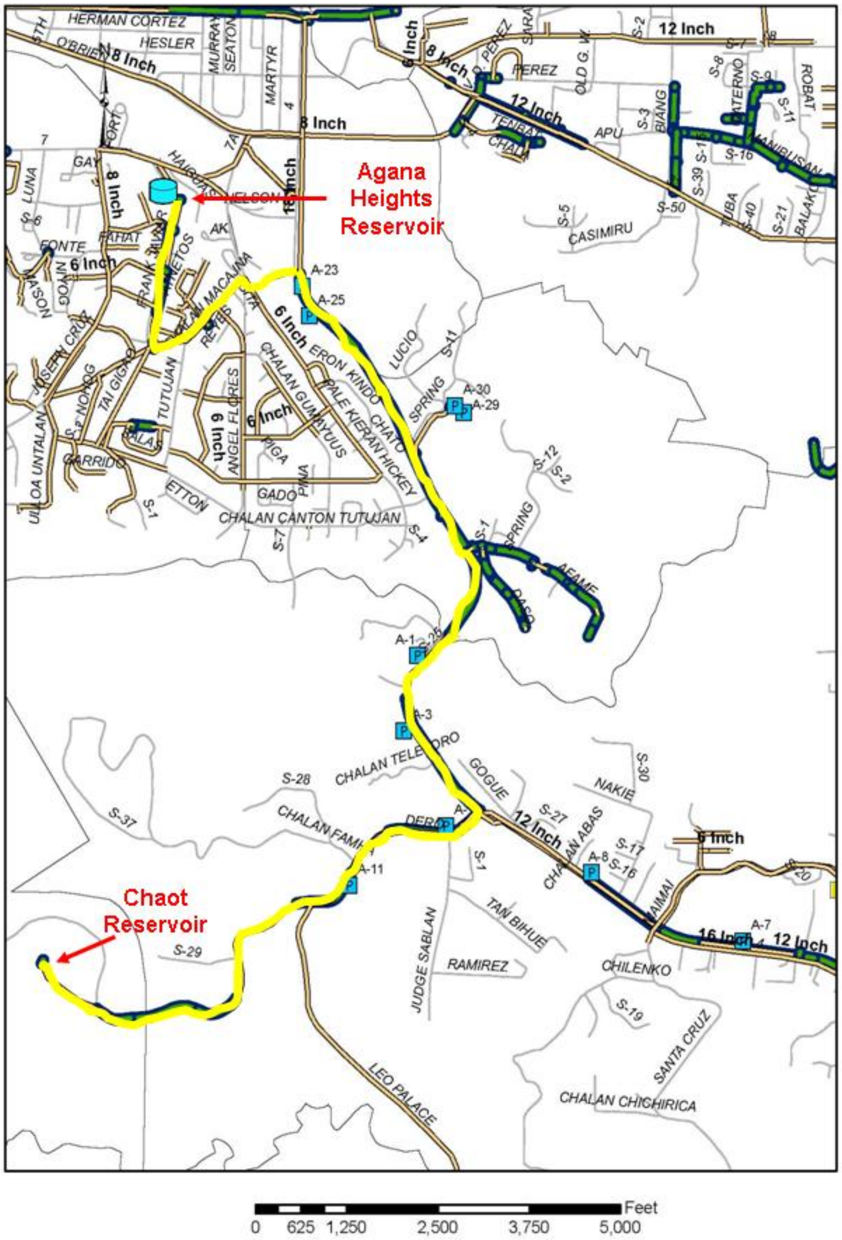
An alternative to interception of unsewered properties is to treat the groundwater in centralized facilities before distribution. Transmission lines would be provided to intercept the output of the supply wells and deliver it to a water treatment facility. From there the treated water would be delivered to reservoirs to supply the distribution system. Considerations in development of such systems include the following:

- The ability of the well pumps to deliver adequate flows to the water treatment plant,
- The impact on system pressures. In the current system, the well pumps deliver directly to the distribution system maintaining pressure. Diverting the well output to transmission lines may result in low pressure in portions of the system without the addition of booster pumps, new distribution lines from the reservoirs to the location of the existing pumps, and/or additional reservoirs.

GWA has developed the concept for the Hagatna area as shown in Figure 6-10. Preliminary assessment of this alternative with the water system model indicates that only minor modifications to the well pumps would be needed, if any. Data on the full head-capacity characteristics of the well pumps is not available (only the rated conditions are available). GWA will need to review these pumps and replace them if needed.

The project in Figures 6-10 could be part of a broader plan to provide transmission lines for the entire island or to introduce collector wells feeding reservoirs directly. These systems are described in Volume 2, Chapter 8 – Water System Improvements.

Figure 6-10 – Hagatna Transmission Line



6.9 Conclusions

The foregoing addresses the challenges Guam faces with respect to unsewered areas and the influence of septic systems on potable groundwater sources. GEPA has the primary responsibility for oversight of these systems and regulation of future installations. Even though GWA does not now have responsibility for funding sewers for the areas impacted by septic systems, it is incumbent on the agency to protect ground water sources from contamination. Institutional or legislative modifications may be required to provide the necessary funding. As noted, when this report was prepared, it was not known what the impact of GWUDI would have on types and financing for proposed alternatives.

6.10 Recommendations

The information in this chapter and other parts of the WRMP provides a road map for addressing the protection of water sources on the island. Recommended actions are as follows:

1. Make modifications in regulations and rules to provide a consistent application of septic tank regulations as discussed in Section 6.7.
2. Provide funding via the Sewer Hook-up Revolving Fund mandated in the Stipulated Order to provide service to unsewered properties within 200-feet of existing sewers. Those simultaneously within 1000-feet of deep wells should be done first.
3. Develop a funding mechanism to address the remaining unsewered properties within 1,000 feet of deep wells that will require new sewers. Recognizing institutional or legislative changes are needed, these costs are footnoted in Volume 2, Chapter 9 – Wastewater CIP and Volume 1, Chapter 15 – Capital Improvement Program.
4. Provide funding or alternative mechanisms in the long term for sewer extensions or alternative treatment in areas where densities exceed one unit per acre. Further study may indicate adequate protection would be provided by alternative methods as detailed in Section 6.5 of this chapter.
5. Begin installation of a transmission line system or a collector well system to collect water from the deep wells and provide treatment at the reservoirs prior to distribution. This provides a near term barrier to bacterial contamination of the water supply through disinfection, and allows for more advanced treatment in the future if needed.

6.11 CIP Impacts

A number of projects are identified as important for implementation in unsewered areas, however because of the interpretation of GWA's area of responsibility; they may not be incorporated into the GWA WRMP proposed CIP projects to be funded by GWA. More details on this topic are presented in Volume 1, Chapter 15 – Capital Improvement Program.

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