CHAPTER 1 – WATER SYSTEM DESCRIPTION

1.1 Introduction

GWA operates and maintains over 200 water facilities on Guam. Table 1-1 identifies these facilities by system, type and population served. The facility types can generally be classified as sources, reservoirs and water booster pump stations.

GWA is comprised of three public water systems. The Northern (GU00000006) and Central (GU00000003) Public Water Systems are designated "Large" and the Southern (GU00000001) Public Water System is designated "Small". These are "Distribution" system classifications established by Guam Environmental Protection Agency (GEPA) and are based on the population served.

Table 1-1 – GWA Facilities

System	Wells	Springs	Reservoirs	Booster Stations	Treatment Plants	Population Served[2]
Northern	119[1]	0	14[3]	10[5]	0	146,050
Central	0	1	8[4]	9[6]	0	22,000
Southern	2	4	14	16[7]	1	5,504
Total	121	5	36	35	1	173,554

1. 10 Wells were formerly owned and operated by EarthTech and are now owned and operated by GWA.

2. The values shown in the table above are the population GEPA used in its water system designation. Current GWA water service population values are 133,600; 15,700; and 7,400, for the Northern, Central and Southern Systems, respectively.

3. 11 of the 14 reservoirs are in use. The Barrigada #2, Mangilao #1 and Nissan (Tumon #2) tanks are out of service.

4. Five of the eight reservoirs are in use. The Agana Heights and Asan Springs tanks are out of service and the Nimitz Lower tank is abandoned.

5. Nine of the 10 booster stations are in use. The Mataguac Booster (old) is abandoned.

6. Six of the nine booster stations are in use. The Nimitz Hill (Upper) Booster is out of service, the Yona Water Field Office is abandoned and the Asan Spring Booster is on standby.

7. 14 of the 16 booster stations are in use. The Inarajan and Sinifa Boosters are abandoned.

The public water system boundaries do not offer exact delineations, but the general boundaries are shown on Figure 1-1, Water System Boundaries and are discussed hereafter. Figure 1-2, Water System Overlaps, shows where potential overlaps of water service among the three systems occurs.

1.1.1 Northern Public Water System

The Northern Public Water System is bounded on the north by Andersen Air Force Base. It includes the remaining northern half of Guam and extends southward toward Tamuning and Barrigada and along the east side to Route 17 in Yona. The Northern System overlaps the Southern System in the Windward Hills and Talofofo area along Routes 14, 4 and 4a. All wells except the Malojloj Subdivision MJ-series are located in the northern system. Most of the wells are located north of Route 4 before it turns south near the intersection with Route 10.

1.1.2 Central Public Water System

The Central Public Water System extends along the west side of Guam from Mongmong-Toto-Maite south to Agat. The system extends inland to Sinajana and roughly follows the western borders of Chalan Pago and Yona to Route 17 and then the western border of

Figure 1-1 – Water System Boundaries

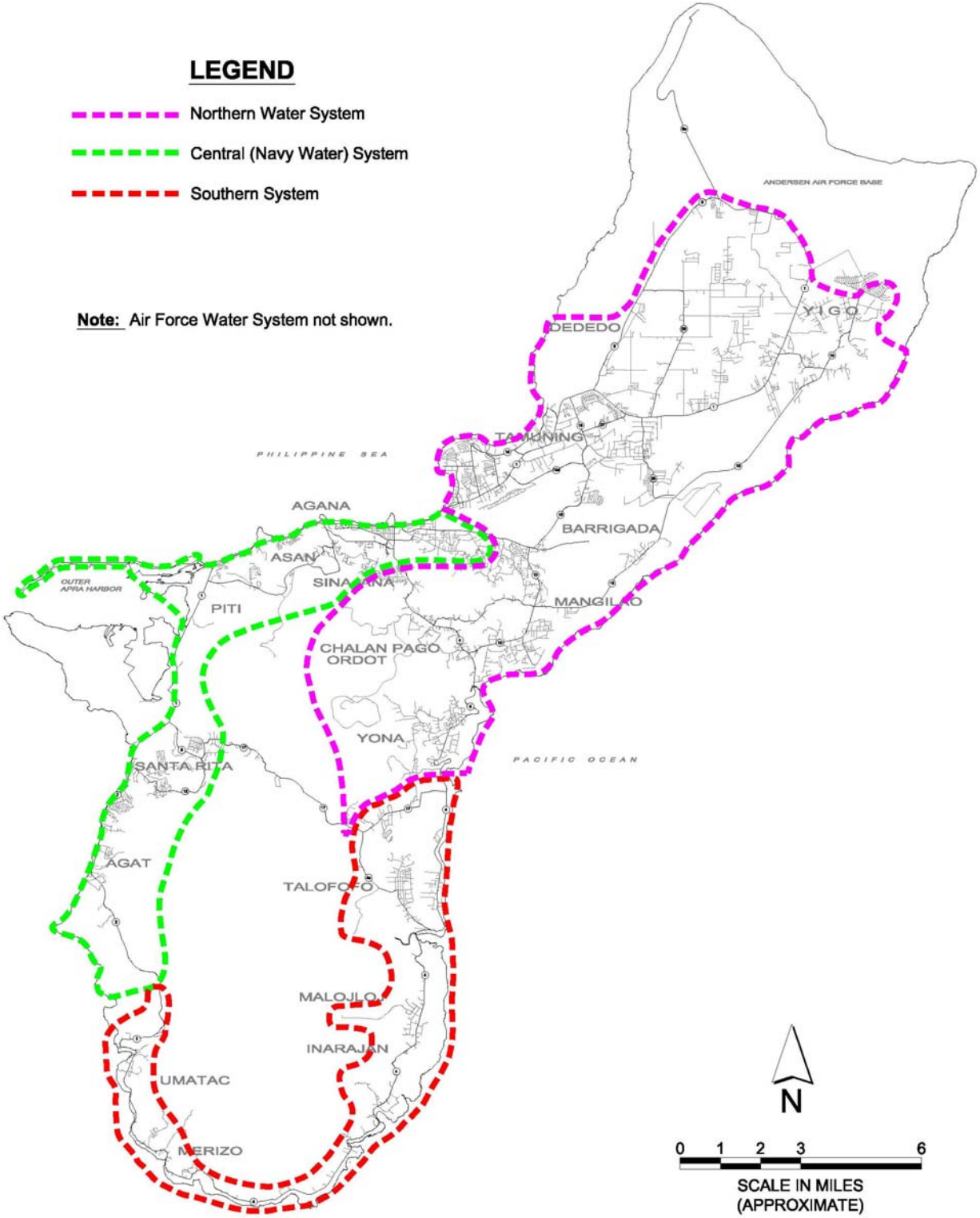
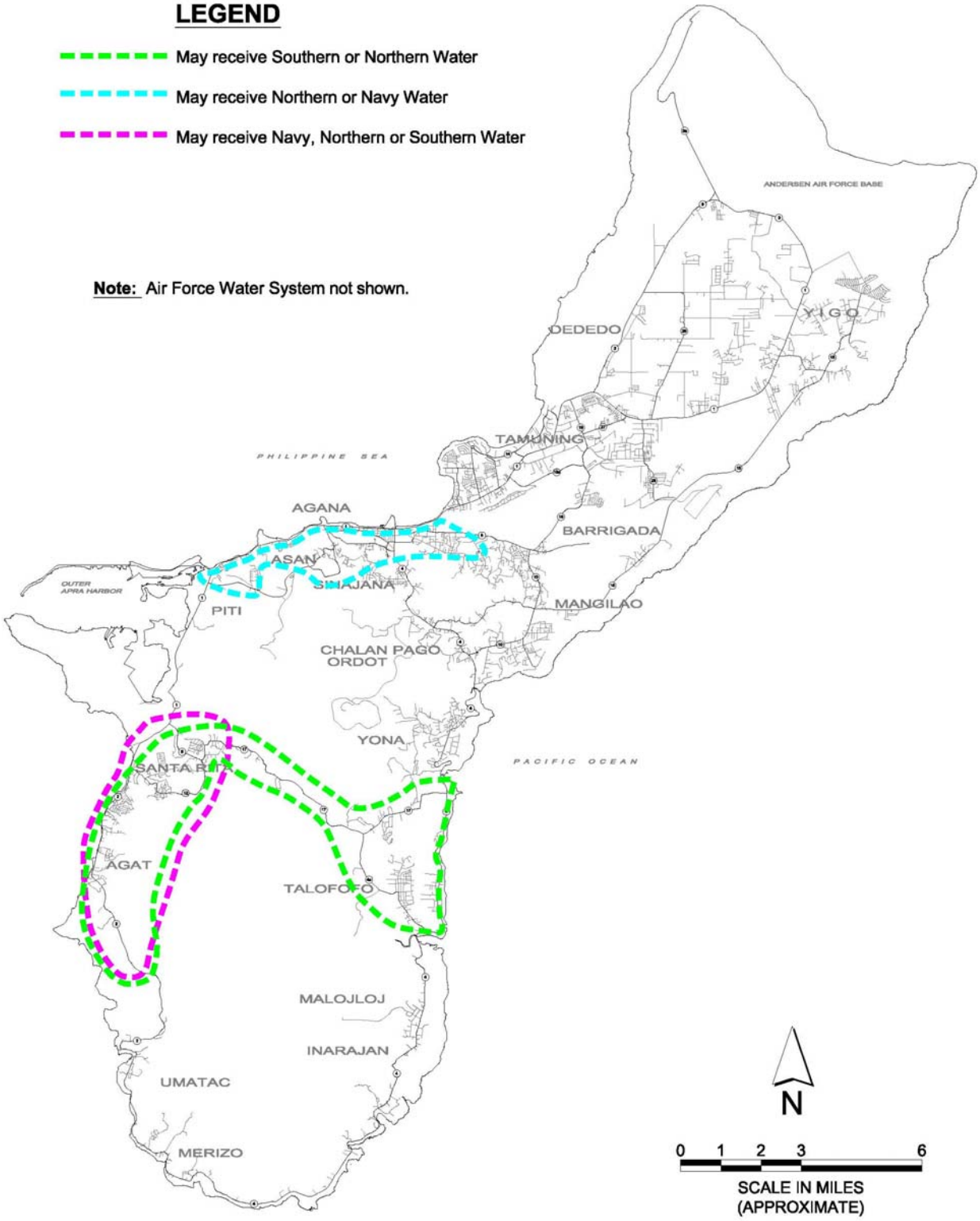


Figure 1-2 – Water System Overlaps



Talofofo to Agat. The main source of water for this area is the U.S. Navy's Fena Water Treatment Plant (WTP), which is discussed hereafter. Northern water can be fed to the Central System in the areas of Mongmong-Toto-Maite, Sinajana, Agana Heights, Asan and parts of Piti. Northern water can also be supplied to Apra Heights, Santa Rita and Agat through water mains that run along Routes 17, 5, 12 and 2.

1.1.2.1 U.S. Navy Fena WTP

The U.S. Navy owns and operates a surface water treatment plant along Route 5 in Santa Rita that treats water from Fena Reservoir. GWA purchases water from the Navy to serve customers in the Central System. However, the water can be conveyed to customers in portions of the Northern and Southern Systems as shown on Figure 1-2.

Fena Reservoir was constructed by the U.S. Navy in 1951 to supply its military operations on Guam. The reservoir has a six-square mile watershed and a capacity of approximately 2.3 billion gallons (7,050 acre-feet). Fena Dam is approximately 85 feet high and 1,050 feet long. Water is pumped from the reservoir to the Fena WTP where the raw water is treated by coagulation, sedimentation and filtration. The treatment plant can produce approximately 13.5 million gallons per day (mgd).

The Fena WTP is currently being upgraded to provide improved treatment reliability but not increased capacity. The improvements include addition of pre-oxidation with potassium permanganate and addition of ballasted floc sedimentation for enhanced solids removal. The goal will be to achieve better solids removal which will in turn provide additional barriers against microbiological contamination. The improvements should also aid in the reduction of disinfection by-products by enhance removal of precursors that contribute to their formation.

There are 54 connections between the U.S. Navy's Fena WTP water supply and GWA's system. Thirty-nine of these connections are active and 15 are inactive. The active connections are shown in Table 1-2, Navy Supply Connections to GWA System. The area served by this supply extends from Agat Reservoir along Route 2 in Northern Umatac on the southern end, through Sinifa Reservoir in Santa Rita in the center, to Guam International Airport on the northern end.

A 1956 agreement between the U.S. Government and the Government of Guam commits 4.25 mgd of Navy water for GWA's use. The distribution of this water is outlined in the agreement as follows:

- 0.75 mgd served from the portion of the Navy's system south of the junction of Routes 1 and 2A;
- 2.50 mgd served from the portion of the Navy's system north of the junction of Routes 1 and 2A; and
- 1.00 mgd from Agana Springs.

A memorandum of understanding in 1991 increased the Navy's commitment to GWA to 4.39 mgd.

From October 1, 2003 to September 30, 2004, GWA used an average of 4.3 mgd of Navy water. The peak month during this same period was approximately 6.7 mgd.

Since the original agreement, the Agana Springs system was abandoned by the Navy and rehabilitated by GWA's predecessor, Public Utility Agency of Guam (PUAG). This source now comprises wells A-29 and A-30.

Table 1-2 – Navy Supply Connections to GWA System

Customer Name	Route Number	Name	Line Size Connection
GWA	56	Agat Rizal Beach	2-inch
GWA	62	Route 5 Apra Area	2-inch
GWA	69	Agat/Santa Rita	10-inch
GWA	74	Route 2A Ching Hueng	2-inch
GWA	75	Orchid Taco Bell Front of Naval Station	1-1/2-inch
GWA	76	Uncle Bob Beer Garden	1-inch
GWA	81	Palai Housing	2-inch
GWA	87	Route 2 A Shell Inc	10-inch
GWA	91	Piti Veterans Cemetery	6-inch
GWA	92	Piti Middle School	3-inch
GWA	93	Piti GWA/GSA Warehouse	8-inch
GWA	98	GWA GORCO Fuel Tank	4-inch
GWA	98F	GOVGUAM GORCO Fuel Tank	8-inch
GWA	106	Piti Village	6- inch
GOVGUAM	109	NimHill Johnston Res	2-inch
GOVGUAM	110	Larson Road, Nimitz Hill	6-inch
GOVGUAM	114	Maina Housing	1-1/2-inch
GOVGUAM	115	Maina Housing Upper	1-1/2-inch
GOVGUAM	116	Maina Panam Housing	1-1/2-inch
GOVGUAM	117	Maina Housing Lower	4-inch
GWA	120	Hansen- Snake Road Adelup/Agana Hts	2-inch
GOVGUAM	124	Agana Heights Route 7	10-inch
GWA	125	Route 33 Mongmong Village	4-inch
GWA	126	GOVGUAM Agana Power Plant	2-inch
GWA	127	Route 8 Maite Village/Tajmahal Apartments	8-inch
GWA	132H/L	Old MCB1 Area High	6-inch
GWA	137	Route 8 Barrigada Across Mormon Church	8-inch
GWA	138	Barrigada Area 1	6-inch
GWA	154H/L	Agana Mazda Auto City	10-inch
GWA	155	Adelup Point	6-inch
GWA	156H/L	Agana Kings Auto Shop High	6-inch
GWA	157H/L	Agana Chamorro Village High	6-inch
GWA	159	Route 3 NCTS STP	3-inch

Table 1-2 – Navy Supply Connections to GWA System (continued)

Customer Name	Route Number	Name	Line Size Connection
GWA	164	Route 3 NCTS STP Bypass	2-inch
GWA	169	Piti Laguas Bridge	2-inch
GWA	173	Agat School Bus Pool	2-inch
GWA	201	Asan Village	6-inch
GWA	222	Sinifa Area	4-inch
GOVGUAM	229	Port Authority Beach	1-1/2-inch
GWA	232	National Park Service	2-inch
GWA	235	Cabras Island Master/Commercial Port	10-inch
GWA	236	Cabras Island Bypass/Commercial Port	8-inch
GOVGUAM	284	Osir Yacht Club	2-inch
GOVGUAM	285	Rt. 3 GOVGUAM Supply	8-inch
--	309	NAVACTS GTA Tel Exchange	1-inch
--	311	Tiyan #1 Old Main Gate	10-inch
GWA	315	Micronesian Hotel Route 8	6-inch that feeds a 12-inch line
Inactive	351	Tiyan #2 New Main Gate	12-inch
Inactive	353	Tiyan #3 Fury Road	16-inch
GWA	356	Tiyan #4 Security Road AUW Area	16-inch
GOVGUAM	365	GWA USDA Plantation	2-inch
GWA	367	Two Lovers Point	2-inch
GWA	398	Route 2A Sewer Plant Master	8-inch
GWA	399	Route 2A Sewer Plant Bypass	4-inch
GWA	427	Piti GSA	2-inch
GWA	458	2000 Liberation Day Carnival	Unknown
--	462	Harbor of Refuge	Unknown
GWA	477	Murray Road Nimitz Hill	Unknown
GWA	479	Murray Road Nimitz Hill	Unknown
NFM	480	QA Spruance Drive Nimitz Hill	Unknown

1.1.3 Southern Public Water System

The Southern Public Water System roughly extends south of Route 17, around the southern tip of Guam to Umatac. Southern water can also be supplied to parts of Yona and Chalan Pago in the Northern System, as well as Santa Rita and Agat in the Central System. There are five water sources that serve the southern system: Ugum WTP, Malojloj Wells, Aalatgue (Laelae) Spring, Geus Spring and Siligan Spring. The sources are described in the following sections.

1.1.3.1 Ugum WTP

The Ugum WTP draws and treats raw water from the Ugum River for use in the Southern Public Water System. The plant generally supplies potable water south along Route 4, terminating at the Umatac-Agat Reservoir along Route 2. The plant can provide water north to the Windward Hills area through the use of the Brigade Booster Pump Station (BPS) that is located near the intersection of Routes 4 and 17, which boosts water from Ugum to the Windward Hills area. However, this area is normally supplied from the Northern Public Water System wells.

1.1.3.2 Malojloj Wells

These two wells are located along Route 4 in Northern Inarajan. The wells have very low production and are not currently in service for providing potable water.

1.1.3.3 Laelae Spring

Laelae Spring is located in the southern part of Umatac and is inactive.

1.1.3.4 Geus Spring

Geus Spring is located in Merizo and is inactive.

1.1.3.5 Siligan Spring

Siligan Spring is located in Merizo and is inactive.

1.2 GWA Water Sources

The sources of water supply include wells, springs and surface water. This section describes each of these sources.

1.2.1 Wells

The GWA wells are identified by a geographical classification system. In the classification system, one or more capital letters, followed by a number refers to the general geographical location and the order of drilling. A summary of the geographical locations is provided below. All wells except the two wells with "MJ" designations are located in the Northern Public Water Supply System.

- The 26 "A" series wells are located in the Agana region and extend from the Adelup-Pago contact to Barrigada.
- The 18 "M" series wells extend from the Naval Communications Station in Barrigada to Dededo-Yigo.
- The 27 "D" series wells run north from the village of Dededo along Y-Sengsong Road. They are part of the Northern Public Water System. Four of these wells were formerly owned and operated by Earth Tech, but are now owned and operated by GWA.
- The 20 "Y" series wells are in the Yigo area. Four of these wells were formerly owned and operated by Earth Tech, but are now owned and operated by GWA.
- The 19 "F", one "H" and two "AG" series wells are located in the Finegayan, Harmon Village and Machananao (Agafa Gumas) areas, respectively. Two of the

F-series wells were formerly owned and operated by Earth Tech, but are now owned and operated by GWA.

- The two "MJ" wells are in the Malojloj area and are the only two wells located in the Southern Public Water System.
- The single "NAS" well is located in Tiyan along Route 16.
- The two "EX" wells are located in the Dededo Golf Course Compound.
- The single "HGC" well is located in the Santa Ana Subdivision in Dededo.

A list of the GWA wells is provided in Table 1-3. The locations of the GWA wells are shown on Figures 1-3a thru 1-3e.

Discharge piping and controls for the wells are essentially the same. There are differences in configuration required to fit each specific site. Multi-stage submersible pumps are used to pump from the well into the distribution system.

Each well site consists of the well, the well head, an air relief valve, a check valve, a bypass line with valve and a flow meter. A typical well site is shown on Figure 1-4. During start-up, the valve on the bypass line opens and the discharge flows onto the ground on a timed basis. The purpose of this start-up procedure is to minimize the head on the pump and motor during start-up and to minimize the discharge of excessive sediment (turbidity) into the distribution system. After a pre-set time, the bypass line valve closes and the well discharge enters the distribution system. The automatic feature of the bypass valve is not operational, so well pumps are started and controlled manually. Since the well pumps are started and stopped manually by the operators, it is not essential at this time that the bypass valve operates on a timer or any other automatic control. When Supervisory Control & Data Acquisition (SCADA) is upgraded and the well pumps are started and stopped remotely or automatically, it will be necessary for the bypass valves to be controlled remotely or automatically.

Buildings on the well site are used to house the emergency generator and in most cases, chlorination facilities. The buildings are owned either by Guam Power Authority (GPA), GWA, or others, depending on generator ownership. Table 1-3 also shows generator ownership for each well. Recently, GWA has begun contracting with GPA for generator maintenance. GWA provides the parts and GWA provides the labor. Electrical issues associated with power and the emergency generators are discussed in more detail in Volume 1, Chapter 12 – Electrical Assessment.

Most well sites are equipped with chlorination facilities in order to meet the requirements of the Safe Drinking Water Act (SDWA) and its amendments. Except for three wells (A-8, F-8 and NAS-01) that have granular activated carbon for organic contaminant removal, chlorination is the sole means of treatment for the Northern System drinking water. Table 1-3 also shows the type of treatment, if provided, at each well site.

Table 1-3 – GWA Wells

Name	Municipality	EPA Permitted Rate, gpm	30-Day Average Rate, gpm[1]	Emergency Generator Owner	Treatment[2,3,4]	Comments
Northern System						
A-01	Chalan Pago-Ordot	216	264	GPA	Chlorination/S	Active
A-02	Chalan Pago-Ordot	241	240	GPA	Chlorination/S	Active
A-03	Chalan Pago-Ordot	180	265	GPA	Chlorination/A	Active
A-04	Chalan Pago-Ordot	244	310	GPA	Chlorination/S	Active
A-05	Sinajana	269	253	GPA	Chlorination/A[4]	Active
A-06	Sinajana	241	315	GPA	Chlorination/A	Active
A-07	Chalan Pago-Ordot	113	0	GPA	None	Inactive
A-08	Chalan Pago-Ordot	206	253	GPA	Chlorination/S/ GAC	Active
A-09	Mangilao	230	318	GPA	Chlorination/A	Active
A-10	Mangilao	233	310	GPA	Chlorination/A	Active
A-12	Chalan Pago-Ordot	235	177	GPA	Chlorination/A	Active
A-13	Mangilao	237	313	GPA	Chlorination/A	Active
A-14	Mangilao	147	301	GPA	Chlorination/S	Active
A-15	Barrigada	231	318	GPA	Chlorination/A	Active
A-17	Mangilao	180	292	GPA	Chlorination/A	Active
A-18	Mangilao	229	304	GPA	Chlorination/A	Active
A-19	Mangilao	138	206	GPA	Chlorination/S	Active
A-21	Mangilao	213	294	GPA	Chlorination/A	Active
A-23	Agana	317	344	GPA	Chlorination/A	Active
A-25	Agana	245	347	GPA	Chlorination/A	Active
A-26	Mongmong-Toto-Maite	50	71	GPA	Chlorination/S	Active
A-28	Barrigada	223	0	GPA	None	Inactive
A-29	Sinajana	403	0	GPA	None	Secured
A-30	Sinajana	755	788	GWA	Chlorination/A	Active
A-31	Agana Heights	293	350	GPA	Chlorination/A	Active
A-32	Agana Heights	173	240	GPA	Chlorination/A	Active
AG-01	Yigo	173	0	GPA	None	Secured
AG-02	Yigo	480	600	GWA	Chlorination/A	Active
D-01	Dededo	257	114	None	Chlorination/S	Active
D-02	Dededo	187	216	GPA	Chlorination/S	Active
D-03	Dededo	149	0	GPA	None	Inactive
D-04	Dededo	172	285	GPA	Chlorination/S	Active

Table 1-3 – GWA Wells (continued)

Name	Municipality	EPA Permitted Rate, gpm	30-day Average Rate, gpm[1]	Emergency Generator Owner	Treatment[2,3,4]	Comments
D-05	Dededo	166	155	GPA	Chlorination/S	Active
D-06	Dededo	189	235	GPA	Chlorination/S	Active
D-07	Dededo	198	229	GPA	Chlorination/S	Active
D-08	Dededo	185	195	GPA	Chlorination/S	Active
D-09	Dededo	196	257	GPA	Chlorination/S	Active
D-10	Dededo	351	252	GPA	Chlorination/S	Active
D-11	Dededo	226	249	GPA	Chlorination/S	Active
D-12	Dededo	188	208	GPA	Chlorination/S	Active
D-13	Dededo	200	196	GPA	Chlorination/S	Active
D-14	Dededo	200	269	GPA	Chlorination/S	Active
D-15	Dededo	202	242	GPA	Chlorination/S	Active
D-16	Dededo	161	235	GPA	Chlorination/S	Active
D-17	Dededo	161	0	GPA	None	Inactive
D-18	Dededo	180	0	None	None	Inactive
D-19	Dededo	227	205	GPA	Chlorination/S	Active
D-20	Dededo	207	227	GPA	Chlorination/S	Active
D-21	Dededo	157	238	GPA	Chlorination/S	Active
D-22	Dededo	200	-- [5]	GPA	None	Secured
D-24	Dededo	180	0	GPA	None	Inactive
D-25	Dededo	400	339	GWA	Chlorination/S	Active - Former Earth Tech Well
D-26	Dededo	250	0	GWA	Chlorination	Inactive - Former Earth Tech Well
D-27	Dededo	400	320	GWA	Chlorination/S	Active - Former Earth Tech Well
D-28	Dededo	200	No Data	GWA	Chlorination/S	Active - Former Earth Tech Well
EX-05A	Dededo	254	410	GPA	Chlorination/S	Active
EX-11	Barrigada	210	221	GPA	Chlorination/S	Active
F-01	Dededo	140	144	GPA	Chlorination/S	Active
F-02	Dededo	121	154	GPA	Chlorination/S	Active
F-03	Dededo	142	157	GPA	Chlorination/S	Active
F-04	Dededo	137	142	GPA	Chlorination/S	Active
F-05	Dededo	145	200	GPA	Chlorination/S	Inactive
F-06	Dededo	151	220	GPA	Chlorination/S	Active
F-07	Dededo	170	-- [5]	GPA	Chlorination/S	Active

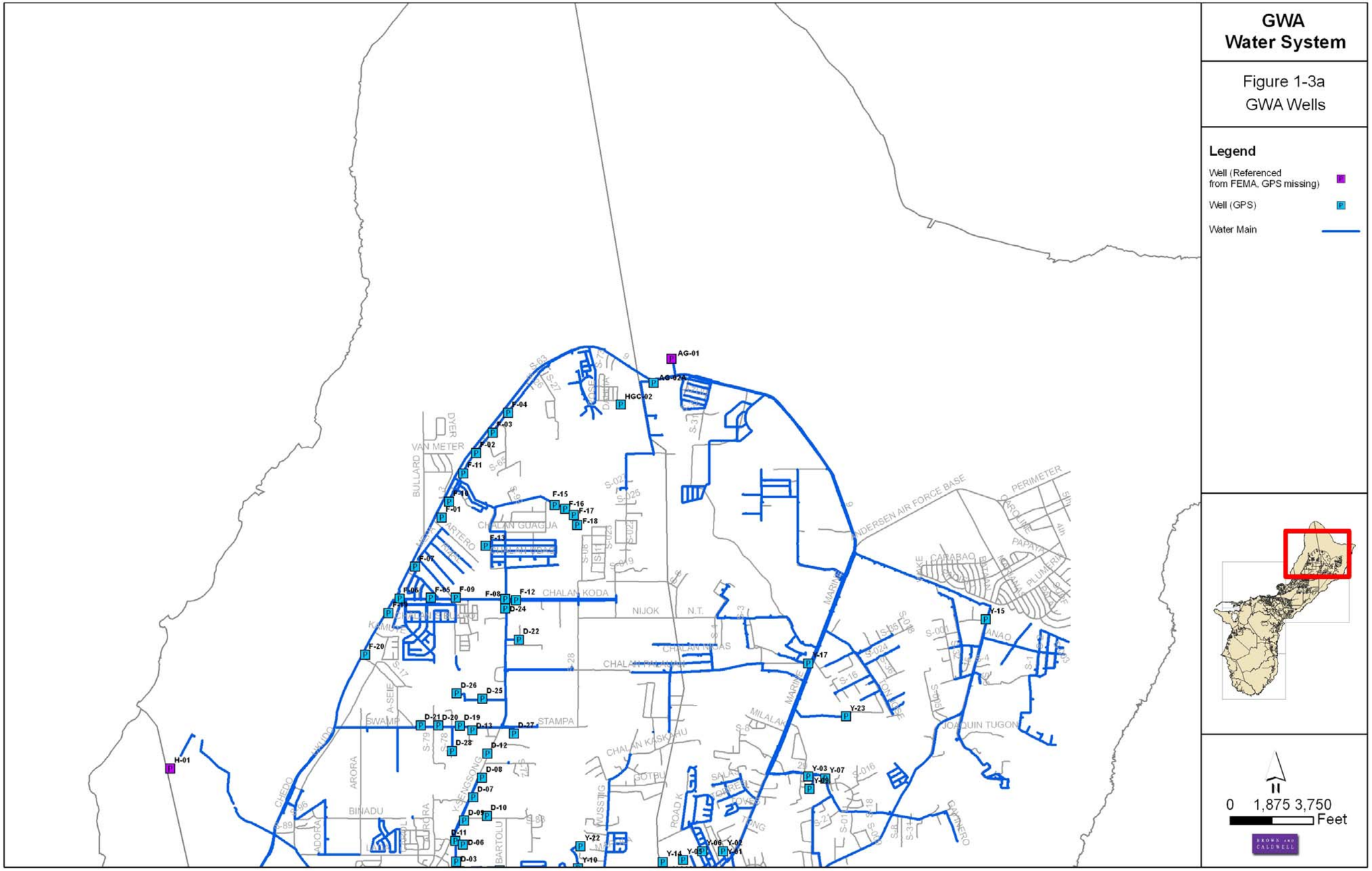
Table 1-3 – GWA Wells (continued)

Name	Municipality	EPA Permitted Rate, gpm	30-day Average Rate, gpm[1]	Emergency Generator Owner	Treatment[2,3,4]	Comments
F-08	Dededo	149	199	GPA	Chlorination/ A3/GAC	Secured
F-09	Dededo	140	199	GPA	Chlorination/S	Active
F-10	Dededo	142	204	GPA	Chlorination/A	Active
F-11	Dededo	142	189	GPA	Chlorination/A	Active
F-12	Dededo	148	160	GPA	Chlorination/S	Active
F-13	Dededo	380	-- [5]	GWA	Chlorination/S	Active
F-15	Dededo	440	238	GWA	Chlorination/A	Active
F-16	Dededo	230	340	GWA	Chlorination/A	Active
F-17	Dededo	240	239	GWA	Chlorination/A	Active
F-18	Dededo	240	352	GWA	Chlorination/S	Active
F-19	Dededo	200	219	GWA	Chlorination/S	Active - Former Earth Tech Well
F-20	Dededo	200	254	GWA	Chlorination/S	Active - Former Earth Tech Well
G-501	Dededo	183	133	GPA	Chlorination/S	Active
H-01	Tumon	288	286	GPA	Chlorination/S	Active
HGC-02	Dededo	444	582	None	Chlorination/S	Active
M-01	Barrigada	109	244	GPA	Chlorination/S	Active
M-02	Barrigada	184	209	GPA	Chlorination/S	Active
M-03	Barrigada	177	225	GPA	Chlorination/S	Active
M-04	Barrigada	138	216	GPA	Chlorination/A	Active
M-05	Barrigada	176	225	GPA	Chlorination/S	Active
M-06	Barrigada	168	229	GPA	Chlorination/S	Active
M-07	Dededo	175	242	GPA	Chlorination/S	Active
M-08	Barrigada	158	237	GPA	Chlorination/A	Active
M-09	Barrigada	162	148	GPA	Chlorination/S	Active
M-12	Dededo	104	0	GPA	None	Inactive
M-14	Dededo	239	0	GPA	None	Secured
M-15	Dededo	172	253	GPA	Chlorination/S	Active
M-17A	Barrigada	202	0	GPA	None	Inactive
M-17B	Barrigada	153	316	GPA	Chlorination/S	Active
M-18	Barrigada	325	291	GPA	Chlorination/S	Active
M-20A	Barrigada	400	228	GPA	Chlorination/S	Active
M-21	Airport Road DW	250	343	GIAA[6]	Chlorination/S	Active

Table 1-3 – GWA Wells (continued)

Name	Municipality	EPA Permitted Rate, gpm	30-day Average Rate, gpm[1]	Emergency Generator Owner	Treatment[2,3,4]	Comments
M-23	Barrigada	225	257	None	Chlorination/S	Active
NAS-01	Tiyan	200	0	None	Chlorination/S/ GAC	Secured
Y-01	Yigo	141	240	GPA	Chlorination/A	Active
Y-02	Yigo	161	238	GPA	Chlorination/A	Active
Y-03	Yigo	138	221	GPA	Chlorination/A	Active
Y-04	Yigo	220	240	GPA	Chlorination/S	Active
Y-05	Yigo	148	157	GPA	Chlorination/A	Active
Y-06	Yigo	136	240	GPA	Chlorination/A	Active
Y-07	Yigo	514	0	GPA	None	Inactive
Y-09	Yigo	472	599	GPA	Chlorination/A	Active
Y-10	Yigo	250	274	GWA	Chlorination/S	Active
Y-12	Yigo	235	312	GWA	Chlorination/S	Active
Y-14	Yigo	400	0	GWA (Vandalized)	None	Inactive
Y-15	Yigo	600	520	GWA	Chlorination/A	Active
Y-16	Yigo	250	319	GWA	Chlorination/S	Active
Y-17	Yigo	350	320	GWA	Chlorination/S	Active
Y-18	Yigo	250	484	GWA	Chlorination/S	Active - Former Earth Tech Well
Y-19	Yigo	500	404	GWA	Chlorination/S	Active - Former Earth Tech Well
Y-20	Dededo	500	379	GWA	Chlorination/S	Active - Former Earth Tech Well
Y-21	Yigo	350	251	GWA	Chlorination/S	Active
Y-22	Dededo	300	296	GWA	Chlorination/S	Active - Former Earth Tech Well
Y-23	Yigo	380	318	GWA	Chlorination/A	Active
Central System						
None	--	--	--	--	--	--
Southern System						
MJ-01	Malojloj	56	0	GPA	None	Secured
MJ-05	Malojloj	58	0	None	None	Secured

1. Data from July 2006, Deepwell Production Report
2. Treatment consists of chlorination, granular activated carbon (GAC), or none.
3. A = automatic switchover chlorination systems; S = single chlorine tank systems.
4. Chlorination is by direct injection due to insufficient contact time before the first residence.
5. Defective water meter
6. Guam International Airport Authority (GIAA)


GWA
Water System
Figure 1-3a
GWA Wells
Legend
Well (Referenced from FEMA, GPS missing)
Well (GPS)
Water Main
AG-01
AG-02A
HGC 02
F-04
F-03
F-02
F-11
F-14
F-01
F-15
F-16
F-17
F-18
F-13
F-07
F-06
F-05
F-09
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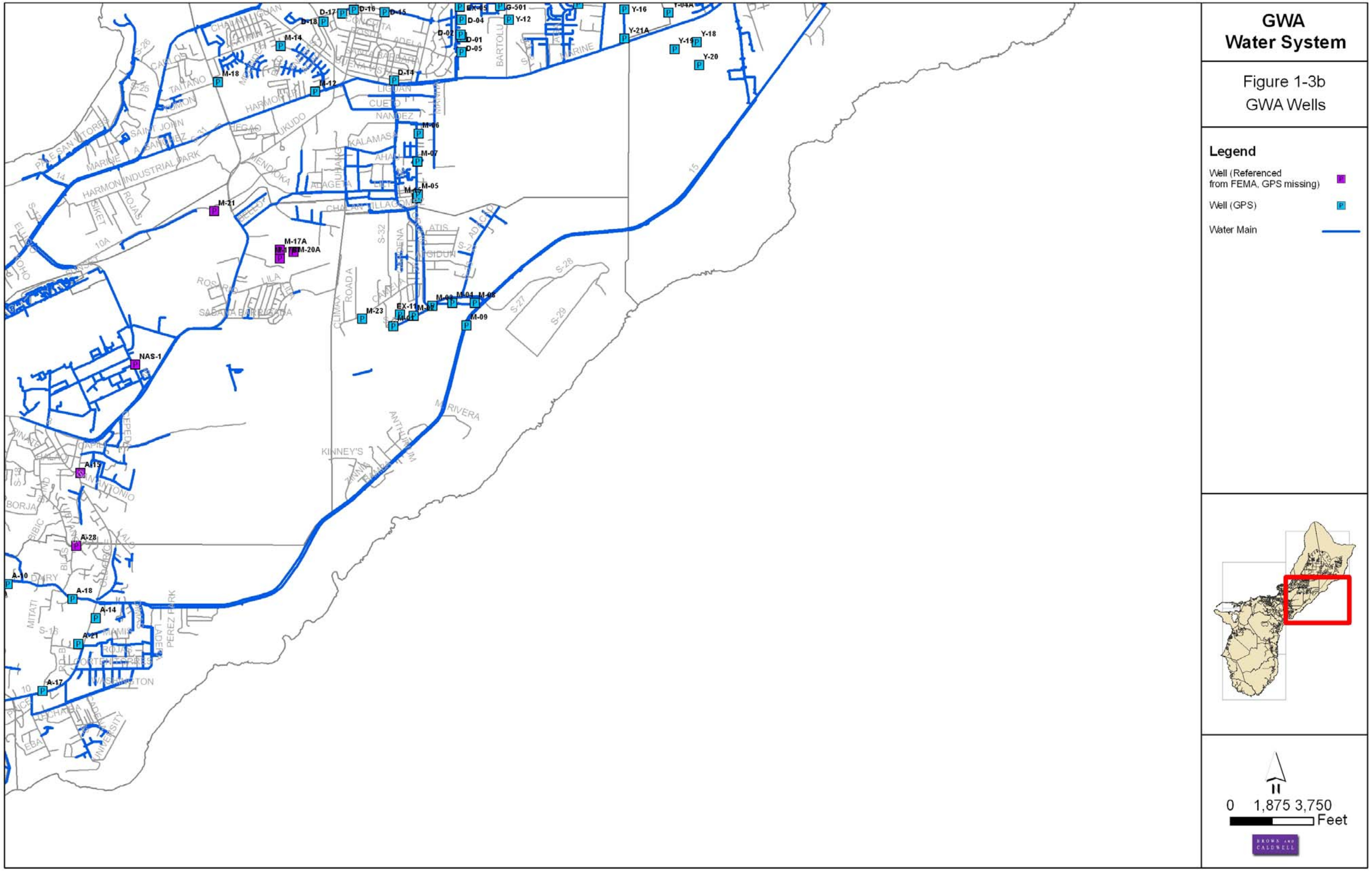
D-28
D-12
D-08
D-07
D-10
D-09
D-11
D-06
D-03
H-01
Y-22
Y-10
Y-14
Y-06
Y-02
Y-01
Y-03
Y-07
Y-17
Y-15
Y-23
CHALAN GUAGUA
CHALAN KODA
NIJOK
N.T.
CHALAN MEAS
CHALAN KASKASHU
STAMPA
SWAMP
BINADU
BOTBU
MILALAK
ANDERSEN AIR FORCE BASE
PERIMETER
CARABAO
PAPAYA
PLUMERIA
JOAQUIN TUGONO
VAN METER
BULLARD
ARTERO
CHEDO
ARORA
BARTOLU
RUSSING
ROAD K
0 1,875 3,750
Feet
BROWN AND CALDWELL


GWA
Water System
Figure 1-3b
GWA Wells
Legend
Well (Referenced from FEMA, GPS missing)
Well (GPS)
Water Main
0 1,875 3,750
Feet

GWA Water System

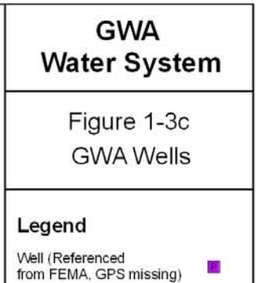
Figure 1-3c
GWA Wells

Legend

Well (Referenced from FEMA, GPS missing)

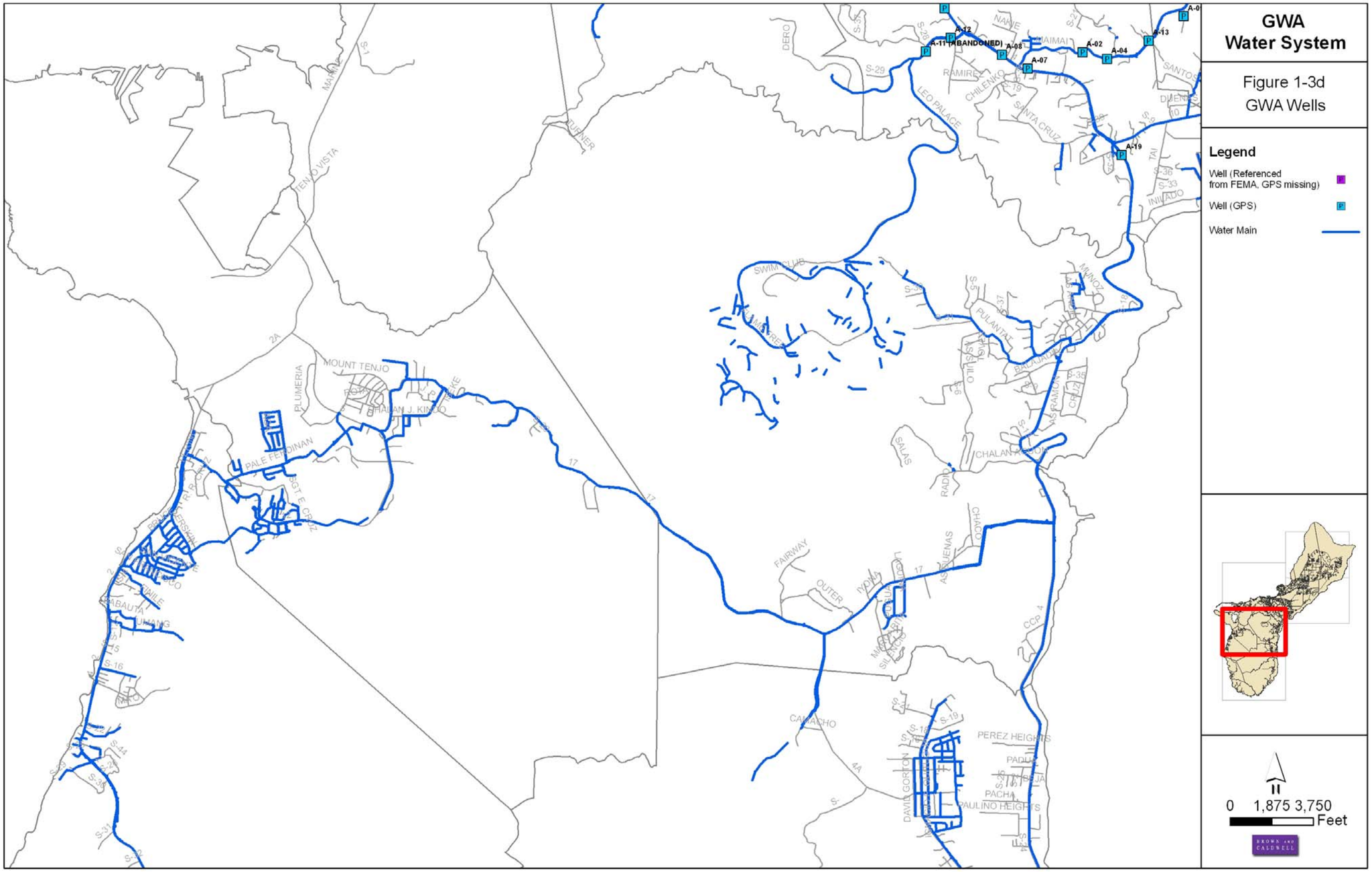
Well (GPS)

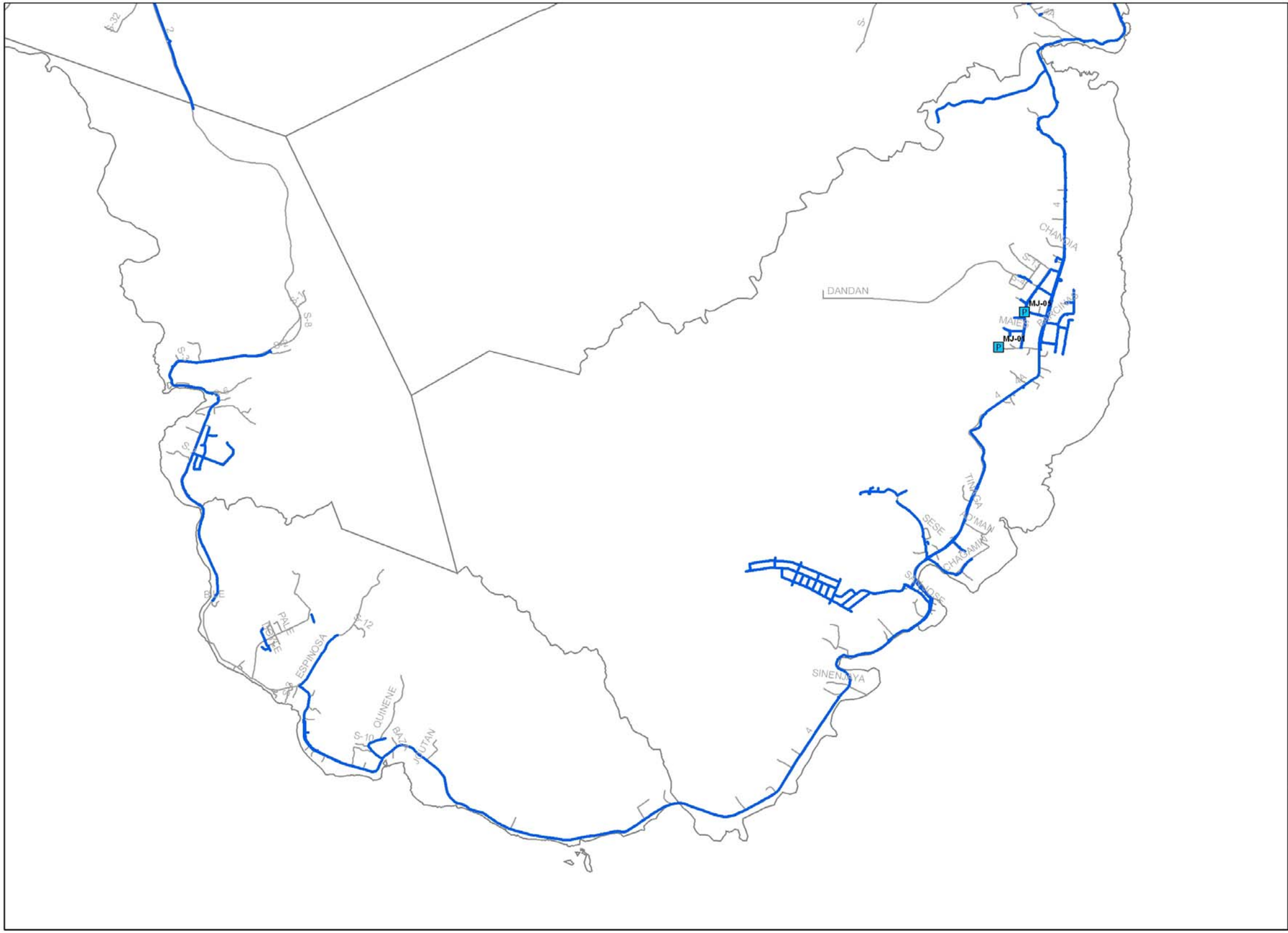
Water Main



0 1,875 3,750 Feet

BROWN AND CALDWELL


GWA
Water System
Figure 1-3d
GWA Wells
Legend
Well (Referenced from FEMA, GPS missing)
Well (GPS)
Water Main
A-12
A-11 (ABANDONED)
A-08
A-07
A-02
A-04
A-13
A-19
MOUNT TENJO
PALE FERDINAN
MARBELLA
TENJO VISTA
PLUMERIA
SWIM CLUB
PULANTAL
BALKARAN
CHALAN GUAM
SALAS
FAIRWAY
OUTER
CAMACHO
PEREZ HEIGHTS
PADUA
PACHA
PAULINO HEIGHTS
0 1,875 3,750
Feet
BROWN AND CALDWELL



GWA Water System

Figure 1-3e
GWA Wells

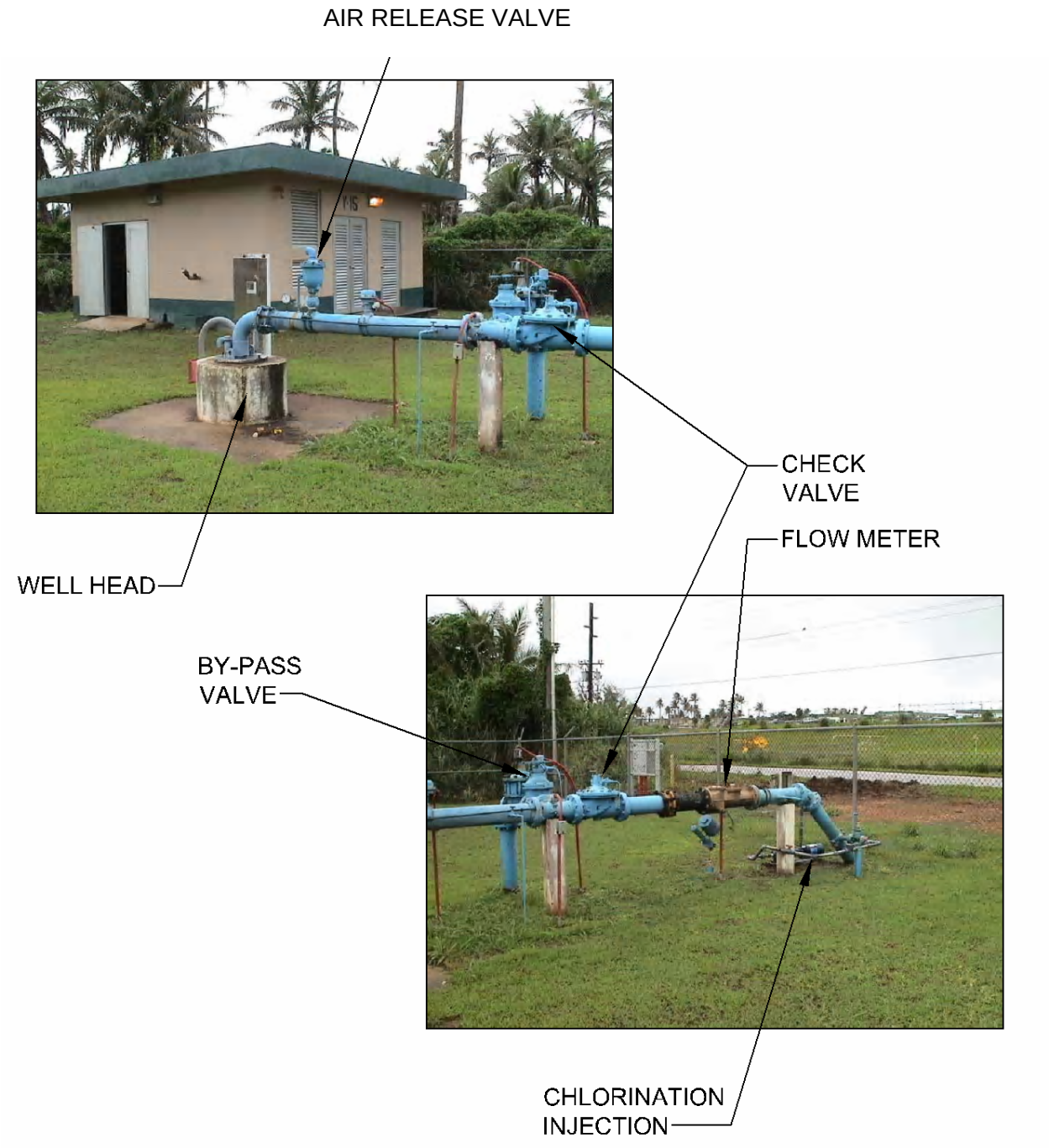
Legend

- Well (Referenced from FEMA, GPS missing)
- Well (GPS)
- Water Main

0 1,875 3,750 Feet

BROWN AND CALDWELL

Figure 1-4 – Typical Well Site



The chlorination system typically includes a chlorine scale for two 150-pound gas cylinders, a cylinder-mounted 0 to 25 pound per day chlorinator and an injection pump. The injection pump creates a vacuum to draw chlorine gas through the chlorinator and mix the gas into a chlorine solution for disinfection. The chlorine feed is adjusted manually by the operator. There is no flow-paced or chlorine residual control.

Operationally GWA targets a chlorine residual of 2.0 mg/L at each wells site but this can vary depending on the distance to the first customer. GWA targets a minimum concentration-time (CT) value of 2.0 at the first customer and a minimum of 0.2 mg/L of chlorine residual at all points in the system.

Thirty-three of the chlorination systems have two cylinders stored on site and are equipped for automatic switchover. The remaining systems have only one cylinder. Three well sites, D-12, M-8 and M-12, use direct injection of chlorine rather than a pump. Chlorine cylinders have been removed from those sites that are out-of-service. In the case where chlorine leak detection systems are located at facilities, they are typically inoperable. Figure 1-5 shows a typical indoor chlorination system installation at a well site. Though most systems are located indoors, some are located outdoors as shown on Figure 1-6.

Figure 1-5 – Typical Indoor Well Chlorination System Installation

Figure 1-6 – Typical Outdoor Well Chlorination System Installation

The records for chloride levels in the wells were reviewed for the 10-year period from 1996 thru 2005 to identify wells that had chloride levels exceeding 250 milligrams per liter (mg/l), or the maximum contaminant level (MCL) for potable water quality based upon the Secondary Drinking Water Regulations. Due to the volume of data, the chloride level readings for 1996 thru 2000 are provide in Tables 1-4a and 1-4b and the readings for 2001 thru 2005 are provided in Tables 1-5a and 1-5b. The chloride levels provided is a single reading within a three-month period or quarter of the year and the levels exceeding 250 mg/l are highlighted in red. A few of the wells (i.e., A-9, A-30 and D-9) have just a single quarter over the past 10 years with the chloride levels exceeding 250 mg/l, while other wells (i.e., A-10, 13, 14, 17, 18, 19, 21 and 28; and D-8, 13 and 17) have multiple chloride levels exceeding 250 mg/l. The pumping rate for the wells with chronic values that exceed the MCL for chlorides should be reevaluated to see if a lowering of the pumping rate can achieve a chloride level that is consistently below 250 mg/L.

1.2.2 Springs

There are five springs that are serving or have served as sources in the Southern System. All springs except Asan and Santa Rita Springs are located in the Central System. All other springs are located in the Southern System. Only Santa Rita Spring is currently providing potable water. A list of the springs is provided in Table 1-6. The location of GWA springs is shown on Figure 1-7.

Table 1-4a - Chloride Levels in GWA Wells, 1996 thru 2000

WELL NO.	1996				1997				1998				1999				2000			
	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
A-1	18	22	18	34	16		18	22	18	20	32		26	35	18	20	25	20	13	25
A-2	20	28	16	30	26		26	22	26	26	28		26	35	27	20	25	25	50	37
A-3	20	22	18	14	20		16	14	20	18	20		18	40	15	15	20	25	23	24
A-4	48	60	44	56	46		50	40	40	48	48		52	70	36	50	60	42	66	56
A-5	22	24	26	22	18		22	18	22	22	26		24	30		25	25	25	31	26
A-6	30	32	20	34	20		28	18	22	28	34		34	65		35	45	45	52	43
A-7	28	30	22	28	26		24	20	24	24	26		24	60		25	30	25	31	29
A-8	22	24	20	18	16		18	14	24	22	24									31
A-9	198	190	146	198	178		186	162	202	196	194			169		164	184	164	189	171
A-10	324	330	246	302	256		322	222	248	324	342		316	344	204	279	324	289	308	173
A-12	16	22	22	22	18		20	22	22	20	30		22	40	21	25	30	35	32	148
A-13	464	436	316	504	418		404	378	586	416			406	234	318	470	453	329	220	273
A-14	340	314	324	320	314		328	254	274	266	284		294	164	174		284		159	163
A-15	164	150	148	166	92		164	118	128	148	164		154	90	99	139	149	164	172	
A-17	512	470	472	370	436		456	322	270	298	326		306	189		314	384	369	448	459
A-18	450	422	420		400		406	278	326	340	374		378	204	234		354	344	466	
A-19	382	348	388		320			284	302	342			312	154	198		274	259	451	437
A-21	436	416	264	448	430		410	338	258	290	302		306	339	201	400	359	349	454	356
A-23	28	28	38	30	30		28	26	28	78	54		52	70	45	70	50	55	66	45
A-25	52	52	78	52	32		52	22	26	54	84		92	110	78	110	70	65	68	75
A-26	78	82	62	88	70		78	230	174	68	78		76	80	78	80	90	80	92	107
A-28	172	168	168	184	184		148	22	28	144	160		154	349	84	349	139	130	180	146
A-29	50	58	72	38	28		78	22	40	72	98		90	90	66	90	70	60	93	61
A-30	78	154	120	54	70		300	96	32	170	162		108	110	63	110	95	85	135	78
A-31	32	38	30	30	34		30	30	28	26	36		36	40	30	40	40	45	41	43
A-32	26	26	22	22	24		22	22	26	20	26		28	30	24	30	35	35	32	35
AG-1	54	54	18	60			46	52		54	46	48	44	50	27	45			50	50
AG-2A	20	40	24	24			18												20	50
D-1	70	70	68	70	64		66	62	70	72	74	68	62	75	48	65	70	70	45	75
D-2	68	72	64	72	64		60	62	68	68		62	68	85	45	65	60	75	56	
D-3	36	42	50	36	46		36	34	36	38	30	36	32	50	27	35	35	35	35	50
D-4	44	42	44	42	42		42	40	42		44	40	44	70	33	45	50	60	40	55
D-5	84	64	44	60	56		56	56	58	58	56	54	56	75	42	55	60	55	55	78
D-6	58	64	54	60	58		54	56	60	64	66	64	66	100	39		65	55	60	65
D-7	64	54	88	66	60		50	66	64	56	54	54	48	40	39	55	60	65	234	75
D-8	276	260	194	266	238		222	198	244	230	202	198	180	374	117	169	204	259	55	264
D-9	170	170	228	176	196		180	154	154		136	134	124	289	90	159	169		110	140
D-10	46	40		52	46		40	36	50	42	40	36	38	30	27	50	45	45	40	43
D-11		80	214	72	78		74	62	110	130	134	134	144	159	81	90	100	100	90	100
D-12	20	18	172	30	22		16	18	24	20	22	16	26	30	48	20	35	30	35	30
D-13	396	449	326	510	322		334	266	188	172	212	380	286	284	135	390	364	159		379
D-14	80	82	118	86	32		62	60	58	58	60	94	62	65	45	55	70	80	60	85
D-15	118	112	86	116	110		114	112	96	86	88	90	78	95	51		90	95		
D-16	102	104	96	114	92		86	94	78	84	92	92	100	100	54	70	85	80	80	107
D-17	264	250	22	228	244		280	256	248	244	242	242	130	274	138		105	130	154	139
D-18	118	110	122	92	106		92	84	66	78	88	88	204	95	60	90	100	65		
D-19	74	68	118	70	64		58	52	56	54	56	54	64	85	39	70	70	60	60	70
D-20	66	60	64	70	60		54	52	54	50	52	52	56	75	48	70	80	70	70	85
D-21	62	78	80	90	88		80	88	94	84	82	80	76	80	57	65	75	65	65	90
D-22			106	32	20		14	16	16	18	16		26	60						
D-24	52	56	62	64	38		40	28	34	28	28	28	32	65	42	55	60	60	45	85
D-25																				
D-26																				
D-27																				
D-28																				
EX-5A	38	48	46	38			44	40	40	40	38		44	54	42	50	55	50	45	55
EX-11	38	40	36	42	40		40	40	42	46	48		62	105			35	35	55	50

Table 1-4b - Chloride Levels in GWA Wells, 1996 thru 2000

WELL NO.	1996				1997				1998				1999				2000			
	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
F-1	164	160	166	140	128	104			84		76	86	99	90	84	135	144	144	140	143
F-2	126	124	92	124	128	128		118	132	122	122	116	122	125	78	120	130	135		128
F-3	110	106	108	104	132	126			148	124	104	86	76	90	54	90	100	115	90	115
F-4	258	260	70	268	260	230		222	148	174			114	159	120		120	135	170	184
F-5	126	122	130	128	110		106	90	78	84	80	82	92	110	66	115	130	135	140	168
F-6	316	326	364	320	296		258	234	166	148	138	146	174	194						
F-7	100	106	112	108			100	92	80	82	80	106		84	60	80	90	100	90	108
F-8	28	24	20	28				24	22		24			40	30	35	40	70	45	49
F-9	62	72	74	68			52	52	48	52	54	60	166	70	39	75	100	95	100	
F-10	282		122	300			300	264	218		156	172	66	209	174	204	219	70		268
F-11	182	174	110	170			150	142	132	116	104		186	125	102	139	154	154	150	186
F-12	20	18	30	28			18	20	24	12	22	22	124	35	36	25	35	35	40	57
F-13	340			332			212	176	146		142	150	22	144		174	209	269	219	286
F-15	44	46	54	32		86	86	60	62	40	40	22	156	45	30	30	30	45	30	33
F-16		18	20	14			10	16	26	20	40	20	24	30	21	25	25	20		
F-17		18	20	18	16		16	22	20	18	16	18	18		21		20	35	20	25
F-18		16	16	14					18	16	20	18	16	30	24	10	25	25	25	26
F-19																				
F-20																				
GH-501	102	90	104	96	92		90	90	94		84	86	82	90	54	95	115	120	123	112
H-1	138		136	146			146		148	162	150	150	156	55	96	135	149	139	167	172
HGC-2	22	20	18	26			18	20	18	16	18	24	24	35	21	30	35	25	23	24
M-1	150	134	194	196	204		200	198	216	192	176	176	156	130	93	130	125	120	130	116
M-2	132	124	134	124	116		106	96	88	90	90	92	98	130	63	95	110	110	139	143
M-3	30	32	32	32	24		26	24	30	28	28	28	28	45	18	35	30	30	44	46
M-4	22	26	30	32	28		20	26	24	24	28	28	26	40	27	35	45	30	32	40
M-5	68	74	80	66	66		56	48	46	44	46	46	54	65	33	60	60	55	54	72
M-6	144	154	184	136	94		86	62	52	50	52	52	60	85	45	80	95	120	99	163
M-7	46	48	50	46	48		42	36	38	38	38	38	36	60	24	40	45	35	35	
M-8	24	30	28	26	20		22	22	24	24		24	28	40	24	25	30	30	30	
M-9	198	206	190		250		198	204	196	190	110	130	136	149	81	115	95		144	
M-12	126	128	124	102	30		76	80	60	74										
M-14	40	40	48	30	30		50	20	28	64	68	74		100	42	50	50	50	41	49
M-15	68	74	148	74	60		42	38	28	26	32	34	40	55	33	55	60	65	90	84
M-17A	76	84	84	90			116	76	116	50		56	58	70	48	70	70	70	82	87
M-17B	88	74	74	78	70		66	64	62	48	50	50		60	45	55	75	65	58	81
M-18							46	40	56	60	58	62	62	85	42	55	65		74	64
M-20A				96	92		80	86	72	58	56	50	50	60	45	70	75	65	70	
M-21												74			45				90	
M-23																				144
NAS-1										54	58	62	60	70	51	70	95	80	110	100
Y-1	22	20	32	26	22		22	22	26	22	24	26	24	25	18	25	25	15	25	23
Y-2	24	24	32	30	26		22	26	28	22	22	26	26	30	18	30	30	25	35	30
Y-3	20	24	20	24	44		16	20	24	26	24	24	22	30	21	35	45	25	30	30
Y-4A	24	26	26	30	46		24	30	30	26	26	28	24	35	21	40	40	30	30	32
Y-5	26	58	62	64	62		56	22	56	48	40	46	40	55	33	50	50	55	59	60
Y-6	56	18	38	26	16		22	22	24	16	22	26	20	30	12	25	30	25	29	33
Y-7	20	26	32	28	20		18	22	24	24	24	24	22	30	18	30	35	25	35	25
Y-9	18	22	18	24	22		20		24		22	26	24	35	18	30	30	25	28	29
Y-10								34	34	40	36	36	34	50	27		45	33		
Y-12		58		64	24		52	60	64	42	54	56	56	62	33	55	55	50	57	56
Y-14										32	50	50								
Y-15	20	26	54	28	24		6		20	18	22	24	24	25	15	25	25	20	25	28
Y-16																				
Y-17																				
Y-18																				
Y-19																				
Y-20																				
Y-21																				
Y-22																				
Y-23																				
MJ-1		18	42	48			38												45	
MJ-5																				

Table 1-5a - Chloride Levels in GWA Wells, 2001 thru 2005

WELL NO.	2001				2002				2003				2004				2005			
	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
A-1	18	7	24	68	25	30			32	29	28	33	17	32	24	30	43	17	27	18
A-2	39	26	30	60	31	43		28	42	42	42	35	33	31	34	49	41	37	84	41
A-3	27	26	33	48	21	29		25	29				27	25	26	30	33	31	30	62
A-4	72	68	95	83	75	100		78	74	79	78	59	67	73	68	63	71	53	41	71
A-5	31	35	41	48	26	35		44	33	49	36	31	33	46	32	41	36	41	35	47
A-6	45	25	59	47	37	43		46	41	61	45	27	37	71	41	51	41	42	29	62
A-7	35	31	38	32	23	40		52												
A-8	235	28	36	31	28	33		27	26	41	54	41	30	43	30		32	40	53	61
A-9				158	171	174		199	199	213	199	193	143	279	239	182	184	206	226	179
A-10	264	296	358	272	298	331		190	326	380	411	348	301	452	331	271	177	276	384	325
A-12	33	23	35	36	31	32		27	31	50	33	36	40	43	26	40	41	40	43	43
A-13	173	137	171	198	238	257		259	413	417	447	454	436		470	418	425	389	442	199
A-14	307	304	290	279	284	277		254	304	377	366	361	349	351	331	307	290	301	344	278
A-15	150	172	204	157	156	152		135	138			105	124	152	133	108	121	139	149	151
A-17	570	511	615	425	431	419		351	307	355	330	249	368	390	327	311	285	288	339	351
A-18	349	363		311	362	391		319	294	335	346	339	314	363	372	264	261	307	309	350
A-19	457	453	493	492	362	464		457	415	456	443	426	359	381	312	305	298	322	369	384
A-21	411	405	497	497	384	454		421	383	444	413	339	392	400	332	289	281	298	264	309
A-23	56	65	92	55	57	51		43	44	73	64	41	35	49	41	52	47	65	86	71
A-25	83	82	127	87	72	88		44	53	61	74	51	56	69	51	46	48	51	56	72
A-26	114	110	139	137	118	123		103	103	111	100	90	104							
A-28	164	138	166	181	166	181		206	178	178	177	182	191	176	220	223	194	180	132	200
A-29														98	30	12	51	84	131	
A-30	88	82	106	72	43	73		33	55	58	62	30	38	188	73	40	64	137	169	60
A-31	42	45	46	55	42	52		43	54	60	62	46	44	51	53	55	65	56	61	57
A-32	37	29			37	47		32	45									58		
AG-1	65	50			26	60		58				54	70	70	70		69	60	65	53
AG-2A	29	20	23	34				45	34	37	28	33	35	35	33	23	43	42	48	41
D-1	70	77	67	61	72	77		71	68	88	85	65	74	54	52	78	56	58	78	90
D-2		55	63	69	76			66	77	110	85	66	67	69	69	61	72	30	85	93
D-3	52	54	50	42	59	47		37												
D-4	55	51	51	52	56	59		49	56	86	62	46	69	64				53	74	60
D-5	73	68	64	69	75	70		63	67	90	70	66	76	73	58	61	63	72	85	93
D-6		55	66	56	67	60		52	66	87	75	61	72	71	70				70	85
D-7	83	94	85	80	76	85		64	65	90	72	53	79	65	80	89		80	80	85
D-8	238	301	326	345	376	321		183	492	506	532	516	414	358	394			103	141	222
D-9	152	196	178	187	177	196				202	209	203	189	185	149	218	170	147	168	162
D-10	62	71	52	49	57	56		56	59	66	67	58	56	62	57	67	63	63	62	74
D-11	105	112				69		57				34	72	93	79	61	81	109	120	107
D-12	28	54	43	33	34	28		36	29			29	34	29		22	26	49	32	37
D-13	86	917	884	884				659	529	415	435	487	736	526	351	253	191	181	399	290
D-14	86	60	79	79	71	63		78	78	94	94	135	98	97	85	80	75	109	66	85
D-15						96		99	100	124	122	139	129	120	112	88	86	73	90	93
D-16	93	108	100	108	101	106		101	82	91	89	97	104	85	84			86	95	95
D-17	192	205	213	188	195	191														
D-18																				
D-19	87	91	98	85	76	74		73	74	90	75	69	84	73	67	72	66	65	80	72
D-20	90	87	95	88	90	98		79	83	91	81	92	78	84	72	67	61	72	84	95
D-21	93	94	81	88	90	94		92	129	102	92	99		100	102	116	108	108	106	107
D-22					219	31						34	30	34	38	34	30	45	32	52
D-24	87	88	98	85	86	74		68												
D-25													48	51	35	24	48	51	35	24
D-26													141	176	196	162	141	176	196	162
D-27													19	16	27	20	19	16	27	20
D-28													46	60	53	58	46	60	53	58
EX-5A	54	65	59	54	67	64		58	60	70	61	48	59	56	51	42	42	60	61	63
EX-11	45	41	49	48	45	56		51	53	69	70	93	80	76	93	76	72	66	74	66

Table 1-5b - Chloride Levels in GWA Wells, 2001 thru 2005

WELL NO.	2001				2002				2003				2004				2005			
	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
F-1	172	164	179	181	143	172		140	110	139	110	116	112	113			58	85	112	104
F-2	146	146	153	238	130			46	161	179	145	92	155	161	124	137	151	127	137	159
F-3	123	117	113	137		107			171	175	143	112	146	138	128	131	128	110	104	112
F-4	225	216		182		138		183	136	128	119	159	206	209	193	171	135	118	123	
F-5	191	171	189	197	179	160		135	127	128	126	196	111	112	88	95	92			96
F-6		490	564	605	531	515				302	303	283	300	268	265	226	186	167	170	182
F-7	123	132	127	162	138	136		139	130	105	124	178	132	120		93	86	91	106	95
F-8	56	55	64	79	49	55		43	41	53	34	60								
F-9	122	123	130	117	117	111		93	109	79		92	93	92	91	72	68	77	80	76
F-10	307	321	343	364	345	383		379	364	329	318	298	113	113			195	176		162
F-11	199	212	229	154	201	244		219	199	188	159	161	159	134	140		132	112	130	120
F-12	273	51	40	40					37	41	37	36	45	36	34	41	45	45	47	36
F-13	342	339	365	299	329	381		373	308	313	289	298		182	201	177	186	173	173	181
F-15	37	49	69	69	53	60		80	83	68	81	85	106	85	60	87	77	78		52
F-16	30	32	54	31	31	41		29		29	49	52	42	53	45	31	66	50	51	31
F-17	35	27		24	27	30		23		23	37	30		39	36	35	52	59	50	32
F-18		23	28	30	26	30		25	27	34	41	110	39	41	26	34	57	43		45
F-19													222	232	212	228	222	232	212	228
F-20													218	242	208	210	218	242	208	210
GH-501	137	158	148	138	140	145		119	112	123	113	106	111	102	114	109	105	106	108	111
H-1	154	167	178	186	185	190		182	167	179	186	175	187	185	185	163	175	149	172	147
HGC-2	39	23	26	24	27			26		46		30		49	35	23	48	41	52	40
M-1	137	123	150	131	133	127		156	157	181		187	149	142			187	152	186	189
M-2	153	174	191	188	188	187		185	150	171	137	121				50	69	82	83	84
M-3	37	35	53	49	41	40		38	46	78	55	48	45	41	17	40	43	57		45
M-4	39	31	43	42	32	37		30	47	61	43	49	37	40	34	43	39	35	50	34
M-5	62	58	66	67	60	63		62	60		73	56	62	57			72	57	74	62
M-6	199	199	226	198	223	248			60	107	108	71	82	39	74	69	53	60	94	74
M-7									48	70		44	47				56	38	73	49
M-8	33	31	47	38	27	35		30	30	45	42	47	43	38	39	38	48	33	55	35
M-9	158	162	171	168	156	161		66	154	170	134	166	155	152	164	138	157	151	183	191
M-12															56	71	101	127	133	112
M-14	54	63	51	38	32	45		31	40	74	81	32	46	57	38		28			
M-15	88	89	101	92	94	99		78	48	67	40	49	46	31	34	41	42	35	56	53
M-17A	87	96	101	98	98	107														
M-17B	77	77		94	88	96		87	74	92	68	65	73	76	60	57	60	29	61	55
M-18	78	82	64	76	62	85			69	96	73	57	69	71	52	49	65	54	105	57
M-20A	90	99	117	117	123	138		116	96	104	118	83	67	82	66	55	59	43	63	71
M-21		112	134	146	149	166		181	137	135	114	102	111	69	92		82	74	96	99
M-23			65	59	44	61		47	51	71	44	36	47	20	36	34	45	32	53	49
NAS-1	146			128	35	34		24		72	80	117	108							31
Y-1	31	31	33	35	32	25		33	32	43	52	35	20	31	51	23	36	40	32	23
Y-2	32	33	32	32	34	73			39	52	27	39	39	29	50	36	30	39	43	30
Y-3	34	42	27	26		28			34	44	39	33	41	38	48	44	39	51	35	
Y-4A	43	42	31	31	38	32		39												
Y-5	72	82	59	65	72	72		77	74	107	80	81	89	90	92	74	75	81	58	61
Y-6	45	34	29	30	33	29		36	33	39	39	33		53	39	52	34	46	32	39
Y-7	38	38	32	27	38	35														
Y-9	39	40	28	28	29	26		34	37	41	49	41	39	47	35	37	37	48	40	32
Y-10	41	58		52	49				63	69	63	72	60	73	59	66	79	46	64	58
Y-12	71	73	59	57	67	33		69	76	90	71	80	72	81	48	93	110	86	83	82
Y-14																				
Y-15	36	42	33	31	28	36		31	40	37	31	40	40	42	31	31	44	60	40	36
Y-16		71	42	43	42	43		40	41	50	50	61	45	52	52	58	33	62	45	49
Y-17						29		24	35	30	26	40	44	36	27		48	45	35	44
Y-18													27	24	31	25	27	24	31	25
Y-19													27	35	39	69	27	35	39	69
Y-20													21	30	31	36	21	30	31	36
Y-21		61	46	48	52	19			59	64	56	70	54	52	60	87	94	75	62	38
Y-22													23	19	23	19	23	19	23	19
Y-23						36		30	50	61	52	40	51	49	34	48	32	47	45	38
MJ-1						6				45	57	77								
MJ-5										57	58	52	48							

Table 1-6 – GWA Springs

Spring	Location	Production, gpm	Area/System Served	Status
Asan Spring	Asan	298	Asan, Piti	Inactive
Santa Rita	Santa Rita	165	Santa Rita Reservoir	Active
Laelae	Umatac	37	Umatac	Inactive
Siligin	Merizo	10	Merizo	Inactive
Geus	Merizo	53	Merizo	Inactive

1.2.3 Surface Water

Two surface water treatment plants provide water to customers in GWA's service area. The U.S. Navy's Fena WTP serves customers in the Central System and was discussed in Section 1.1.2.1. The Ugum WTP serves customers in the Southern System and is discussed below.

The Ugum WTP is the major source of water supply for the Southern Public Water System and the only surface water treatment plant owned and operated by GWA. The plant draws raw water from the Ugum River near its confluence with the Talofofo River. Withdrawal is contingent upon maintaining minimum stream flows to support aquatic life. The minimum stream flows are 1.3 mgd (2 cubic feet per second) during the dry season and 4.5 mgd (7 cubic feet per second) during the wet season.

Based on data (WERI Technical Report 109, December 2005) for 1977 to 2000 from Ugum River stream gauge station 16854500, average daily discharge of the Ugum River is 24.32 cubic feet per second (cfs). The minimum flow recorded is 2.50 cfs and the maximum discharge on the Ugum River is 1,000 cfs. A minimum streamflow of 8.2 cfs is required to maintain minimum stream flow and permit the Ugum WTP to withdraw 4.0 mgd for drinking water purposes. This value is exceeded approximately 75% of the time. For March and July, this value is exceeded 80% of the time and for April, May and June, this value is exceeded greater than 20% of the time but less than 50% of the time. Raw water storage is needed for the Ugum WTP to reliably withdraw 4.0 mgd year-round.

The Ugum Watershed covers an area of approximately 19 square kilometers (7.3 square miles). The Ugum Watershed includes the Bubulao and Ugum River systems and their tributaries and stretches from the top of Mount Bolanos to the mouth of the Ugum River where it meets the Talofofo River about 0.8 kilometer from the coast (Ugum Watershed Best Management Practices, Demonstration Project, March 1998).

A diversion was created in the Ugum River in 1992 to provide a shallow pool from which the Ugum WTP can draw up to a 2 mgd drinking water source from runoff and spring discharge from the watershed. The Ugum WTP was constructed near the diversion site and was designed to process 4 million gallons of water per day. The surface water treatment plant's treatment processes include chemical coagulation, sedimentation, filtration and disinfection. A process schematic is shown on Figure 1-8. Design data are presented in Table 1-7.

Figure 1-7 – GWA Spring Locations

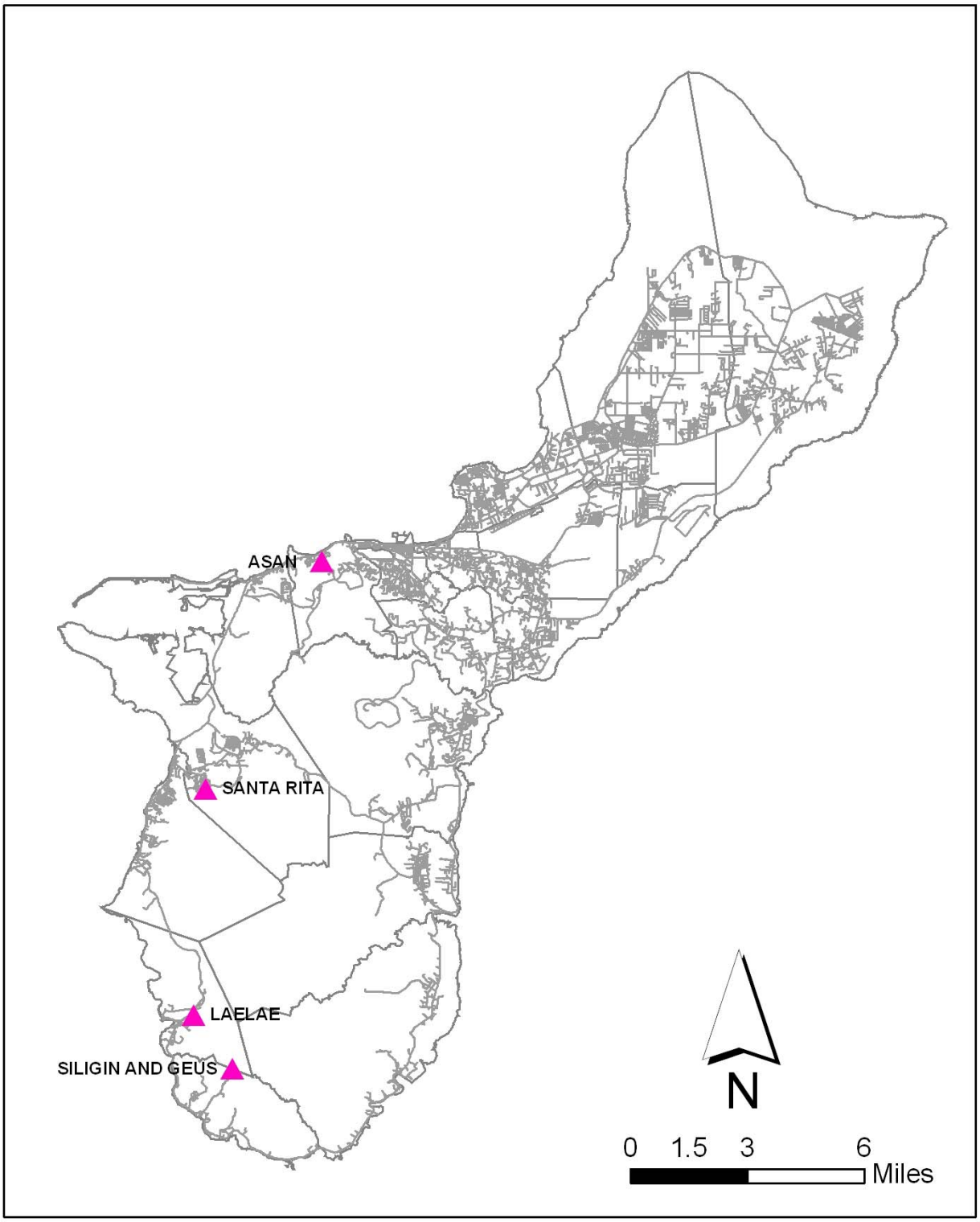


Figure 1-8 – Ugum WTP Process Schematic

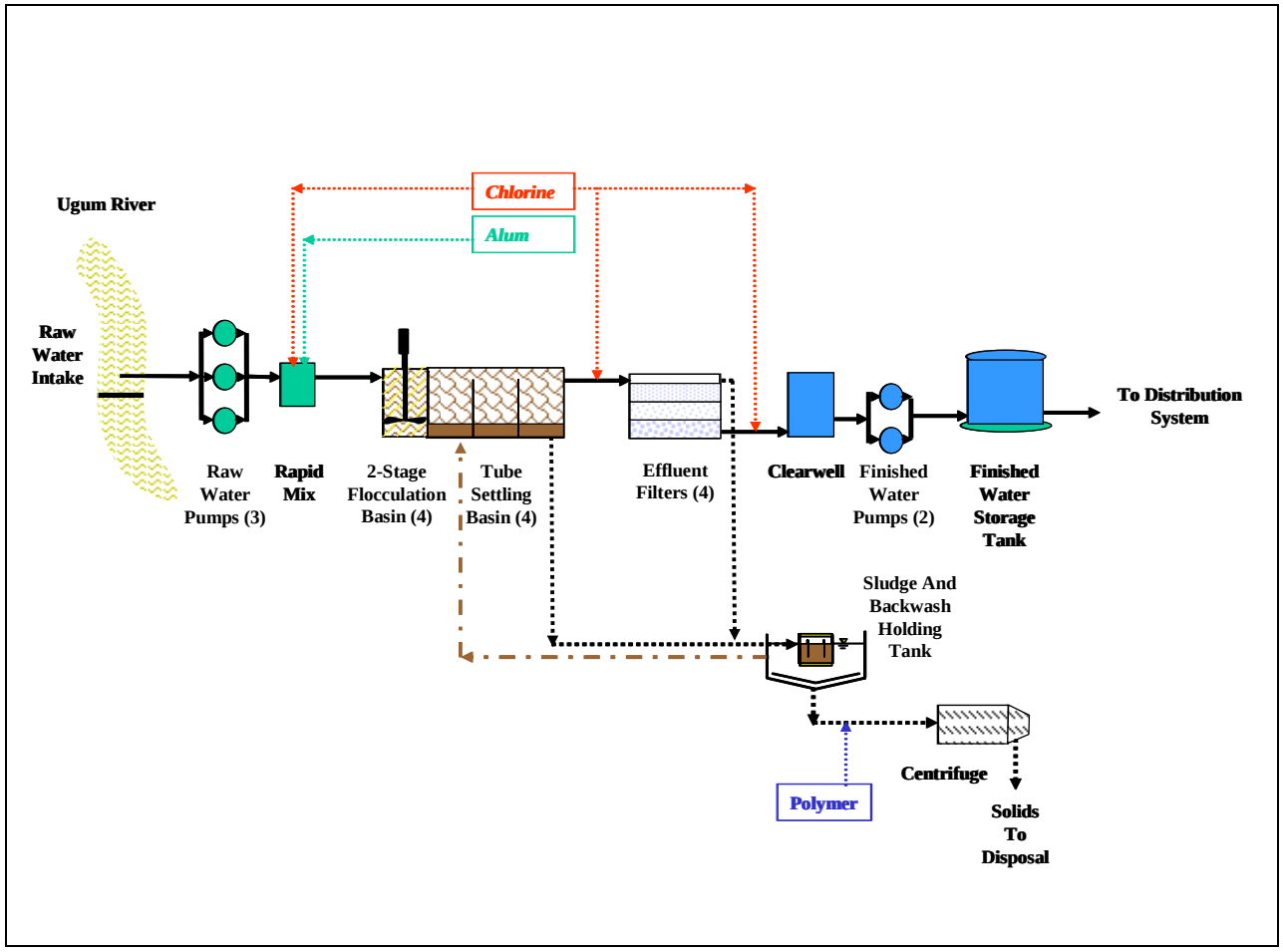


Table 1-7 – Ugum WTP Design Data

Unit Process	Design Data	
Flow	Average daily, mgd	4.0
	Peak daily, mgd	6.0
Raw Water Intake	Capacity, mgd	2.0
Raw Water Pump station	Pumps	3
	Capacity, gpm each	1,800
Rapid Mix	Type	In-line mechanical mixer
	Coagulant	Alum
Flocculation Basins	Number	4
	Type	Two-stage mechanical
	Dimensions	
	Length, feet	12.0
	Width, feet	12.0
	Depth, feet	9.8
Sedimentation Basins	Number	4
	Type	Rectangular with 60º Tube Settlers
	Basin Dimensions	
	Length, feet	45.0
	Width, feet	12.0
	Depth, feet	11.7
	Tube Settler Dimensions	
	Length, feet	30.0
	Width, feet	12.0
	Depth, feet	11.7
Filters	Number	4
	Type	Dual media (anthracite and silica sand) rapid gravity
	Dimensions	
	Length, feet	13.0
	Width, feet	13.0
Clearwell	Number	1
	Minimum Operating Depth, feet	5.1
	Maximum Operating Depth, feet	9.0
	Dimensions	
	Length, feet	33.0
	Width, feet	17.0
Disinfection	Disinfectant	Elemental chlorine
	Application Points	Raw water, settled water, filtered water
Finished Water Storage	Minimum Operating Volume, MG	1.0
	Maximum Operating Volume, MG	2.0

In 2001, a Comprehensive Performance Evaluation (CPE) was conducted for the Ugum Water Treatment Plant (*Comprehensive Performance Evaluation of the Ugum Water Treatment Plant*, Belanger & Associates, May 2001). The CPE is a methodology developed by the U.S. Environmental Protection Agency (EPA) for assessing performance of water and wastewater treatment facilities. The evaluation identified administration, staffing, financial, design and operation and maintenance limitations for optimum performance.

Optimum performance standards for the Ugum WTP are listed below:

- Settled water turbidity of less than 2 NTU, 95% of the time;
- Individual filter turbidity less than 0.1 NTU, 95% of the time, excluding 15-minute period immediately following filter backwash;
- Individual filter turbidity less than 0.3 NTU for 15-minute period immediately following filter backwash; and
- Disinfectant concentration-Contact time (CT) values to meet primary drinking water standards for microorganisms (outlined in Chapter 2 – Water Regulatory Issues).

These optimum performance standards are more stringent that the regulatory requirements but provide an additional margin of safety when achieved.

- A key finding in the evaluation was the inability of the Ugum WTP to respond to and treat high turbidity source water from the Ugum River. Data showed that raw water turbidity ranged as high as 76 NTU as a result of rainfall and erosion in the watershed. The 95th percentile for settled water turbidity was 4.2 NTU and the 95th percentile for filter water was 1.2 NTU. An operating policy prior to the CPE was to "secure the plant when raw water turbidity exceeds two NTU." In other words, water treatment was suspended. From January through December 2000, water treatment was suspended on 26 different occasions.

From 2000 through 2002, several violations of the surface water treatment rules occurred. In late 2003, polymer addition was initiated to supplement alum coagulation. Since that time, the Ugum WTP has not been "secured" due to variable raw water turbidity and has consistently met regulatory requirements.

Key design limitations that were identified during the CPE include:

- Siltation occurs in the intake structure and transfer pipe
- Lack of a pre-sedimentation basin to remove readily settleable silt in the treatment plant before coagulation and sedimentation
- Interruption of disinfection due to a lack of automatic chlorine container switchover
- Discharge of recycle flows downstream of coagulation when the process is in operation
- A non-integrated operation between the flocculation and sedimentation basins
- Poor instrumentation for turbidity and chlorine residual
- Lack of redundant coagulant feed equipment
- Lack of alarm system for high raw water turbidity, filtered water turbidity, or low chlorine residual

- Inadequate laboratory space

A capacity assessment was also performed as part of the CPE. Table 1-8 shows the capacity of each unit process with all four treatment trains in service and with only three treatment trains in service. One of the filters is off-line due to structural damage caused by an earthquake.

Table 1-8 – 2001 Comprehensive Performance Evaluation Capacity Assessment

Unit Process	Capacity with 3 of 4 trains in service, mgd	Capacity with 4 of 4 trains in service, mgd
Flocculation	5.89	7.86
Sedimentation	2.59	3.45
Filtration	2.92	3.89
Pre- and Post-Disinfection	15.02	16.52
Post-Disinfection	10.51	10.51

Despite the limiting factors identified in the CPE, plant performance has improved tremendously since 2002, when coagulation chemicals were placed in use on a more consistent basis. The Ugum WTP has not failed to meet surface water treatment rules pertaining to water quality since this time, though there have been some administrative violations. Chapter 2 – Water Regulatory Issues, Section 2-2 provides a discussion on regulatory compliance.

The Ugum WTP is scheduled by GWA to be converted from a dual media filtration plant to a membrane filter plant by the end of 2006.

1.3 Transmission and Distribution

The GWA distribution system is a collection of legacy systems beginning with the first Navy installations prior to the Second World War, some changes during the Japanese invasion and further installations after Guam's liberation, during and after the war. The constructed distribution systems were turned over to the Government of Guam to operate for the civilian population.

GWA's water system network does not have a separate water transmission system that conveys water from supply to storage and then from storage through the distribution system. Transmission and distribution are combined into a common network for GWA's system. Water supply sources feed the same pipes to which service connections are made. The installed system provides severe challenges to GWA in attempting to meet the SDWA disinfection requirements because some of the customer connections are adjacent to the wells, or the inception point for disinfection. This shortcoming is one of the high priority CIP projects that must be pursued by GWA to enhance the integrity and reliability of its potable water system.

The main water distribution/transmission pipes roughly follow the major transportation routes around the island. Parallel lines run the length of Route 15, most of Route 1 and Route 16 to serve the most populated areas in the northern and central systems. At the intersection of Routes 4 and 17, where the southern system begins, a single transmission/distribution line extends south around the island to its terminus in Umatac.

The island water system is highly integrated. Isolation and pressure reducing valves are used to ensure water supply reaches customers throughout the island. The southern system is the most vulnerable to water loss. Historical failures of the Ugum WTP have resulted in significant water shortages in the southern system. Although water from the well fields in the northern and central

systems can serve the southern system, meeting the water demands in the northern and central systems and loss transporting water to the south, limits this capability.

A summary of piping material associated with GWA's distribution system is presented in Tables 1-9, 1-10 and 1-11. The information presented in these tables was obtained through queries of the Geographical Information System (GIS) that was developed for GWA as part of the master planning process. GWA's 1998 Fixed Asset Inventory listed approximately 55,000 feet of pipe of diameter of less than six inches. In 2000, an inventory from the island-wide water system maps identified approximately 540,000 feet of pipe of diameter of less than six inches, with approximately 400,000 feet of two-inch-diameter pipe

Table 1-9 – Distribution Piping Material, Age and Length by Village

Village	Pipe Material	Pipe Age, years	Pipe Length, feet
Agat	Ductile Iron	6 - 10	2,600
		11 - 20	4,800
	Polyvinyl Chloride	0 - 5	600
		6 - 10	5,800
		11 - 20	31,200
		21 - 30	1,200
		Unknown	2,700
	Unknown	21 - 30	1,000
Asan	Cast Iron	31 - 40	2,300
	Ductile Iron	21 - 30	300
	Polyvinyl Chloride	11 - 20	19,900
		21 - 30	9,900
		Unknown	1,400
Barrigada	Cast Iron	6 - 10	<100
		21 - 30	12,000
		Unknown	2,200
	Ductile Iron	21 - 30	200
	Polyvinyl Chloride	6 - 10	<100
		11 - 20	9,200
		21 - 30	35,900
		31 - 40	11,300
		Unknown	12,100
Chalan Pago-Ordot	Cast Iron	11 - 20	<100
		21 - 30	3,400
		31 - 40	17,600
		Unknown	1,100
	Ductile Iron	11 - 20	1,000
		21 - 30	6,600
	Polyvinyl Chloride	11 - 20	5,100
		21 - 30	10,100
		Unknown	300
Dededo	Asbestos Cement	21 - 30	4,000
		Unknown	3,100
	Cast Iron	21 - 30	<100
		31 - 40	1,800
		40+	13,700
		Unknown	9,100

Table 1-9 – Distribution Piping Material, Age and Length by Village (continued)

Village	Pipe Material	Pipe Age, years	Pipe Length, feet
Dededo	Ductile Iron	6 - 10	800
		21 - 30	500
		Unknown	<100
	Polyvinyl Chloride	0 - 5	200
		6 - 10	18,400
		11 - 20	96,700
		21 - 30	68,800
		31 - 40	12,900
		40+	5,000
		Unknown	37,700
	Unknown	11 - 20	<100
		21 - 30	700
Hagatna	Cast Iron	21 - 30	10,500
		31 - 40	1,600
	Ductile Iron	11 - 20	2,200
	Polyvinyl Chloride	11 - 20	17,500
		21 - 30	2,600
		31 - 40	600
		Unknown	15,700
Inarajan	Asbestos Cement	21 - 30	25,700
		31 - 40	2,900
	Cast Iron	11 - 20	400
		31 - 40	3,700
	Polyvinyl Chloride	11 - 20	54,600
		21 - 30	39,200
		Unknown	2,200
	Unknown	21 - 30	5,200
Mangilao	Asbestos Cement	Unknown	<100
	Cast Iron	31 - 40	35,700
		Unknown	<100
	Ductile Iron	11 - 20	5,900
		21 - 30	1,200
	Polyvinyl Chloride	0 - 5	200
		6 - 10	<100
		11 - 20	54,800
		21 - 30	25,900
		31 - 40	3,100
		Unknown	12,800
Merizo	Cast Iron	31 - 40	1,300
	Polyvinyl Chloride	21 - 30	1,500
Mongmong-Toto-Maite	Asbestos Cement	31 - 40	3,100
	Cast Iron	21 - 30	33,000
		Unknown	200

Table 1-9 – Distribution Piping Material, Age and Length by Village (continued)

Village	Pipe Material	Pipe Age, years	Pipe Length, feet
Mongmong-Toto-Maite	Polyvinyl Chloride	11 - 20	5,800
		21 - 30	146,400
		31 - 40	4,000
		Unknown	20,000
Piti	Cast Iron	11 - 20	<100
		31 - 40	5,000
	Ductile Iron	Unknown	1,600
	Polyvinyl Chloride	6 - 10	500
		11 - 20	9,100
		21 - 30	500
		31 - 40	9,000
		Unknown	13,100
Santa Rita	Asbestos Cement	21 - 30	100
		Unknown	2,400
	Cast Iron	40+	1,700
		Unknown	<100
	Polyvinyl Chloride	6 - 10	<100
		11 - 20	27,800
		21 to 30	5,800
		Unknown	1,700
	Unknown	21 to 30	11,100
Sinajana	Asbestos Cement	31 to 40	5,100
	Cast Iron	21 to 30	100
		31 to 40	<100
	Polyvinyl Chloride	21 to 30	300
		31 to 40	400
		Unknown	13,400
Talofofo	Asbestos Cement	Unknown	200
	Cast Iron	31 to 40	1,400
		40+	<100
	Ductile Iron	11 to 20	<100
	Polyvinyl Chloride	0 to 5	900
		6 to 10	2,000
		11 to 20	23,100
		21 to 30	1,000
		Unknown	4,900
Tamuning	Cast Iron	11 to 20	1,700
		31 to 40	14,500
		40+	6,600
	Ductile Iron	11 to 20	16,500
	Polyvinyl Chloride	6 to 10	4,700
		11 to 20	43,000
		21 to 30	34,900
		40+	2,300
		Unknown	4,600

Table 1-9 – Distribution Piping Material, Age and Length by Village (continued)

Village	Pipe Material	Pipe Age, years	Pipe Length, feet
Umatac	Asbestos Cement	21 to 30	2,100
	Polyvinyl Chloride	21 to 30	500
		31 to 40	5,100
		Unknown	13,100
Yigo	Asbestos Cement	21 to 30	5,500
		Unknown	<100
	Cast Iron	11 to 20	500
		31 to 40	7,400
	Ductile Iron	6 to 10	24,500
		11 to 20	<100
	Polyvinyl Chloride	0 to 5	43,200
		6 to 10	182,000
		11 to 20	214,700
		21 to 30	24,900
		31 to 40	14,200
		Unknown	23,100
	Unknown	21 to 30	2,700
Yona	Cast Iron	6 to 10	<100
		31 to 40	10,500
	Ductile Iron	6 to 10	100
		11 to 20	4,400
		21 to 30	1,800
	Polyvinyl Chloride	0 to 5	4,200
		6 to 10	<100
		11 to 20	22,900
		21 to 30	31,100
		31 to 40	5,900
		Unknown	89,800
Unknown	Asbestos Cement	21 to 30	200
	Cast Iron	21 to 30	200
		Unknown	<100
	Polyvinyl Chloride	11 to 20	6,800
		21 to 30	300
		Unknown	2,600
Total			>2,000,000

Table 1-10 – Water Distribution Pipe Type and Length

Village	Pipe Length, feet				
	Asbestos Cement	Cast Iron	Ductile Iron	Polyvinyl Chloride	Unknown
Agat	0	0	7,400	41,500	1,000
Asan	0	2,300	300	31,200	0
Barrigada	0	14,200	200	68,500	0
Chalan Pago-Ordot	0	22,100	7,600	15,500	0
Dededo	7,100	24,700	1,400	239,700	700
Hagatna	0	12,100	2,200	36,400	0
Inarajan	28,500	4,100	0	96,000	5,200
Mangilao	<100	35,800	7,100	96,900	0
Merizo	0	1,300	0	1,500	0
Mongmong-Toto-Maite	3,100	33,200	0	176,100	0
Piti	0	5,100	1,600	32,200	0
Santa Rita	2,500	1,700	0	35,400	11,100
Sinajana	5,100	200	0	14,100	0
Talofofo	200	1,400	<100	31,900	0
Tamuning	0	22,800	16,500	89,500	0
Umatac	2,100	0	0	18,700	0
Yigo	5,500	7,800	24,600	502,100	2,700
Yona	0	10,500	6,400	153,900	0
Unknown	200	200	0	9,600	0
Total	<54,000	>199,000	<75,000	>1,690,000	<21,000

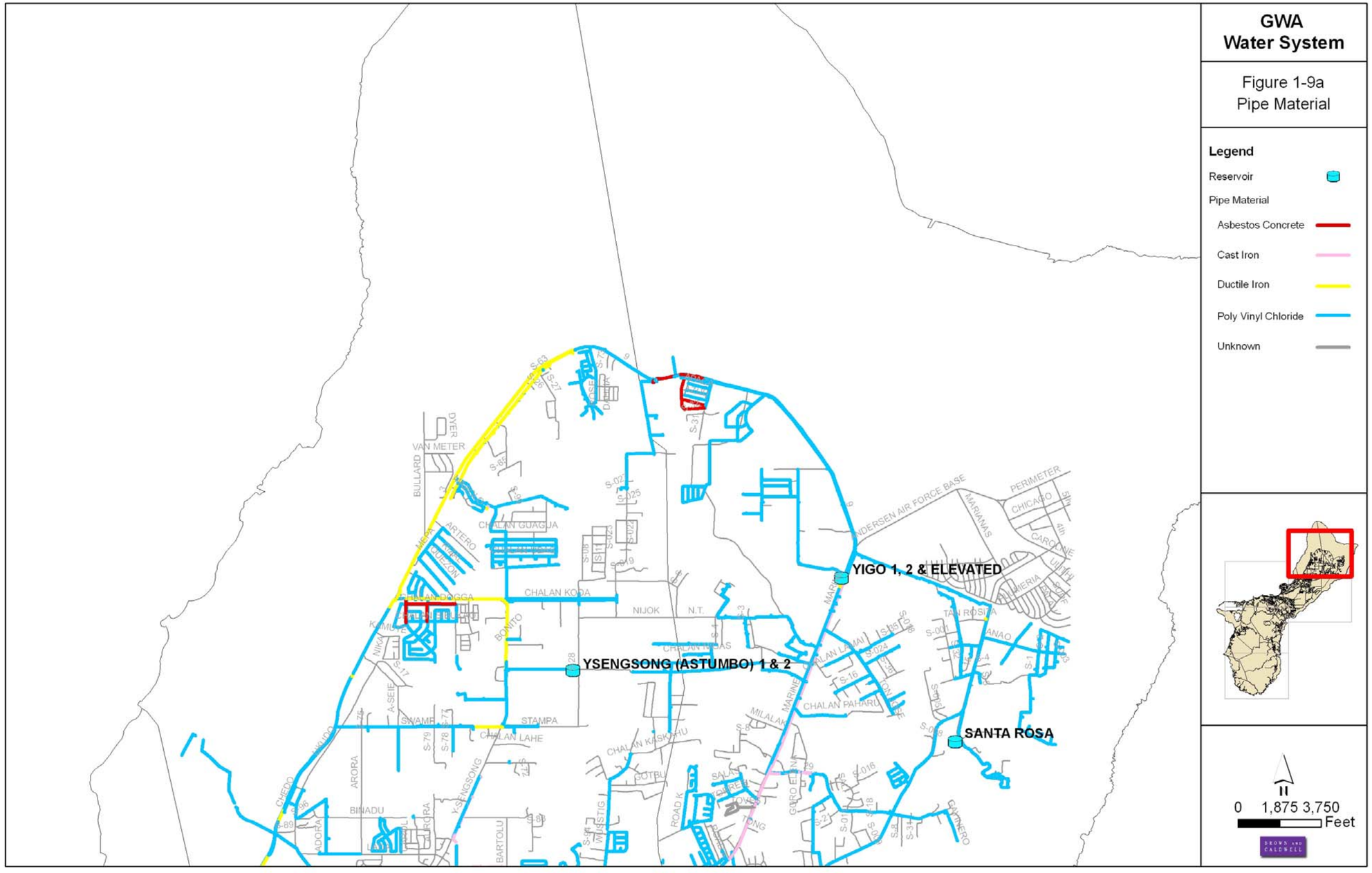
The pipe material for the water distribution system is shown on Figures 1-9a thru 1-9e. Much of the waterlines are currently identified in GWA's database as being polyvinyl chloride (PVC) pipe, but additional confirmation is needed, as the quantity appears to be disproportionably high, particularly for the older aged pipe. The age of the water distribution piping is shown on Figures 1-10a thru 1-10e. It is noted that there are areas on Figures 1-9 and 1-10 that waterlines are not indicated due to the pipes being smaller than six inches, or there is insufficient data on the pipe to indicate its material type or age.

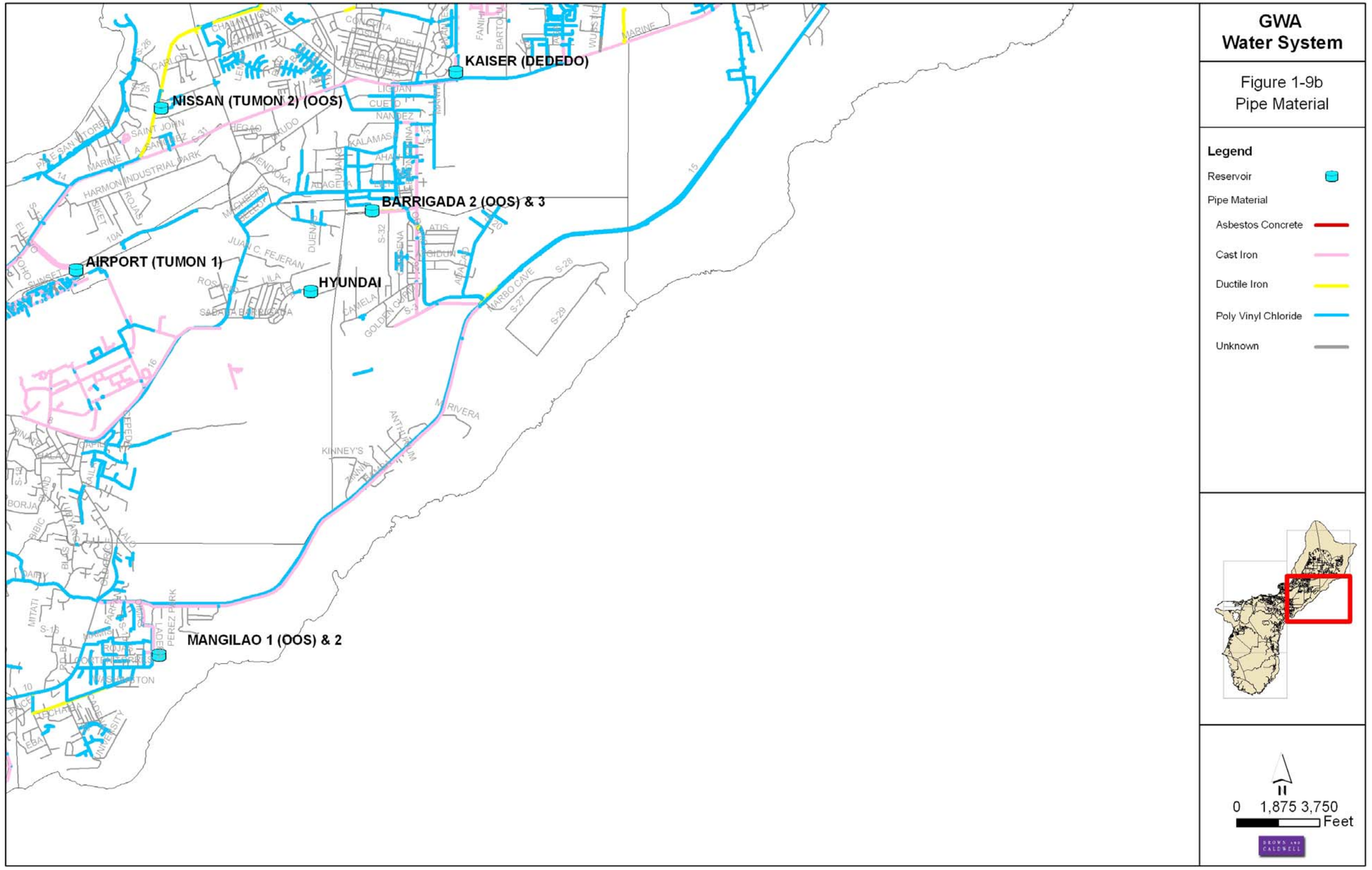
1.4 Pressure Zone Boundaries

GWA's water system is divided into a series of pressure zones established by the elevation of reservoirs that serves the area, or in some cases, booster stations where a reservoir does not exist. Dividing the pressure zones and regulating the transition of pressure in the water system from one zone to the next are a series of pressure reducing valve (PRV) stations or booster stations. In some locations, a closed valve serves to isolate one pressure zone from another. The locations of the PRVs and major pressure zone boundaries are identified on Figures 1-11a to 1-11e. In some cases, PRVs serve individual facilities or small areas that are not indicated on Figures 1-11a to 1-11e due to their negligible impact on the overall water system.

Table 1-11 – Water Distribution Pipe Length by Diameter

Village	Pipe Length, feet											
	<=2	4	6	8	10	12	14	16	18	20	24	Unknown
Agat	300	0	27,000	1,800	0	5,400	0	15,400	0	0	0	
Asan	0	0	8,000	3,000	0	11,900	400	3,400	0	7,200	0	
Barrigada	0	0	38,400	4,200	7,900	5,200	200	16,600	1,500	6,900	2,100	
Chalan Pago-Ordot	<100	200	8,600	2,900	<100	24,400	0	9,000	0	0	0	
Dededo	<100	4,700	118,000	46,600	8,500	73,400	13,400	6,400	0	1,200	1,200	
Hagatna		0	15,100	14,700	<100	8,500	0	3,200	2,200	7,100	0	
Inarajan	300	<100	22,100	43,200	2,100	63,200	0	2,900	0	0	0	
Mangilao	0	0	20,000	18,000	0	65,500	0	20,100	0	0	16,200	100
Merizo	0	0	1,500	300	0	1,000	0	0	0	0	0	
Mongmong-Toto-Maite	0	<100	53,800	30,100	32,200	81,100	500	12,600	2,000	0	0	
Piti	0	0	10,000	<100	0	6,600	0	22,200	0	0	0	
Santa Rita	<100	<100	14,000	17,100	<100	11,500	0	6,300	0	0	1,700	
Sinajana	0	0	16,600	2,700	0	100	0	0	0	0	0	
Talofofo	0	0	25,000	5,900	0	2,600	0	100	200	0	0	
Tamuning	900	0	19,800	15,500	0	52,300	11,800	5,900	7,900	4,300	10,400	
Umatac	0	0	13,800	2,000	0	5,000	0	0	0	0	0	
Yigo	1,800	0	319,300	47,700	0	142,600	0	25,500	0	5,700	0	
Yona	0	<100	54,900	10,100	0	87,600	0	18,100	0	0	0	
Unknown	0	<100	8,600	600	0	300	0	600	0	<100	0	
Total	<4,000	<6,000	<795,000	<264,000	<51,000	>648,000	>26,000	>168,000	<14,000	<33,000	>32,000	<1,000


GWA
Water System
Figure 1-9a
Pipe Material
Legend
Reservoir
Pipe Material
Asbestos Concrete
Cast Iron
Ductile Iron
Poly Vinyl Chloride
Unknown
YIGO 1, 2 & ELEVATED
YSENGSONG (ASTUMBO) 1 & 2
SANTA ROSA
0 1,875 3,750
Feet
BROWN AND CALDWELL


KAISER (DEDEDO)
NISSAN (TUMON 2) (OOS)
BARRIGADA 2 (OOS) & 3
AIRPORT (TUMON 1)
HYUNDAI
MANGILAO 1 (OOS) & 2
GWA
Water System
Figure 1-9b
Pipe Material
Legend
Reservoir
Pipe Material
Asbestos Concrete
Cast Iron
Ductile Iron
Poly Vinyl Chloride
Unknown
0 1,875 3,750
Feet
BROWN AND CALDWELL

GWA Water System

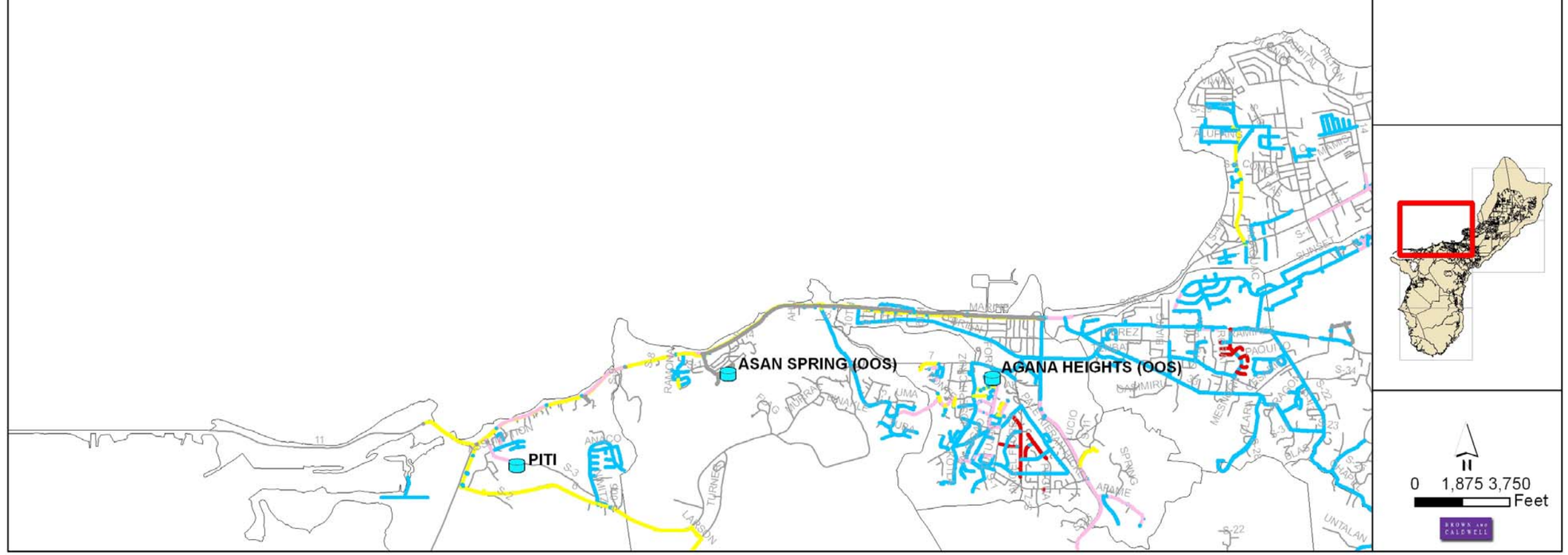
Figure 1-9c
Pipe Material

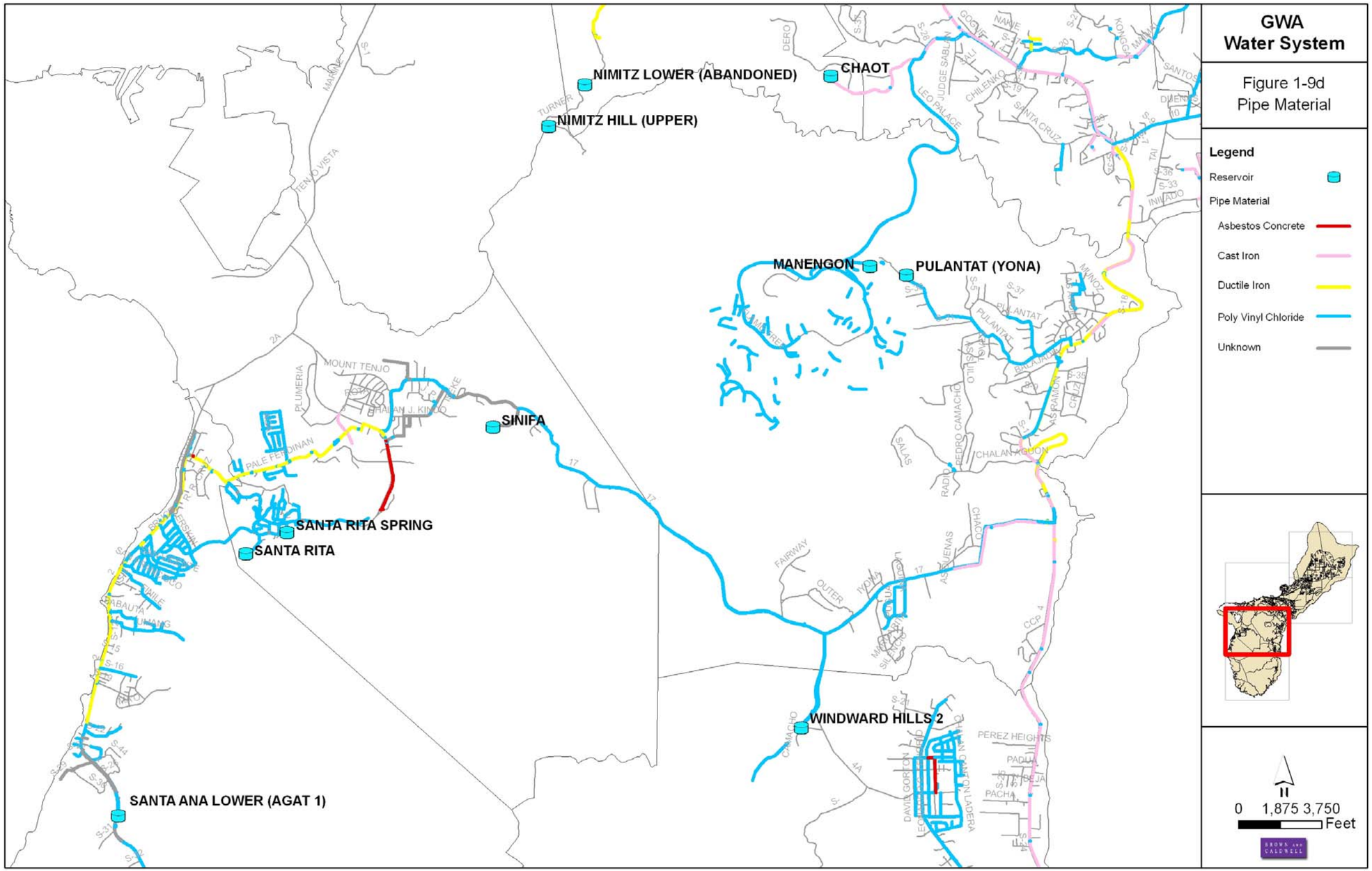
Legend

Reservoir

Pipe Material

- Asbestos Concrete
- Cast Iron
- Ductile Iron
- Poly Vinyl Chloride
- Unknown





GWA Water System

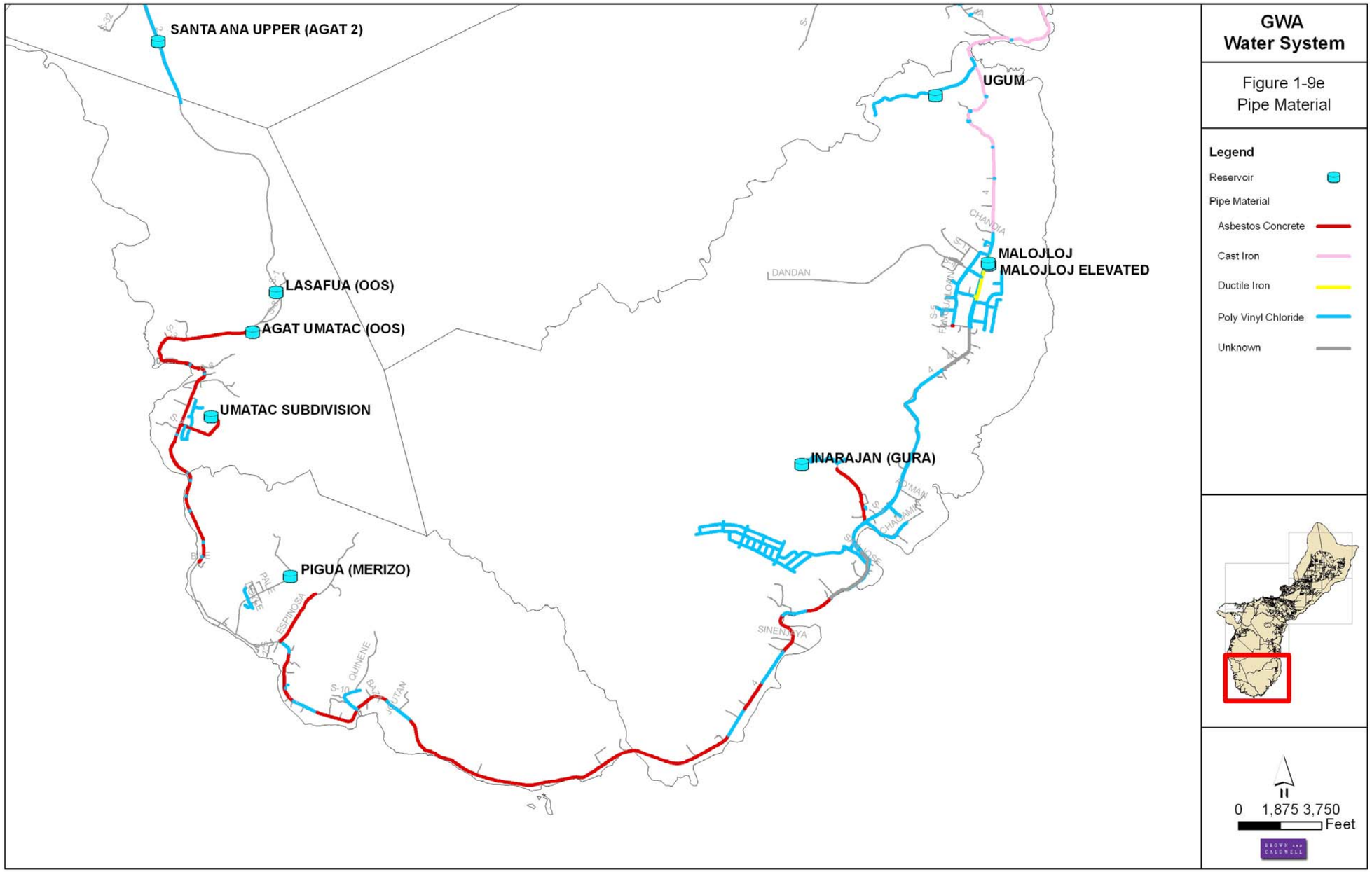
Figure 1-9d
Pipe Material

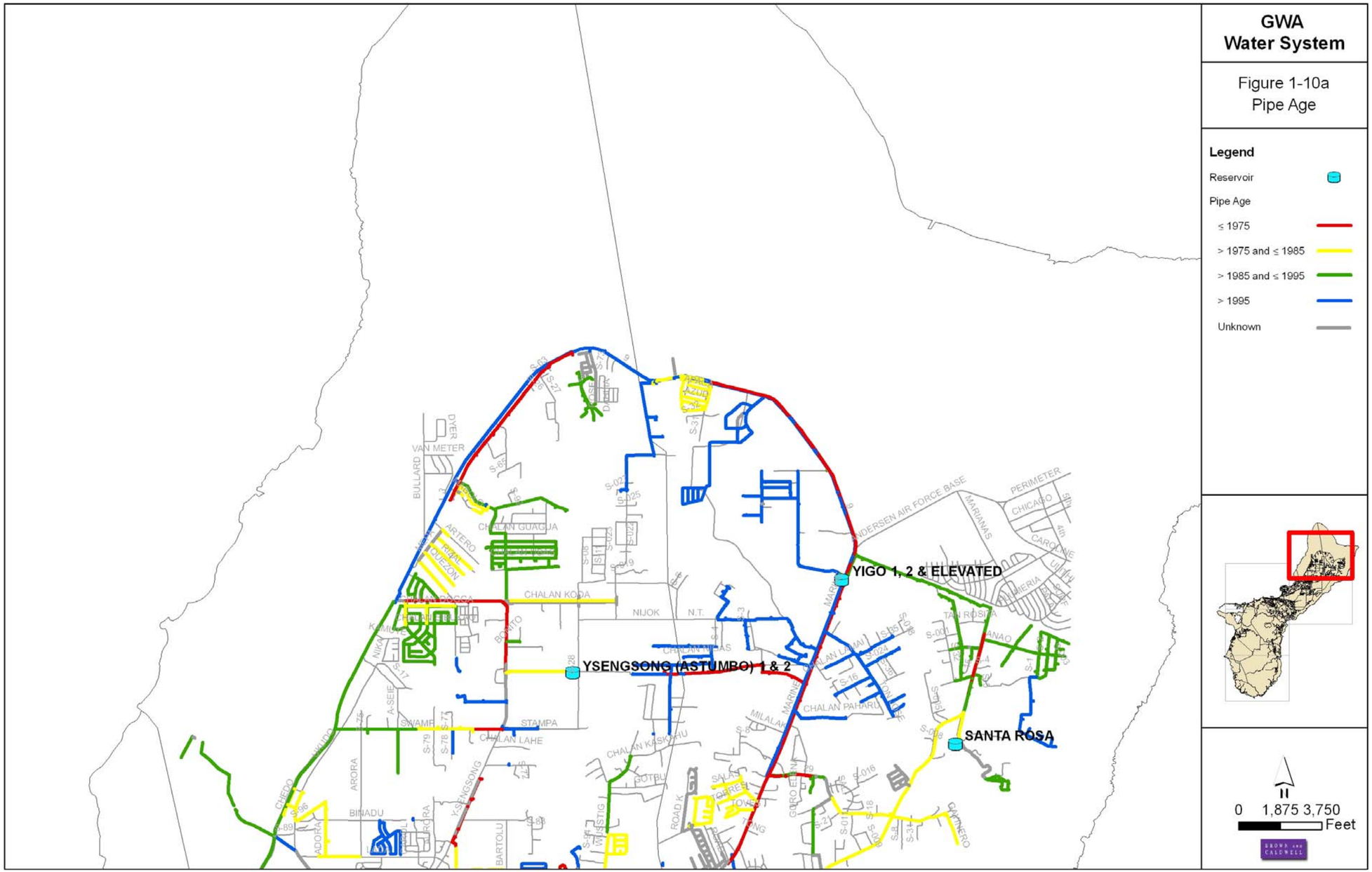
Legend

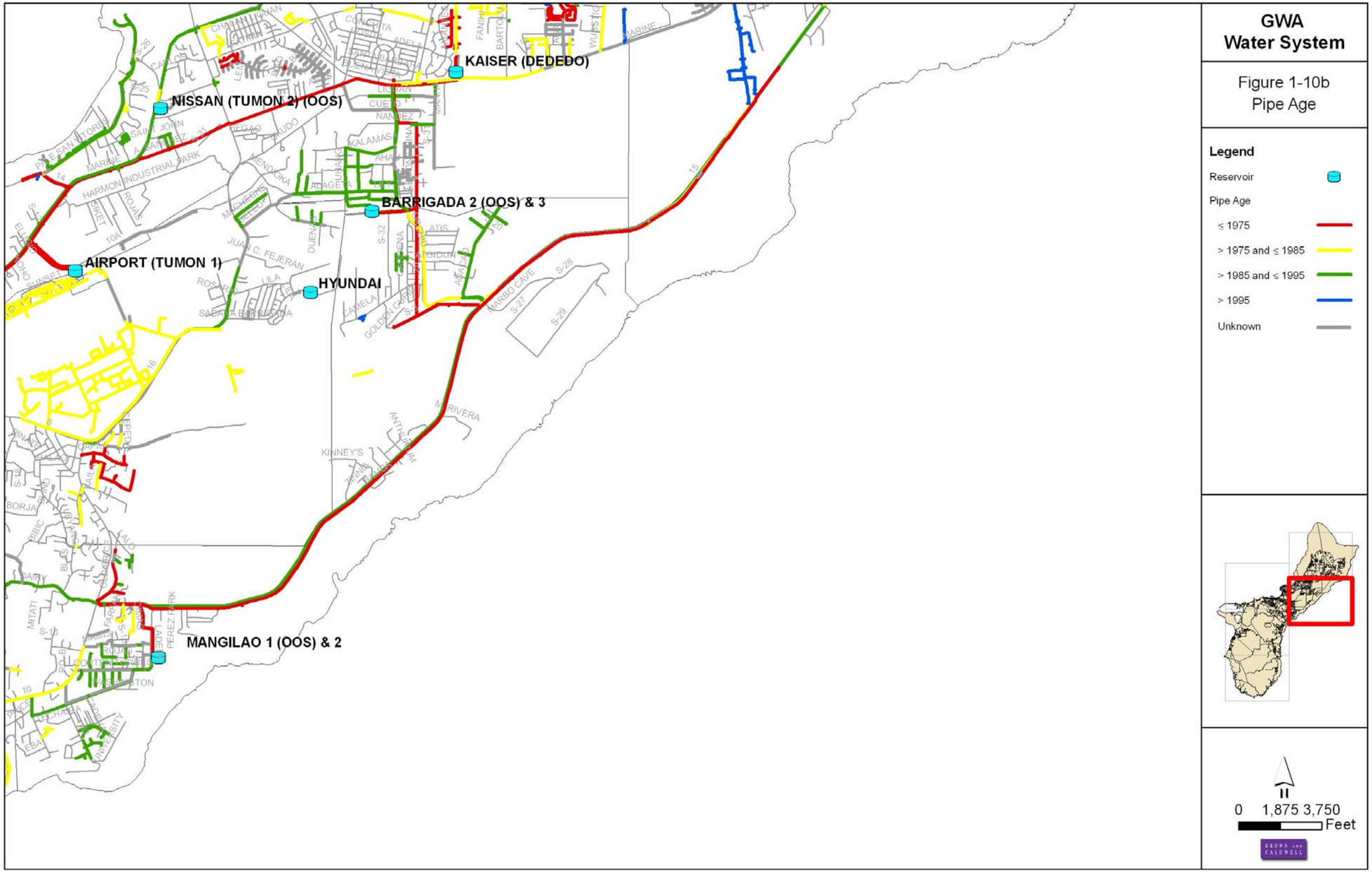
Reservoir

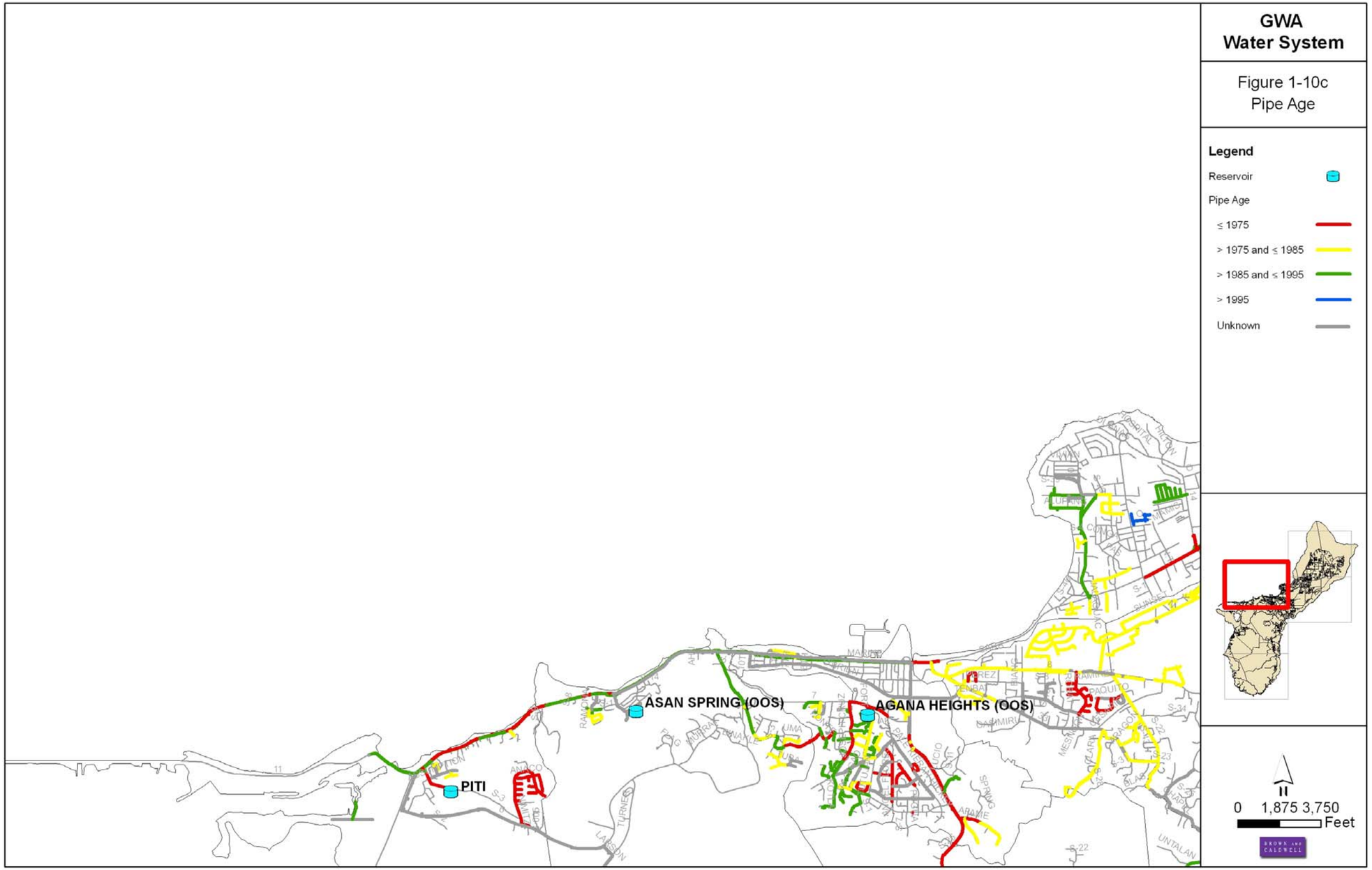
Pipe Material

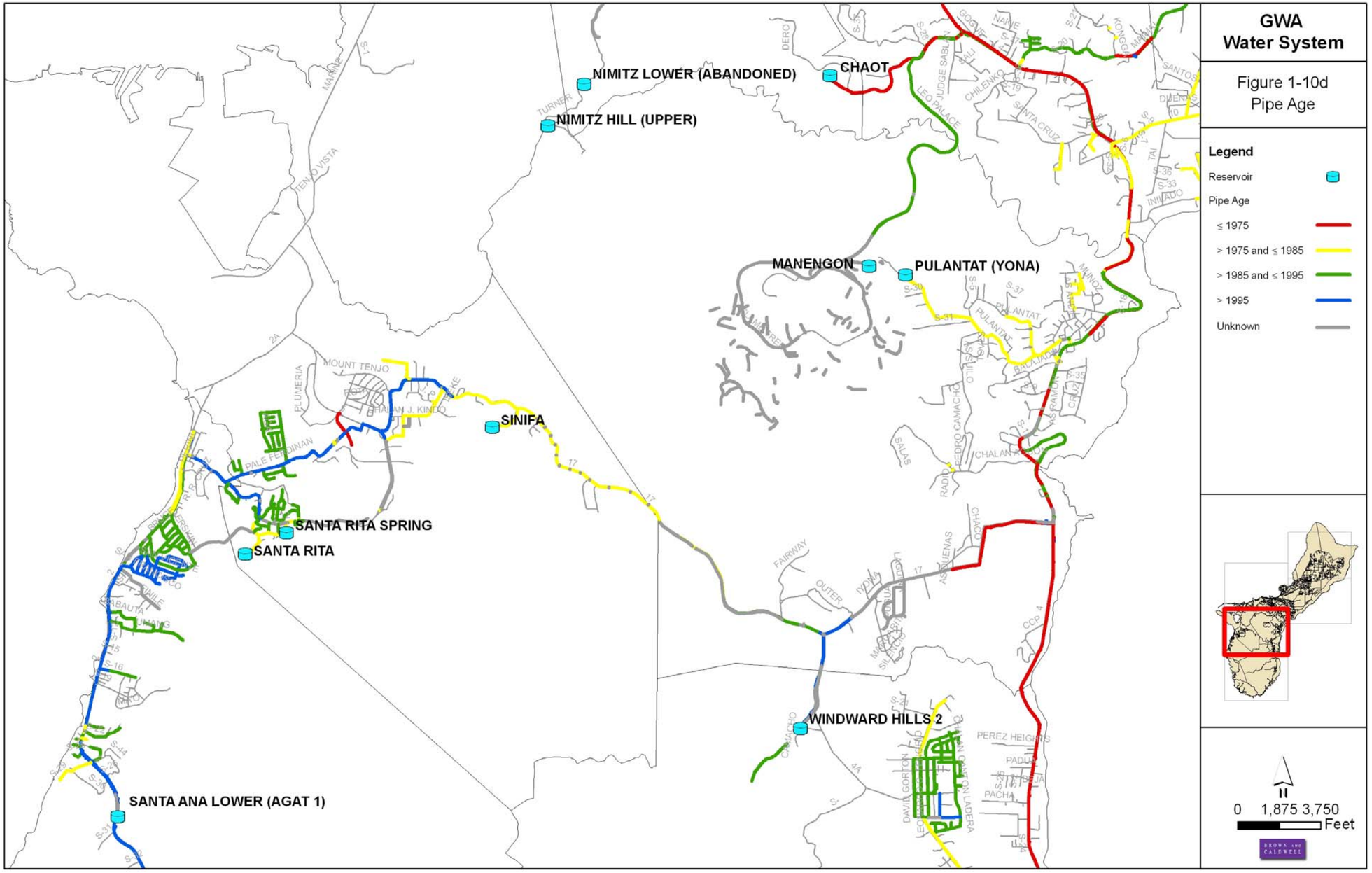
- Asbestos Concrete
- Cast Iron
- Ductile Iron
- Poly Vinyl Chloride
- Unknown

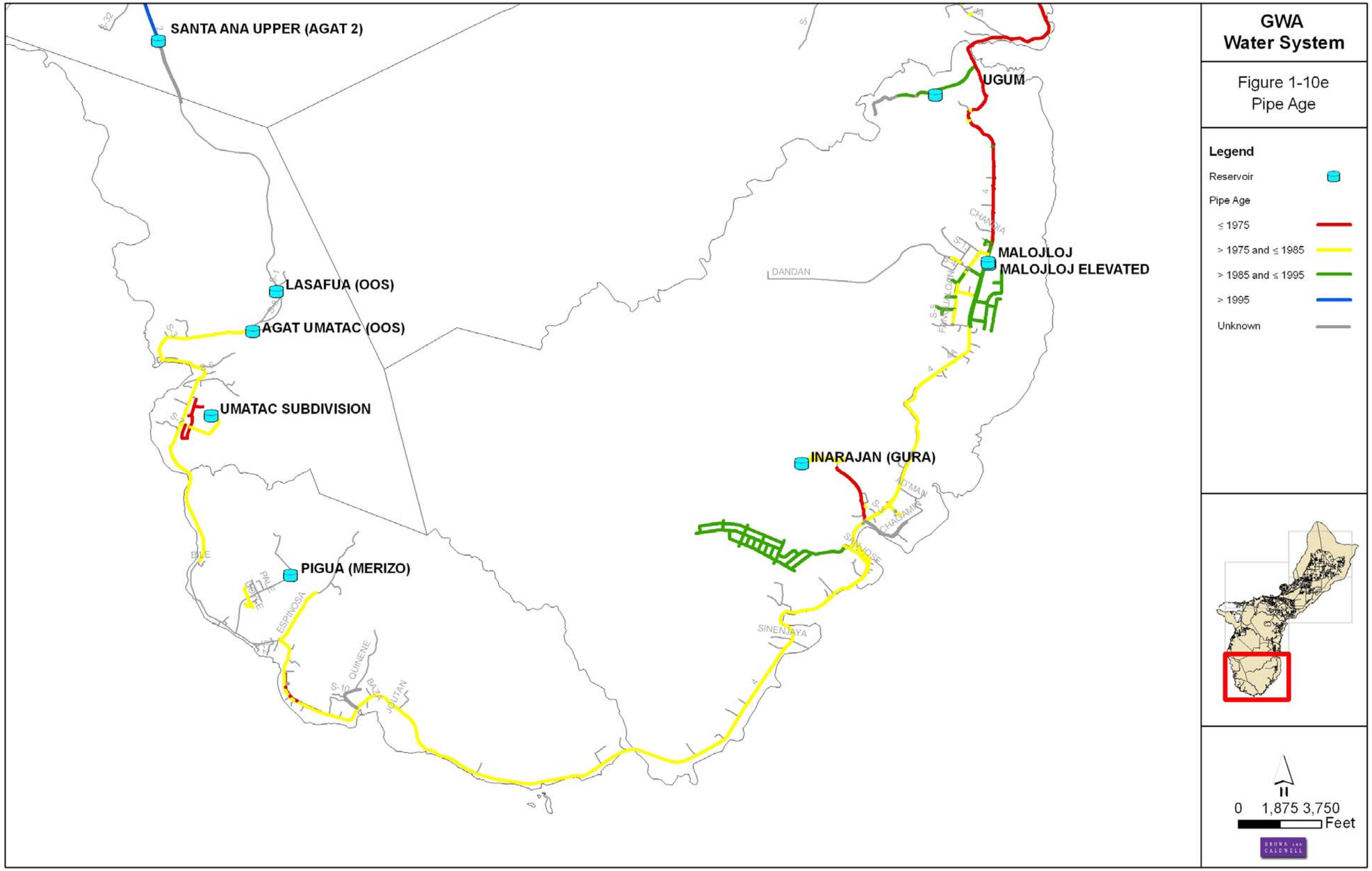

SANTA ANA UPPER (AGAT 2)
LASAFUA (OOS)
AGAT UMATAC (OOS)
UMATAC SUBDIVISION
PIGUA (MERIZO)
UGUM
MALOJLOJ
MALOJLOJ ELEVATED
INARAJAN (GURA)
DANDAN
CHANDIA
ESPINOSA
QUINENE
SINENGSYA
GWA
Water System
Figure 1-9e
Pipe Material
Legend
Reservoir
Pipe Material
Asbestos Concrete
Cast Iron
Ductile Iron
Poly Vinyl Chloride
Unknown
0 1,875 3,750
Feet
BROWN AND CALDWELL

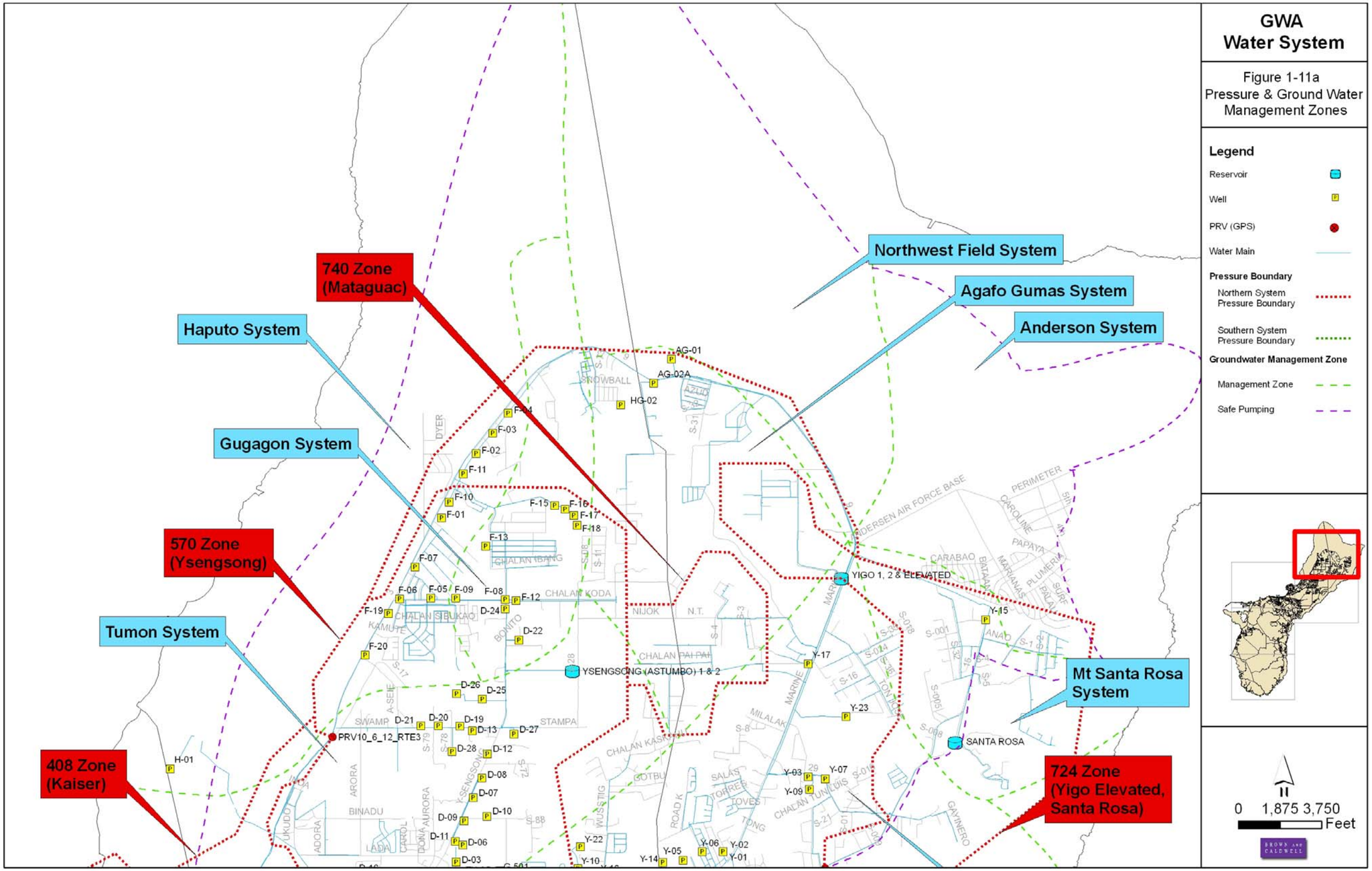

GWA
Water System
Figure 1-10a
Pipe Age
Legend
Reservoir
Pipe Age
≤ 1975
> 1975 and ≤ 1985
> 1985 and ≤ 1995
> 1995
Unknown
YIGO 1, 2 & ELEVATED
YSENGSONG (ASTUMBO) 1 & 2
SANTA ROSA
0 1,875 3,750
Feet
BROWN AND CALDWELL

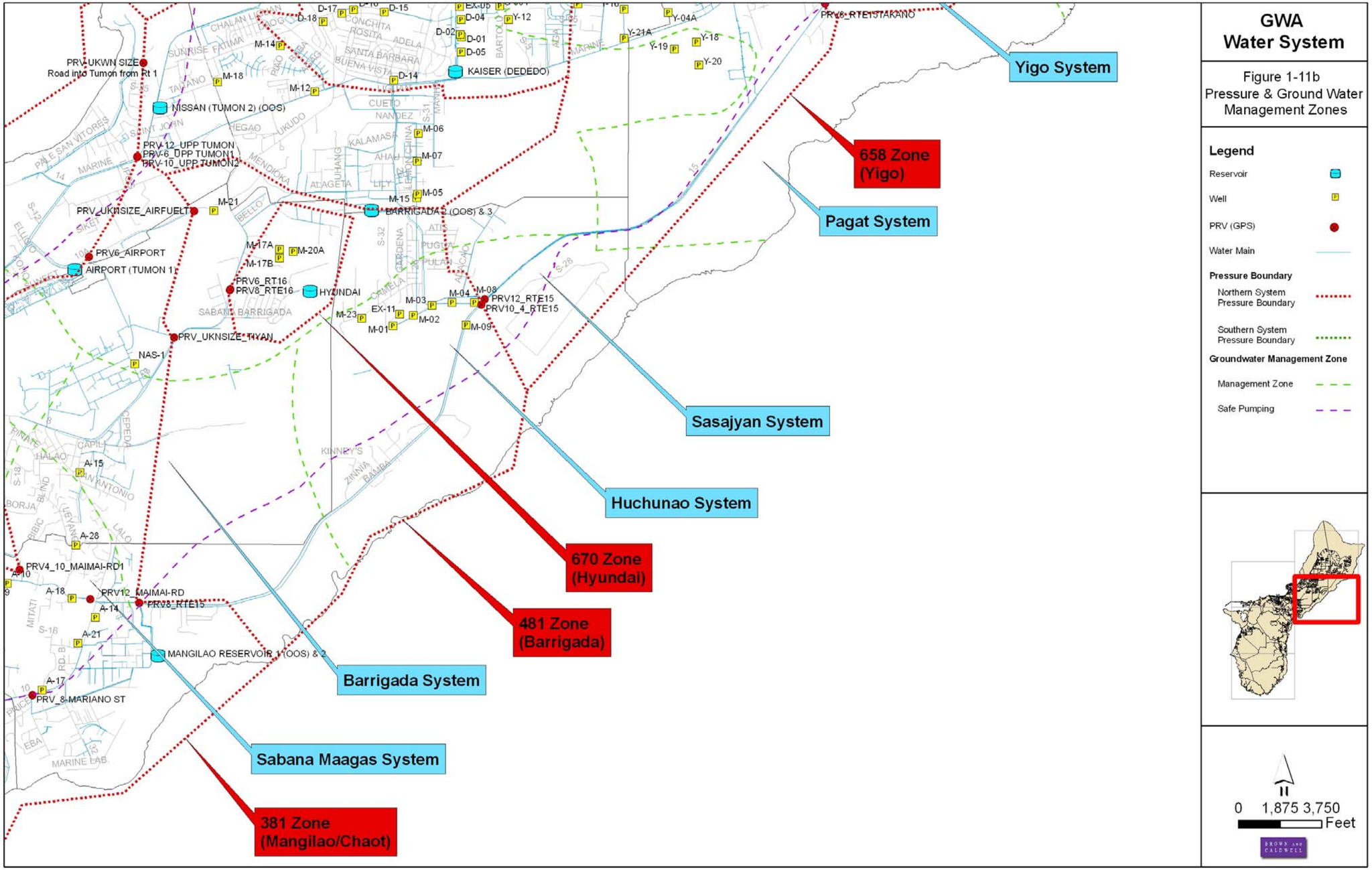

KAISER (DEDEDO)
NISSAN (TUMON 2) (OOS)
BARRIGADA 2 (OOS) & 3
AIRPORT (TUMON 1)
HYUNDAI
MANGILAO 1 (OOS) & 2
GWA
Water System
Figure 1-10b
Pipe Age
Legend
Reservoir
Pipe Age
≤ 1975
> 1975 and ≤ 1985
> 1985 and ≤ 1995
> 1995
Unknown
0 1,875 3,750
Feet
BROWN AND CALDWELL


GWA
Water System
Figure 1-10c
Pipe Age
Legend
Reservoir
Pipe Age
≤ 1975
> 1975 and ≤ 1985
> 1985 and ≤ 1995
> 1995
Unknown
ASAN SPRING (OOS)
AGANA HEIGHTS (OOS)
PITI
0 1,875 3,750
Feet
BROWN AND CALDWELL


NIMITZ LOWER (ABANDONED)
NIMITZ HILL (UPPER)
CHAOT
MANENGON
PULANTAT (YONA)
SINIFA
SANTA RITA SPRING
SANTA RITA
SANTA ANA LOWER (AGAT 1)
WINDWARD HILLS 2
GWA
Water System
Figure 1-10d
Pipe Age
Legend
Reservoir
Pipe Age
≤ 1975
> 1975 and ≤ 1985
> 1985 and ≤ 1995
> 1995
Unknown
0 1,875 3,750
Feet
BROWN AND CALDWELL


SANTA ANA UPPER (AGAT 2)
LASAFUA (OOS)
AGAT UMATAC (OOS)
UMATAC SUBDIVISION
PIGUA (MERIZO)
UGUM
MALOJLOJ
MALOJLOJ ELEVATED
INARAJAN (GURA)
DANDAN
CHANDIA
ESPINOSA
QUINENE
SINENJAYA
CHAGAMIN
SINAHOSE
GWA
Water System
Figure 1-10e
Pipe Age
Legend
Reservoir
Pipe Age
≤ 1975
> 1975 and ≤ 1985
> 1985 and ≤ 1995
> 1995
Unknown
0 1,875 3,750
Feet
BROWN AND CALDWELL


GWA
Water System
Figure 1-11a
Pressure & Ground Water
Management Zones
Legend
Reservoir
Well
PRV (GPS)
Water Main
Pressure Boundary
Northern System
Pressure Boundary
Southern System
Pressure Boundary
Groundwater Management Zone
Management Zone
Safe Pumping
740 Zone
(Mataguac)
Haputo System
Gugagon System
570 Zone
(Ysengsong)
Tumon System
408 Zone
(Kaiser)
Northwest Field System
Agafo Gumas System
Anderson System
Mt Santa Rosa
System
724 Zone
(Yigo Elevated,
Santa Rosa)
AG-01
AG-02A
HG-02
F-04
F-03
F-02
F-11
F-10
F-01
F-15
F-16
F-17
F-18
F-13
F-07
F-06
F-05
F-09
F-08
F-12
F-19
D-24
F-20
D-22
YSENGSONG (ASTUMBO) 1 & 2
D-26
D-25
D-21
D-20
D-19
D-13
D-27
PRV10_6_12_RTE3
D-28
D-12
H-01
D-08
D-07
D-10
D-09
D-11
D-06
D-03
Y-22
Y-10
Y-14
Y-05
Y-06
Y-02
Y-01
YIGO 1, 2 & ELEVATED
Y-15
Y-17
Y-23
SANTA ROSA
Y-03
Y-07
Y-09
0 1,875 3,750
Feet
BROWN AND CALDWELL



GWA Water System

Figure 1-11b
Pressure & Ground Water Management Zones

Legend

- Reservoir
- Well
- PRV (GPS)
- Water Main

Pressure Boundary

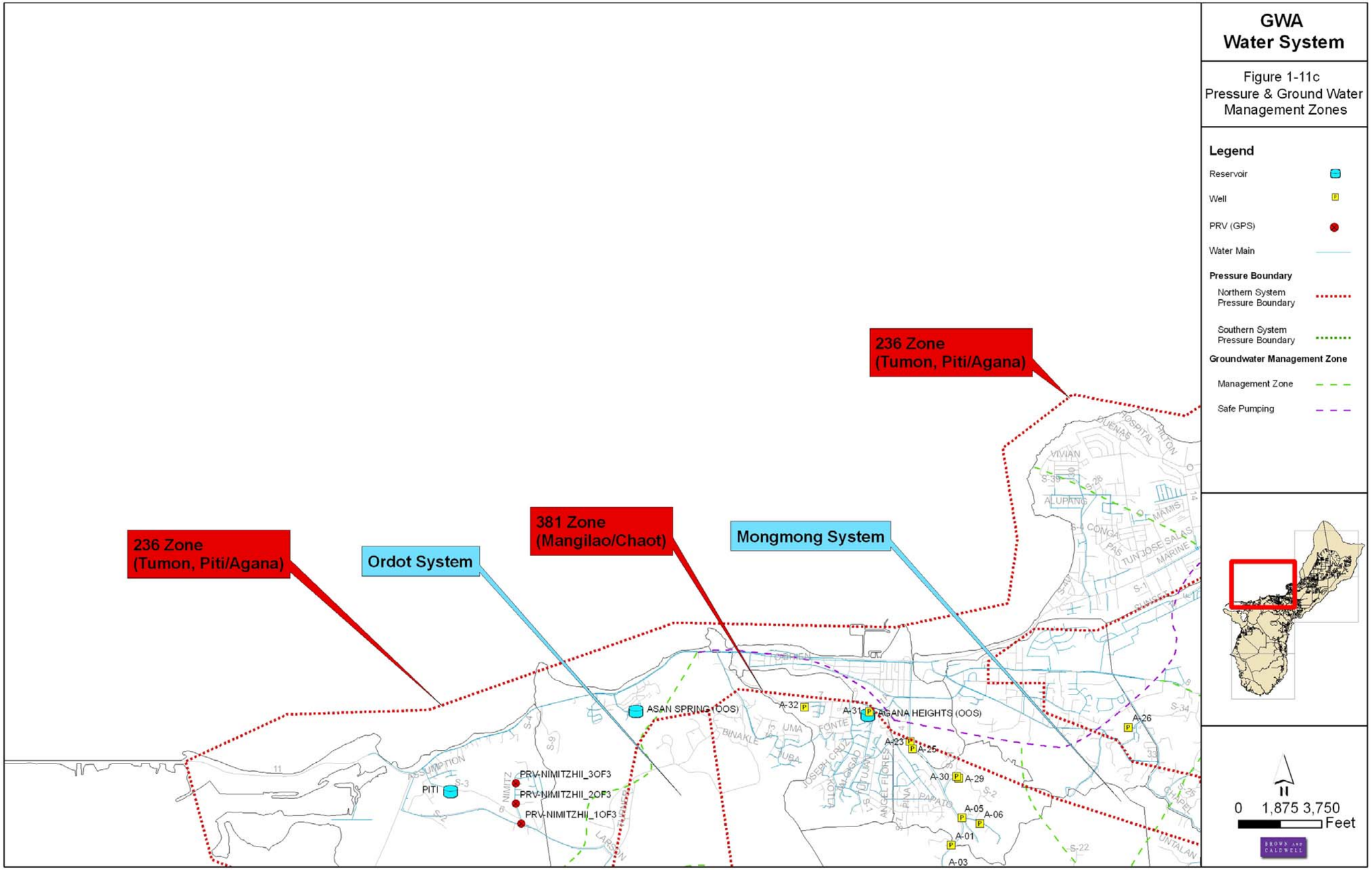
- Northern System Pressure Boundary
- Southern System Pressure Boundary

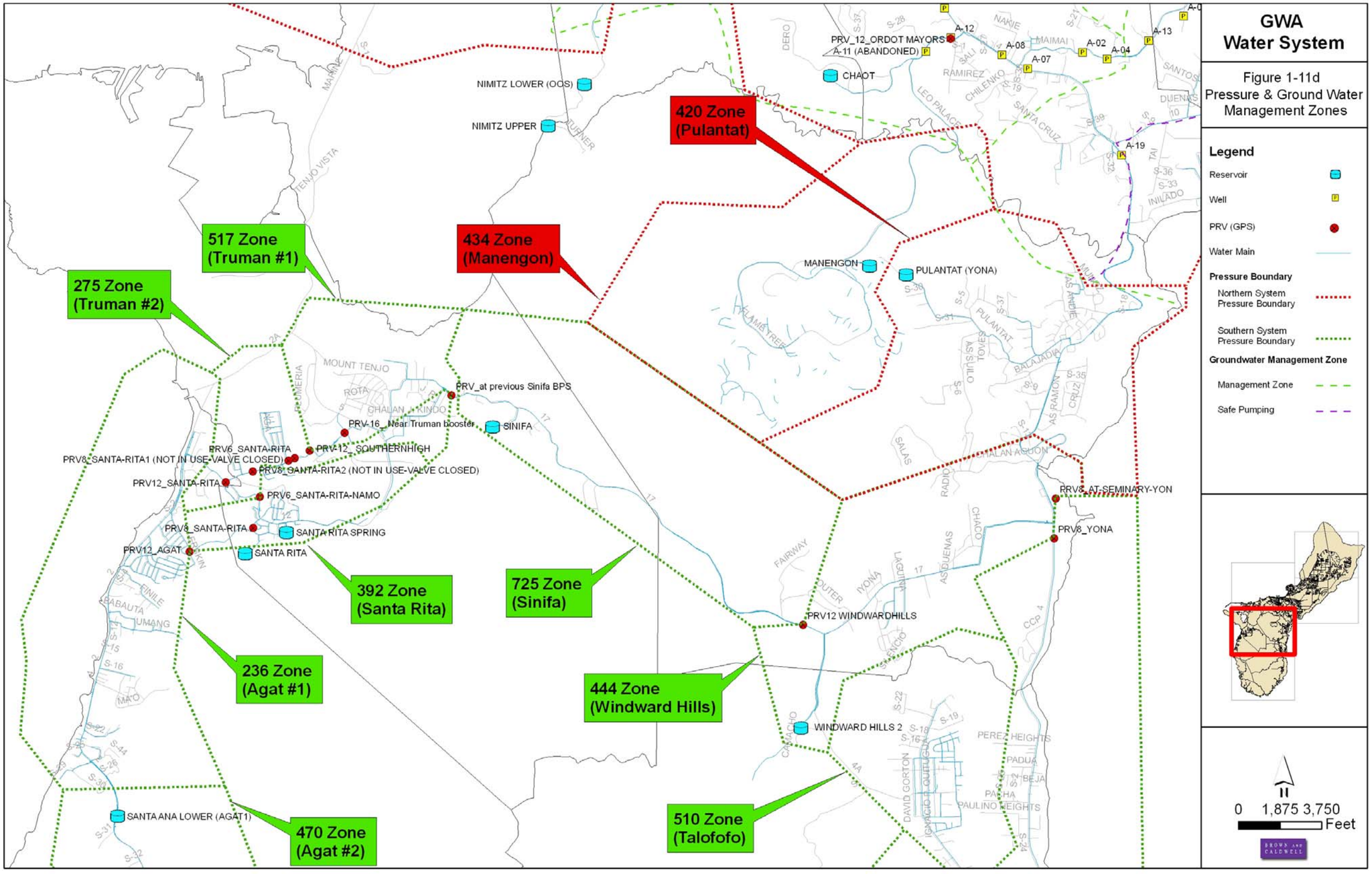
Groundwater Management Zone

- Management Zone
- Safe Pumping

0 1,875 3,750 Feet

BROWN AND CALDWELL


GWA
Water System
Figure 1-11c
Pressure & Ground Water
Management Zones
Legend
Reservoir
Well
PRV (GPS)
Water Main
Pressure Boundary
Northern System
Pressure Boundary
Southern System
Pressure Boundary
Groundwater Management Zone
Management Zone
Safe Pumping
236 Zone
(Tumon, Piti/Agana)
Ordot System
381 Zone
(Mangilao/Chaot)
Mongmong System
ASAN SPRING (OOS)
AGANA HEIGHTS (OOS)
PITI
PRV-NIMITZHII_3OF3
PRV-NIMITZHII_2OF3
PRV-NIMITZHII_1OF3
A-32
A-31
A-23
A-25
A-26
A-30
A-29
A-05
A-06
A-01
A-03
0 1,875 3,750
Feet
BROWN AND CALDWELL



GWA Water System

Figure 1-11d
Pressure & Ground Water Management Zones

Legend

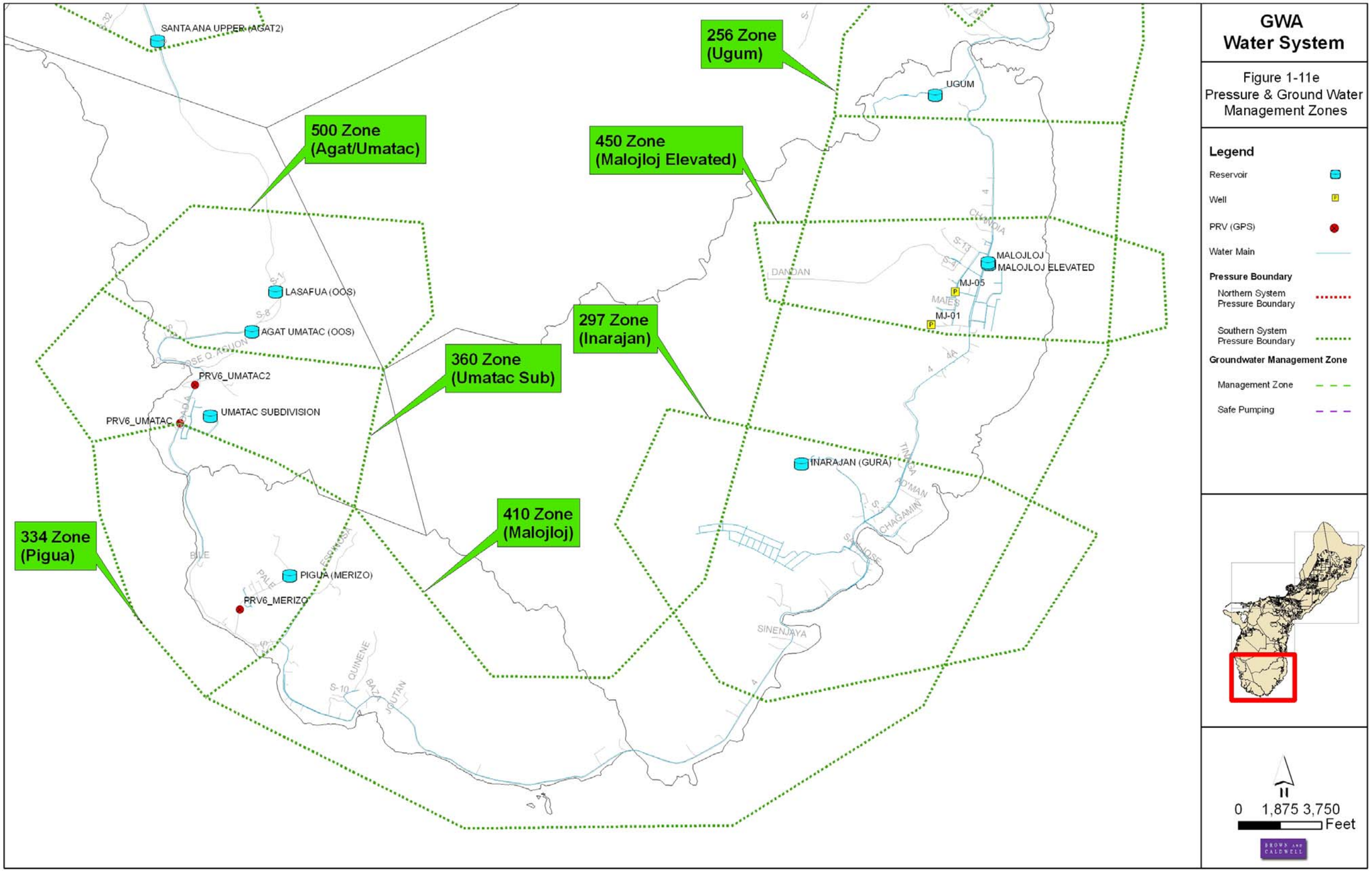
- Reservoir
- Well
- PRV (GPS)
- Water Main

Pressure Boundary

- Northern System Pressure Boundary
- Southern System Pressure Boundary

Groundwater Management Zone

- Management Zone
- Safe Pumping


256 Zone (Ugum)
500 Zone (Agat/Umatac)
450 Zone (Malojloj Elevated)
297 Zone (Inarajan)
360 Zone (Umatac Sub)
410 Zone (Malojloj)
334 Zone (Pigua)
SANTA ANA UPPER (AGAT2)
UGUM
LASAFUA (OOS)
AGAT UMATAC (OOS)
PRV6_UMATAC2
UMATAC SUBDIVISION
PRV6_UMATAC
MALOJLOJ
MALOJLOJ ELEVATED
MJ-05
MJ-01
INARAJAN (GURA)
PIGUA (MERIZO)
PRV6_MERIZO
DANDAN
SINENJAYA
QUINENE
GWA Water System
Figure 1-11e
Pressure & Ground Water Management Zones
Legend
Reservoir
Well
PRV (GPS)
Water Main
Pressure Boundary
Northern System Pressure Boundary
Southern System Pressure Boundary
Groundwater Management Zone
Management Zone
Safe Pumping
0 1,875 3,750
Feet
BROWN AND CALDWELL

The PRVs that have been located by GWA and confirmed to be currently in use is provided in Table 1-12, which includes its identifying name, upstream and downstream pressure zones it serves, street location, and PRV and line size. The number for the pressure zone is representative of the overflow elevation of the reservoir serving that zone.

Table 1-12 – Pressure Reducing Valve Stations

No.	Name	High Pressure Zone	Low Pressure Zone	Street	PRV Size	Line Size
1	PRV10_6_12_RTE3	570 Ysengsong	408 Kaiser	Along Route 3 & South of Swamp	10	12
2	PRV8_RTE15TAKANO	728 Yigo Elevated/Santa Rosa	658 Yigo	Route 15 & Trebor	8	12
3	PRV-UKWN SIZE- Road into Tumon from Rte 1	408 Kaiser	236 Piti/Tumon	Pale San Vitores	N/A	12
4	PRV-12_UPP TUMON	408 Kaiser	236 Piti/Tumon	Along Route 1 near to Adrian Sanchez St.	12	16
5	PRV-6_UPP TUMON1	408 Kaiser	236 Piti/Tumon	Along Route 1 near Adrian Sanchez St.	6	8
6	PRV-10_UPP TUMON2	408 Kaiser	236 Piti/Tumon	Along Adrian Sanchez St. near to Route 1	10	14
7	PRV_UKNSIZE-AIRFUELT	481 Barrigada	381 Mangilao/ Chaot	Along Route 10A west of Route 16 intersection	N/A	12
8	PRV6_AIRPORT	381 Mangilao/ Chaot	Micronesian Hospitality Institute	Along Route 10a & Northeast of Chalan Pasaheru	6	8 to 12 (need confirmation)
9	PRV6_RT16	670 Hyundai	481 Barrigada	Route 16 & N. Sabana Barrigada	6	16
10	PRV8_RTE16	670 Hyundai	481 Barrigada	Route 16 & N. Sabana Barrigada	8	16
11	PRV10_4_RTE15	658 Yigo	481 Barrigada	Route 15 & Street S-3	10	12 to 24 (need confirmation)
12	PRV12_RTE15	658 Yigo	481 Barrigada	Route 15 & Marbo Cave	12	12
13	PRV_UKNSIZE_TIYAN	481 Barrigada	381 Mangilao/ Chaot	Along Route 16 southwest of intersection with Sabana Barrigada	N/A	16
14	PRV4_10_MAIMAI-RD1	381 Mangilao/ Chaot	236 Piti/Tumon	North of Dairy Road & East of Eging Dr.	10	12
15	PRV12_MAIMAI-RD	381 Mangilao/ Chaot	381 Mangilao/ Chaot	Along Dairy Road & West of Route 10	12	16

Table 1-12 – Pressure Reducing Valve Stations (continued)

No.	Name	High Pressure Zone	Low Pressure Zone	Street	PRV Size	Line Size
16	PRV_12_ORDOT MAYORS	381 Mangilao/Chaot	381 Mangilao/Chaot	Along Dero Rd & Judge Sablan St.	12	12
17	PRV8_RTE15	481 Barrigada	381 Mangilao/ Chaot	Along Route 15 at Terao	8	16
18	PRV_8-MARIANO ST	381 Mangilao/ Chaot	381 Mangilao/ Chaot	Along Jesus Mariano and Route 10	8	8 to 16 (need confirmation)
19	PRV_NIMITZHILL_1OF3	Navy Nimitz Hill	Navy Nimitz Hill	Nimitz Dr. near Route 6	6	6
20	PRV_NIMITZHILL_2OF3	Navy Nimitz Hill	Navy Nimitz Hill	Nimitz Dr. near Guaifon Circle	6	6
21	PRV_NIMITZHILL_3OF3	Navy Nimitz Hill	Navy Nimitz Hill	Nimitz Dr. near Acho Circle	6	6
22	PRV12_SANTA-RITA	275 Truman #2	236 Agat #1	Along Route 12 & Pale Ferdinan Way	12	16
23	PRV8_SANTA-RITA2 (Not in use – valve closed)	275 Truman #2	Subarea along Pale Ferdinan Way	Along Pale Ferdinan & East of Santa Maria Ave.	8	8
24	PRV8_SANTA-RITA1 (Not in use – valve closed)	275 Truman #2	Subarea along Pale Ferdinan Way	Along Pale Ferdinan & East of Santa Rosa Ave.	8	8
25	PRV6_SANTA-RITA	275 Truman #2	Truman Elementary School	Along Pale Ferdinan & East of Santa Rosa Ave. (East of PRV8_SANTA-RITA1)	6	6
26	PRV-12_SOUTHERNHIGH	517 Truman #1	275 Truman #2	Along Pale Ferdinan & West of Sumay Memorial	12	12
27	PRV6_SANTA-RITA-NAMO	392 Santa Rita	275 Truman #2	Along Route 12 & Annex	6	8
28	PRV8_SANTA-RITA	392 Santa Rita	236 Agat #1	Along Pale De Leon St., west of Chalan Pale Duenas Haya	8	12

Table 1-12 – Pressure Reducing Valve Stations (continued)

No.	Name	High Pressure Zone	Low Pressure Zone	Street	PRV Size	Line Size
29	PRV12_AGAT	392 Santa Rita	236 Agat #1	Along Erskin & Duenas	12	12
30	PRV-16_Near Truman booster	517 Truman #1	517 Truman #1	Along Sumay Memorial	16	16
31	PRV at previous Sinifa BPS	725 Sinifa	517 Truman #1	Along Route 17	N/A	12
32	PRV12 WINDWARDHILLS	725 (Sinifa)	444 Windward Hills	Along Route 17 & East of Fairway Dr.	12	12
33	PRV8_AT-SEMINARY-YON	420 Pulantat	256 Ugum	Along Route 4 & North of Route 17	8	12 to 16 (need confirmation)
34	PRV8_YONA	420 Pulantat	256 Ugum	Along Route 4 & South of Route 17	8	12 to 16 (need confirmation)
35	PRV6_UMATAC2	500 Agat/ Umatac	360 Umatac Sub	Along Route 4 & South of Jose S. Quinata	6	6 to 12 (need confirmation)
36	PRV6_UMATAC	360 Umatac Sub	334 Pigua	Along Route 4 & Jesus A. Quidachay	6	12
37	PRV6_MERIZO	334 Pigua	334 Pigua	Along Chalan Joseph A. Cruz & North of Route 4	6	8

1.5 Water Booster Pump Stations

There are 35 water booster pump stations, with six of the pump stations out of service or on standby. These booster stations are listed in Table 1-13 and shown on Figure 1-12. The water booster pump stations help maintain in-line pressure, fill reservoirs and serve small communities where a reservoir is not available. The pump stations also serve as a means of dividing one pressure zone from another, particularly when there is no reservoir serving that pressure zone.

Many of the booster stations have diesel-powered, emergency generators on-site. Most of the emergency generators are the responsibility of GPA, but some are operated and maintained by GWA. Generators operated by GPA have outside diesel fuel storage, whereas those operated by GWA have inside diesel storage.

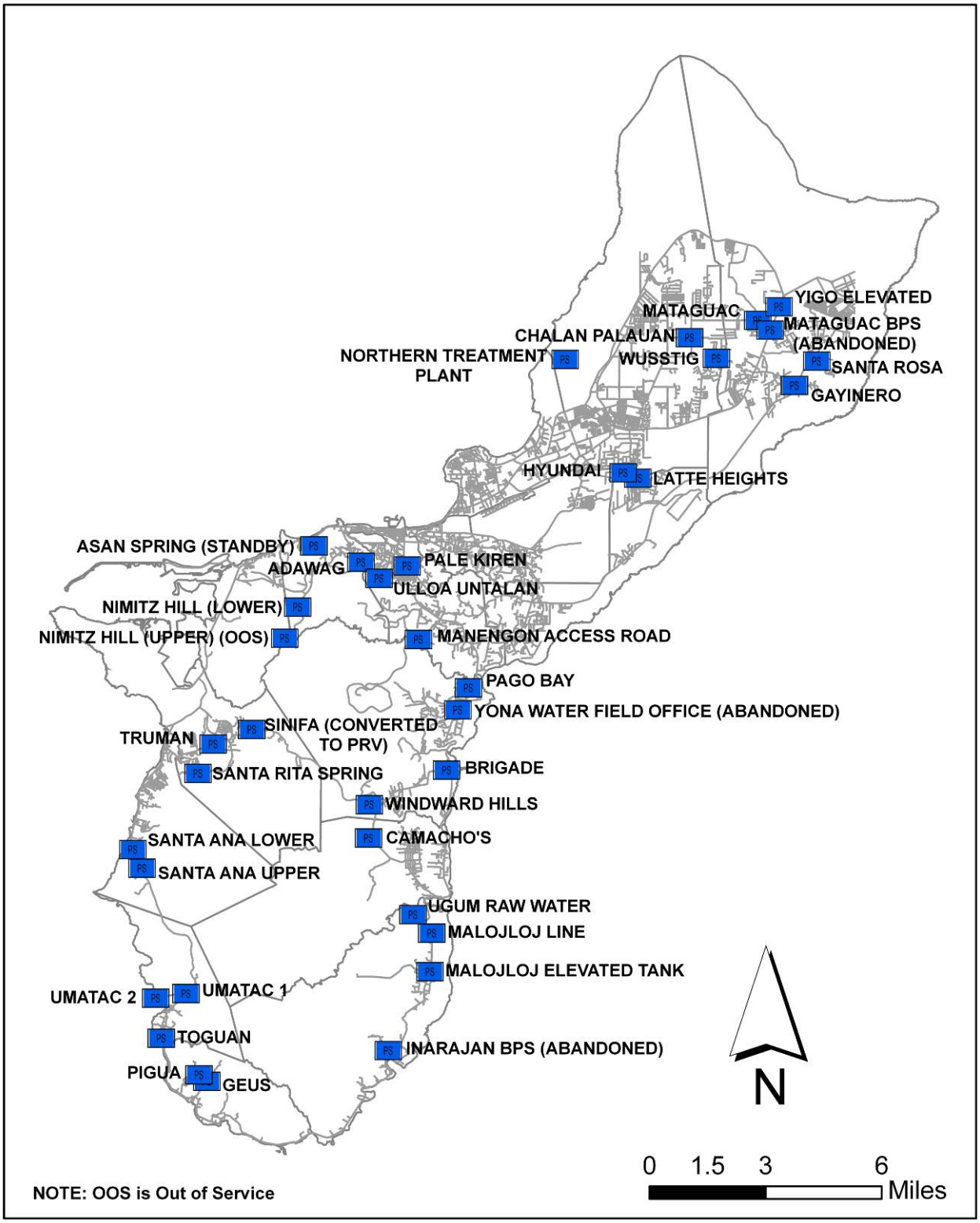
Table 1-13 – GWA Water Booster Pump Stations

Name	Water Source	Capacity				Areas Served
		Qty Pumps	Capacity per pump, gpm	HP	TDH, feet	
Northern System						
Chalan Palauan (Astumbo) Booster	Wells feeding into Ysengsong #1 1.0 M.G. & Ysengsong #2 2.0. M.G. Reservoirs	1	5	1.5	N/A	Chalan Palauan Area
Gayinero Booster	Y-series wells	2	350	15	120	Boost water through a 12-inch waterline to 1.0 M.G. Santa Rosa Reservoir
Hyundai Booster	M- and D-Series Wells	2	600	50	260	Hyundai Reservoir
Latte Heights Booster	Wells feeding into Barrigada #2 and #3 Reservoirs	3	550	15	60	Mangilao #1 and #2 Reservoirs. Areas served need to be confirmed.
Mataguac Booster (New)	Y-Series Wells	3	300	25	210	Chalan Maanao to upper portion of Wusstig area
Mataguac Booster (Old) (Abandoned)	Out-of-Service	--	--	--	--	Abandoned Booster Station
Northern Treatment Plant Booster	Well H-1 (Harmon)	1	25	15	N/A	Northern WWTP and NCS Beach
Santa Rosa Booster	Y-15 Well	2	85	10	230	Upper Santa Rosa area.
Wusstig Booster	Y-Series Wells	1	125	15	120	Upper Wusstig area.
Yigo Elevated Tank Booster	Yigo #2 Reservoir	2	100	5	130	Chalan Emsley area through the 0.1 M.G. elevated tank.
Central System						
Adawag Booster	A-Series and Navy Source	1	15	10	N/A	Upper Adawag area.
Asan Spring Booster (Standby)	Asan Springs (Out-of-Service)	3	280	10	85	Asan Village
Camacho's Booster	Northern Wells through Windward Hills #2 Rsvr.	1	40	1	140	Camacho's Compound.
Manengon Access Road Booster	A- and M-Series Wells.	3	650	60	N/A 240 210	Manengon 2.0 Reservoir
Nimitz Hill (Lower) Booster	Navy water supply.	2	50	5	85	Nimitz Hill Lower Reservoir.
Nimitz Hill Booster (Upper) (Out-of-Service)	Navy water supply from the Lower Nimitz Reservoir.	2	22	5	N/A	Nimitz Hill Upper Reservoir.
Pale Kiren Booster	A- and M-Series Wells	1	130	7.5	67	Sinajana High Elevation area.
Yona Water Field Office Booster (Abandoned)	Out-of-Service	-	--	--	--	Abandoned Booster Station
Ulloa/Untalan Booster	A-Series Wells	1	5	1.5	140	Ulloa Residence at high elevation.

Table 1-13 – GWA Water Booster Pump Stations (continued)

Name	Water Source	Capacity				Areas Served
		Qty Pumps	Capacity per pump, gpm	HP	TDH, feet	
Southern System						
Brigade Booster	Northern Wells or dual source with Ugum WTP.	3	800	100	340	Windward Hills #2 Reservoir and Windward Booster
Geus Booster	Ugum WTP	3	400	25	185	Upper Pigua area and 0.5 M.G. Reservoir
Inarajan Booster (Abandoned)	Ugum WTP	--	--	--	--	Inarajan Reservoir.
Malojloj Line Booster	Ugum WTP	2 1	540 200	40 20	190	Malojloj 1.0 M.G. Reservoir
Malojloj Elevated Tank Booster	Ugum WTP through Malojloj Line Booster	3	250	10	N/A	Boosts water to the 0.075 M.G. Malojloj Elevated Reservoir
Pago Bay Booster	Northern & Central Wells	3	1,100	75	240	Portion of Yona area and Brigade Booster Pump.
Pigua Booster	Ugum WTP	1	80	5	150	Pigua Subdivision and Land for the Landless
Santa Ana Lower Booster	Navy water supply or Santa Rita Springs.	1	300	25	375	Upper Agat area.
Santa Ana Upper Booster	Navy water supply or Santa Rita Springs.	3	350	50	140	Santa Ana (Agat) #2 Reservoir.
Santa Rita Springs Booster.	Navy water supply and Santa Rita Spring.	2	650	40	185	Santa Rita Reservoir.
Sinifa Booster (Converted to PRV, Abandoned)	Navy water supply through Truman/Lower Apra Heights Booster.	--	--	--	--	Sinifa Reservoir.
Toguan Booster	Ugum WTP	2	N/A	15/25	N/A	Umatac Reservoir #2.
Truman Booster	Navy water supply or Santa Rita Springs.	1 1 1	180 200 400	10 30 50	290 430 430	Sinifa Booster Pump Station.
Umatac #1 Booster	Ugum WTP	No Data	--	--	--	Lasafua Reservoir
Umatac #2 Booster	Ugum WTP	2	N/A	10 7.5	N/A N/A	Umatac Reservoir #1 and Agat Elevated Reservoir.
Windward Hills Booster	Northern water wells or Ugum WTP	3	400	60	400	Sinifa Reservoir.

Figure 1-12 – GWA Booster Pump Station Locations



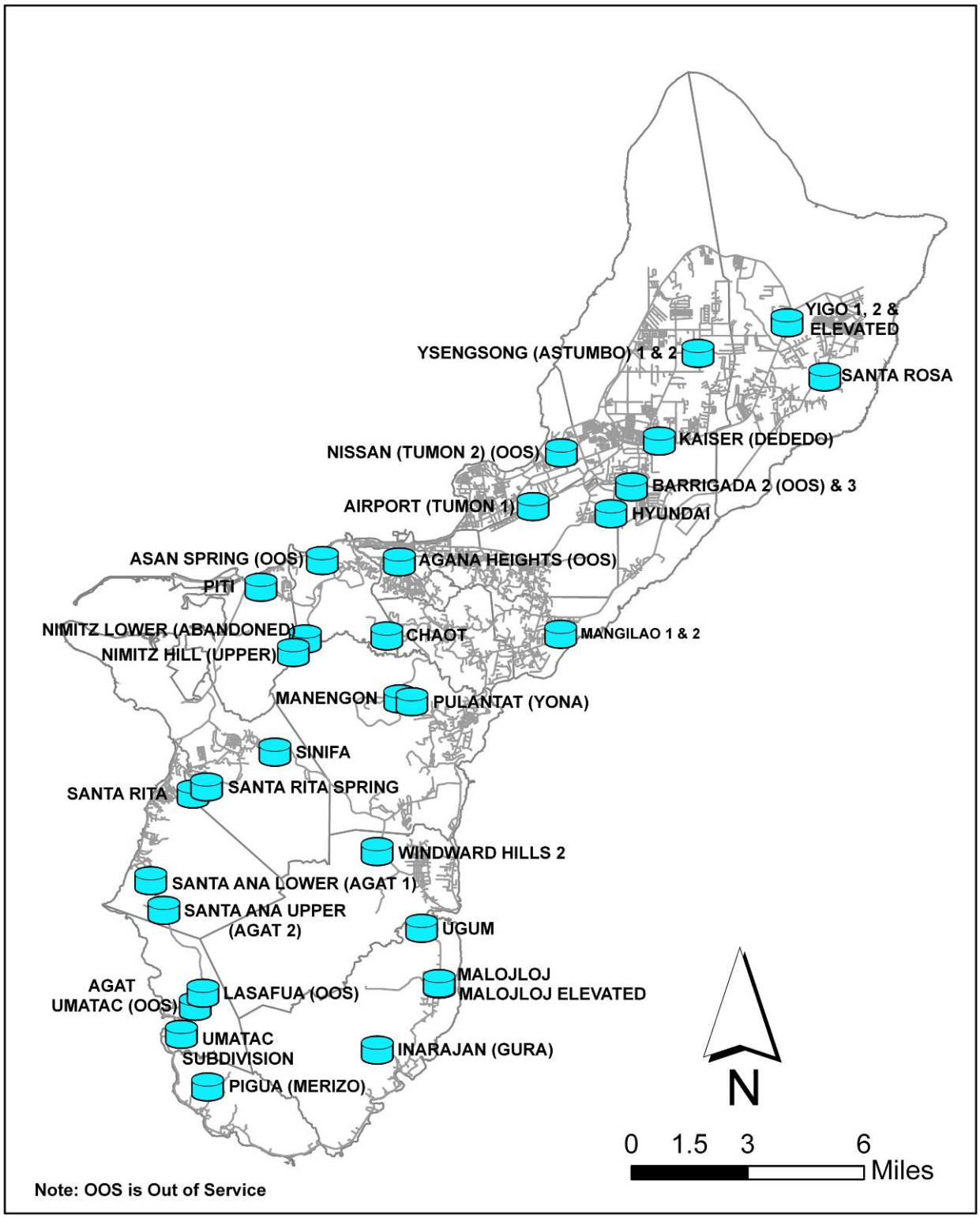
1.6 Reservoirs

Reservoirs consist of ground-level and elevated tanks. The elevated tanks have on-site booster stations to supply water. A list of the GWA's reservoirs is provided in Table 1-14 and shown on Figure 1-13. As previously mentioned, the overflow elevation (rounded to the nearest foot) for the reservoir is used to indicate the pressure zone served by the specific reservoir, i.e., 481 Barrigada.

Table 1-14 – GWA Reservoirs

Reservoir Name	Capacity, million gallons	Height, feet	Overflow elevation, feet	Floor elevation, feet	Comment
Northern System					
Airport (Tumon #1)	1.0	40.0	236.00	196.00	
Barrigada #2	2.0	40.0	497.80	457.80	Out of service
Barrigada #3	3.0	40.0	481.50	441.50	
Hyundai	1.0	40.0	670.00	630.00	
Kaiser Dededo	2.5	40.0	408.00	368.00	
Mangilao #1	1.0	40.0	381.60	341.60	Out of service
Mangilao #2	2.0	40.0	381.60	341.60	
Nissan (Tumon #2)	1.0	40.0	252.60	212.60	Out of service
Santa Rosa	1.0	40.0	724.00	684.00	
Yigo #1	0.5	40.0	658.00	618.00	
Yigo #2	2.5	40.0	658.00	618.00	
Yigo Elevated	0.1	--	728.75	704.75	
Ysengsong #1 (Astumbo #1)	1.0	40.0	570.00	530.00	
Ysengsong #2 (Astumbo #2)	2.0	40.0	570.00	530.00	
Central System					
Agana Heights	1.0	40.0	236.00	196.00	Out of service
Asan Spring	0.1	10.7	146.70	136.70	Out of service
Chaot	1.0	32.1	381.60	349.50	
Manengon	2.0	40.0	434.50	394.50	
Nimitz, Lower	0.005	*No Data*			Abandoned
Nimitz Hill (Upper)	0.010	*No Data*			
Piti	1.0	40.0	236.00	196.00	
Pulantat (Yona)	1.0	65.0	420.00	355.00	
Southern System					
Agat-Umatac	0.2	24.0	404.75	380.75	Out of service
Inarajan (Gura)	0.2	24.0	297.50	273.50	
Lasafua	0.03	8.	428.00	420.00	Out of service
Malojloj	1.0	40.0	410.70	370.70	
Malojloj Elevated	0.075	--	450.75	370.75	
Pigua (Merizo)	0.5	40.0	334.00	294.00	
Santa Ana Lower (Agat #1)	1.0	40.0	236.00	196.00	
Santa Ana Upper (Agat #2)	0.5	40.0	470.00	430.00	
Santa Rita	1.0	40.0	392.00	352.00	
Santa Rita Spring	0.104	Not Applicable	300.00	293.00	
Sinifa	1.0	40.0	765.00	725.00	
Ugum	2.0	40.0	256.40	216.40	
Umatac Subdivision	0.5	40.0	360.00	320.00	
Windward Hills #2	1.0	40.0	444.00	404.00	

Figure 1-13 – GWA Reservoir Locations



1.7 Hydraulic Profile

A hydraulic profile illustrating the connection and elevation relationships of the aforementioned reservoirs, booster pump stations and pressure reducing valve stations is provided on Figure 1-14 for the northern system and Figure 1-15 for the south and central water systems. The sizes of water mains connecting the BPS to reservoirs are also indicated on the hydraulic profiles, as well as selected water sources and service areas.

1.8 Conclusions

The following conclusions can be drawn from the assessment of the current design of GWA's water system:

- GWA operates and maintains over 200 water facilities and over 120 chlorination systems.
- Chlorine disinfection is the only barrier to microbiological contamination for the northern lens potable water supply.
- Reliability of the disinfection system has improved during the past two years.
- The entire water supply and distribution system is operated manually, requiring an operator to be physically present to start and stop pumps, adjust chemical feed and record information.
- There are high chloride levels in some wells due potentially to overpumping.
- The full capacity of the Ugum WTP is limited by seasonal fluctuations in the Ugum River flow and the need to maintain minimum stream flow and physical damage to one of the four process trains.
- Only one finished water reservoir is available at the Ugum WTP.
- The reservoirs (see Volume I, Chapter 11) show significant corrosion.
- Transmission and distribution are combined in the same pipe affecting well pump efficiency and disinfection control.

1.9 Recommendations

The following recommendations are made for addressing existing water system deficiencies:

- GWA must continue to give chlorine disinfection operation and maintenance a high priority.
- Wells showing high chloride levels should be evaluated to determine if a reduced pumping rate will lower the chloride levels.
- Wells with higher pumping rates than the GEPA permitted levels, but with consistent chloride levels that are below the MCL, should be discussed petitioned with GEPA for having their pumping rates increased to a higher allowable level.
- A corrosion control program and prioritization program should be developed, particularly for the reservoirs.
- SCADA improvements should be initiated to provide better control over the water supply and distribution system.

- Separate transmission and distribution lines should be constructed.
- Upgrade the Ugum WTP to its full capacity of 4.0 mgd.
- Improve the water intake at Ugum WTP to reduce the impact of siltation on raw water quality.
- Acquire land and plan for raw water storage at Ugum WTP to accommodate low river flow periods.

1.10 CIP Impacts

Some of the recommendations in the previous section have been developed into specific projects, which are included in the 20-year CIP presented in Chapter 9 and in Volume 1, Chapter 15. These projects are summarized below:

- Conversion of Ugum WTP to a 4.0 mgd membrane filtration facility.
- Modification of the Ugum WTP intake at the diversion in the Ugum River.
- Transmission line construction.
- SCADA improvements.
- Corrosion control program.
- Raw water storage land acquisition and reservoir construction at Ugum WTP.

Figure 1-14 – Hydraulic Profile for North Network

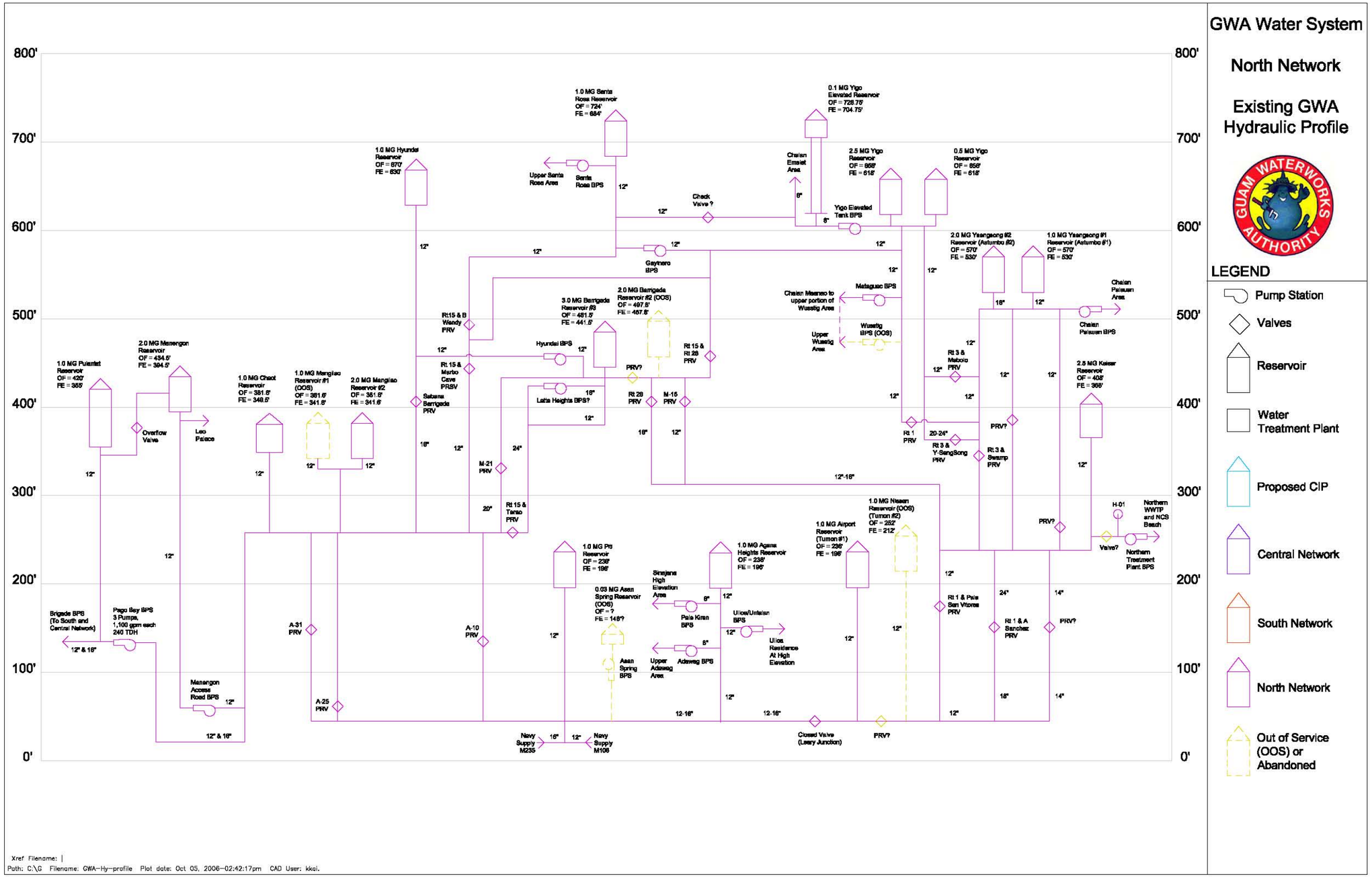
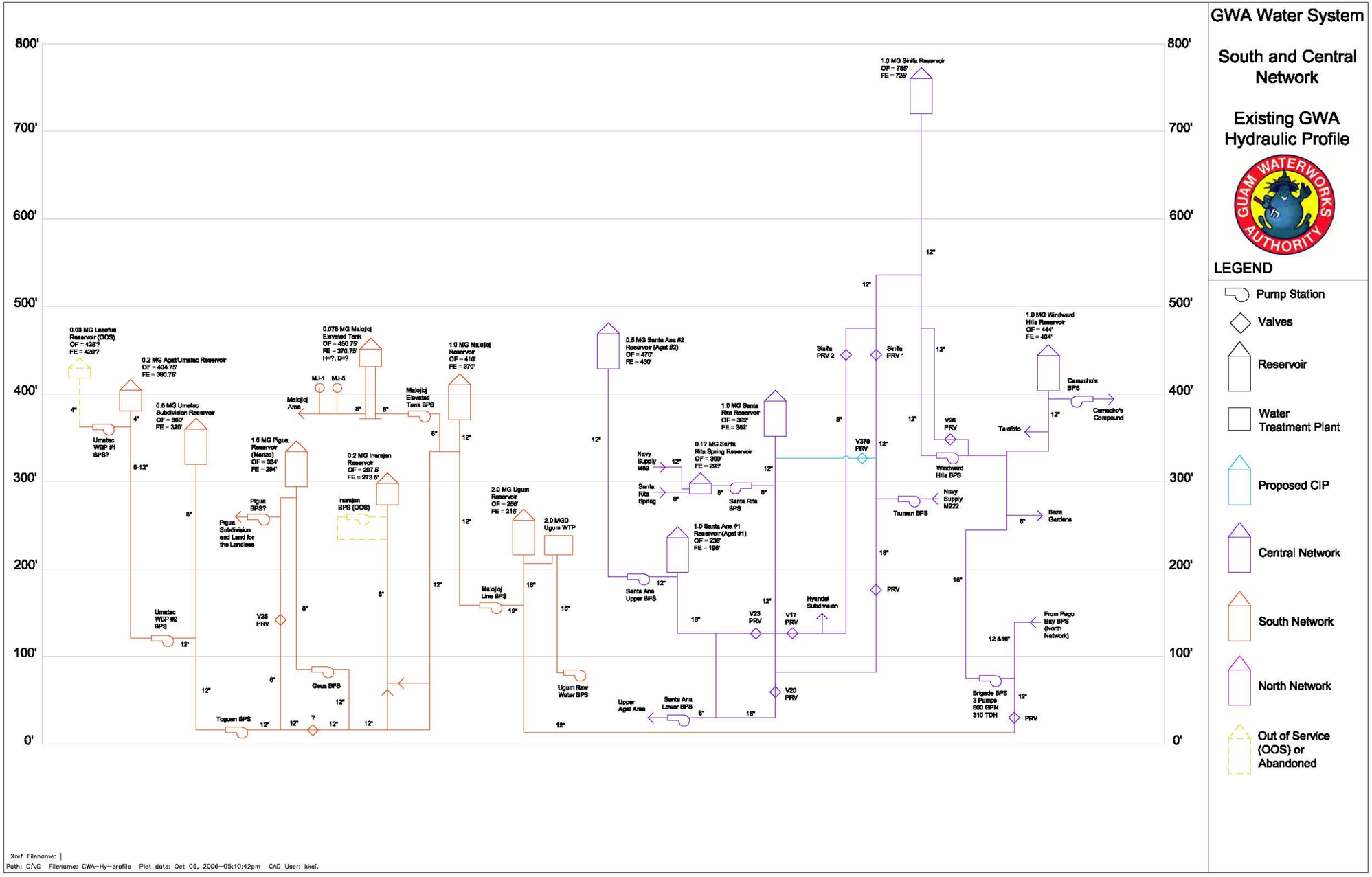


Figure 1-15 – Hydraulic Profile for South and Central Network



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