CHAPTER 4 – WASTEWATER COLLECTION SYSTEM

4.1 Introduction

The Wastewater Collection System Assessment is intended to develop a program that address the requirements of the EPA NOV issued for frequent spills and poor condition of the existing system. The programs developed will identify and describe projects that will reduce Inflow and Infiltration (I/I) and provide adequate capacity for the current and expected future development conditions.

4.1.1 Objectives

The key objectives of this chapter include:

- Provide a background of the existing system and programs
- Develop a prioritized inspection and maintenance program
- Evaluate the current hydraulic capacity and
- Identify potential CIP projects for the 20-year CIP

4.2 Existing Collection System

4.2.1 System Description/Overview

Construction of the existing GWA collection system began in the mid-1960's. The collection system consists of approximately 1,420,000 feet of gravity sewer pipes, 77 forcemains that total approximately 240,000 feet, six siphons that total 650 feet and 3 ocean outfalls that total 12,000 feet. There are approximately 6,480 manholes and 77 pump or ejector stations (70 of which have been accounted for by GWA staff field GPS location).

The collection system is divided into six major service areas identified by the wastewater treatment system to which the wastewater is transmitted. The largest service areas are located in the northern and central parts of the island and bring wastewater to the Northern District STP (NDSTP), the Hagatna STP, and the Agat STP.

4.2.2 Gravity Sewers

The largest component of the collection system is the gravity sewer system. Of the approximately 1,420,000 feet of installed gravity sewer pipes, the sizes range from 4 to 48 inches in diameter with a majority of the pipes being 8-inch diameter. Based on information available in the GIS system, the size distribution of the existing gravity sewer pipes is as follows:

- < 8" – approximately 110,00 feet
- 8" – approximately 800,000 feet
- 10" to 15" – approximately 270,000 feet
- >15" – approximately 230,000 feet
- Unknown – approximately 8,000 feet

Information available in the GIS was used to determine the sewer pipe materials of construction, however there appear to be discrepancies between some of the GIS information and what is believed to be in place. It is recommended that the materials of construction be verified and, if necessary, updated in the GIS database. The best information to date shows the following materials and estimated quantities in service in the GWA collection system: (note: for ranking purposes CIPC, PCP and RCP were grouped together as concrete pipes; CIP and DIP were grouped together as iron pipes; PEP and PVC were grouped together as plastic pipes; and TCP and VCP were grouped together as clay pipes).

- Asbestos Concrete Pipe (ACP): approximately 460,000 feet
- Cast In Place Concrete (CIPC): approximately 2,000 feet
- Polymer Concrete Pipe (PCP): approximately 200 feet
- Reinforced Concrete Pipe (RCP): approximately 11,000 feet
- Cast Iron Pipe (CIP): approximately 5,000 feet
- Ductile Iron Pipe (DIP): approximately 800 feet
- Polyethylene Pipe (PEP): approximately 600 feet
- Polyvinylchloride (PVC): approximately 580,000 feet
- Terracotta Pipe (TCP): approximately 400 feet
- Vitrified Clay Pipe (VCP): approximately 100 feet
- Unknown: approximately 360,000 feet

4.2.3 Pump Stations/Forcemains

The GIS identifies 77 forcemains associated with the 77 pump stations or ejector stations (GWA staff has verified 70 of those pump stations using GPS). The pump stations and ejector stations are generally spread evenly between the north, central and southern parts of the island. The forcemains range in diameter from 2 to 36 inches with 28 forcemains that are greater than 1,000 feet in length.

4.2.4 Manholes

There are approximately 6,500 manholes in the collection system, about 6,300 of which are standard manholes, 200 are drop manholes, 20 are shallow drop manholes and two are pressure manholes. The chamber material used for the majority of the manholes is concrete.

4.2.5 Laterals

The wastewater lateral connects each individual wastewater discharger to the collection system. A typical lateral consists of a four-inch cleanout at the discharger's property line and a six-inch line that connects to the sewer main. There are approximately 13,400 laterals that range in diameter from four inches to eight inches; however the majority of the laterals are six inches in diameter. Laterals were not specifically evaluated during the collection system maintenance prioritization.

4.3 Completed Work/Existing Programs

4.3.1 Completed Manhole Inspections

GWA, in conjunction with MGD Technologies has completed inspection of just over 300 manholes targeting the known problem areas and large diameter (>10-inch diameter) portions of the collection system. The inspections included visual inspection from grade, photographs of the manhole chamber and up each of the influent and effluent pipes, and conductivity measurements. The inspections and findings are described in more detail in Section 4.6.1.

4.3.2 Flushing Program

Currently GWA performs flushing of the gravity collection system on an as-needed basis which is generally determined by reports of flow surcharging or spills. Recommendations for a more proactive flushing program are described in Section 4.8.

4.4 Critical Sewer Assessment

Fieldwork such as manhole inspections, smoke testing, or closed circuit TV (CCTV) is needed in a perpetual effort to obtain additional data on the collection system in order to complete a comprehensive sewer condition analysis and determine the scope of rehabilitation projects. The wastewater collection system is a dynamic system with its condition changing over time. For this reason, collected field data regarding the condition of a particular sewer segment may have a limited applicable lifetime. In addition, fieldwork is costly and time consuming. In order to optimize the value of field data, fieldwork should be focused on areas that are expected to require the most immediate attention with respect to maintaining the integrity of the sewer system and mitigation of wastewater spills. This section presents the assessment approach used to recommend and prioritize sewer inspection and data gathering processes for GWA's gravity wastewater collection system. The assessment approach uses the concept of critical sewers.

Critical sewers are pipelines that have a high risk and/or consequence of failure. Comparison of the risk and consequence of failure for different sewers allows development of a prioritized data gathering and assessment program to protect against unexpected spills and structural collapse. The degree of risk or consequence of a failure will help to determine the urgency of conducting detailed inspection, assessment, and corrective work on the sewer. Sewers that have no apparent risk or consequence of failure are considered non-critical (non-problem) and will not be recommended for additional field investigation, but will be addressed by the GWA's normal preventive maintenance program.

4.4.1 Risk of Failure

Risk of failure describes the likelihood that a component of the collection system will fail with respect to meeting the goals of the wastewater program. A failure may be defined as a wastewater spill, pipe collapse, or sewers that require excessive preventive maintenance to keep the system operable.

Spills can be classified as dry weather spills or wet weather spills. Dry weather spills are usually attributed to structural or operational failure of the collection system, such as a collapse or a root or grease blockage. Occasionally third party causes (e.g. unrelated construction that damages or breaks a sewer line) will generate dry weather spills. Wet weather spills are most often due to hydraulic failures such as excessive inflow or infiltration or limitations in the capacity of the sewer line.

The mechanisms of failure can be broken into two general categories, structural or operational. Pipes that are at a high risk of failure typically have identified structural or operational failure mechanisms or may be thought to be susceptible to them. The two types of failure mechanisms are described in the following sections.

4.4.1.1 Structural Failure Mechanisms

The structural integrity of the collection system can fail in various ways leading to spills and even street collapses. Fortunately, potential structural failure mechanisms can often be identified by early visual inspection. Pipes that have a high risk of failure due to a structural mechanism tend to exhibit at least one of the following conditions:

- Cracks or breaks – may indicate a structurally compromised condition and allow infiltration
- Infiltration – fresh or salt water entering a gravity sewer, usually through cracks, holes or offset joints, can cause a migration of the surrounding soil into the pipe
- Sags – gravity lines with low points may allow settlement of debris or grease collection if the line flows full
- Joint misalignment – may allow infiltration and inadvertent soil removal around the pipe joint
- Corrosion – most commonly affects unlined concrete or metal conduits and compromises the integrity of the structure, reducing the useful life

4.4.1.2 Operational Failure Mechanisms

Potential failure points due to operational mechanisms are not always identifiable by visual inspection. Pipes with a high risk of a failure due to an operational mechanism will usually exhibit one or more of the following characteristics.

4.4.1.2.1 *High Maintenance.* Areas that require frequent preventive maintenance are at a higher risk of having/causing a failure. Maintenance problems may be due to faulty construction or by the nature of the area serviced. Some of the factors that cause maintenance problems include:

- Grease – commonly found in areas with a high restaurant density or in sewer lines that have sags which can trap grease
- Roots – commonly a problem in private property easements or other areas where trees may be growing in close proximity to sewer lines
- Debris – may indicate broken or misaligned pipe upstream allowing migration of the surrounding soil, or pipe bedding material, into the pipe

4.4.1.2.2 *Spill Incidents.* Areas that have a record of repeat dry weather spills are at especially high risk of future failures. Review of spill records provides an indication of areas that are more likely to be future spill points.

4.4.2 Consequence of Failure

A sewer's consequence of failure describes the magnitude of the effect that a failure in the system will have on public health, the environment, operation of the collection system, everyday business, commercial, or emergency activity. The major factors that affect the consequence of failure are described below.

4.4.2.1 Spill Area Sensitivity

A major consideration in weighing the consequence of a failure is the location where the spilled wastewater will end up. Spill locations where untreated wastewater will likely make contact with a water body are more sensitive than locations where the spill can be contained or confined to the ground. Likewise, the location and the use of the area dictate the relative sensitivity of spills that reach a waterway. The most sensitive areas include:

- Potable water supplies
- Identified sensitive water/nature or wildlife preserves
- Swimming beaches
- Schools
- Public parks

4.4.2.2 Potential Spill Size

Generally, larger diameter pipes carry larger flows and will therefore be more likely to create larger spills. In addition, these pipes have a higher cost of construction, are more difficult to bypass, and impact a greater number of people when out of service.

4.4.2.3 Repair Difficulty

The cost of a failure and the time it takes to repair the collection system are dependent upon the difficulty of the repair location. The cost of the failure includes direct costs associated with the repair work, and indirect costs incurred by traffic disruption, or the loss of business to commercial areas that may have restricted access during construction work. Factors that affect the repair difficulty include:

- Stream or waterway crossings – sewers located near bodies of water have a high consequence of failure since a spill could lead to major environmental damage
- Highway crossings – a sewer failure along a critical traffic route would impede traffic (and possibly emergency services) and would have high direct and indirect costs
- Pipe depth – pipes installed deeper than 25 feet have a high consequence of failure because excavation to those depths requires larger equipment and extensive shoring
- Ground conditions – poor soil conditions (i.e. running sand, saturated silts) would require soil stabilization, dewatering, or special supporting measures which increase construction time and costs

4.5 Critical Sewer Assessment Rating

The relative risk of failure and consequence of failure for each pipe reach was determined using a numerical rating system. The rating system, presented in the next section, is based on the review of information available as of September 15, 2006.

4.5.1 Available Information

Available information, including on-going operation, inspection data, and maintenance activities performed by GWA or outside contractors was evaluated for the critical sewer assessment. ArcView®, GIS viewing program, was one of the essential tools used to analyze the available data. ArcView® was used to view various attributes of the collection system and inspection data simultaneously. Relationships between the various data were evaluated to develop the critical sewer rating system criteria. Available information included:

- Sewer inventory data (available through September 2006)
- Spill records
- Locations of water supply wells, businesses, schools, swimming beaches and parks
- Highways and major streets

4.5.2 Risk of Failure

The risk of failure rating is developed based on the potential that a given segment of the gravity collection system might fail. Table 4-1 summarizes the risk of failure ratings.

Table 4-1 - Risk of Failure

Category	Numerical Rating		
	0	5	10
Age of Pipe	Constructed after 1990	Constructed between 1975 and 1990, or "unknown"	Constructed before 1975
Diameter of Pipe	Larger than 8 inches	8 inches, or "unknown"	Less than 8 inches
Down Stream Forcemain	Non-corrosive pipe(Clay or PVC)		Corrosive Pipe (Concrete or Cast/DuctileIron)
Material	PVC	Reinforced Concrete or Cast/Ductile Iron or "unknown"	Asbestos Concrete or Clay
Ground Water	Invert greater than 2.5 feet above mean sea level	"Unknown"	Invert less than 2.5 mean sea level

4.5.2.1 Sewer Inventory Data

The inventory data used in this evaluation is what was available through September 15, 2006 from the GWA sewer database. The GWA sewer database was created by GWA and Duenas and Associates and is based on as-built USGS maps and available survey information. The database is actively being updated to create a more accurate database of collection system conditions. The following inventory data was used for the risk assessment (For the purpose of this assessment, where information was missing from the database, assumptions were made based on information from adjacent areas. In some areas there was insufficient information to make assumptions, in which case the information was considered as "unknown."):

- Pipe size
- Pipe material
- Pipes located downstream of a force main
- Construction date
- Pipe Invert elevation
- Pipes located within 1,000 feet of a potable water well
- Pipes located within the groundwater protection zone

Note: The complete sets of Sewer Inventory Figures Exhibit 4A.1a-e through Figures 4A.6a-e are included at the end of the chapter.

4.5.2.1.1 <u>*Pipe Size.*</u> The GWA collection system sewer lines range in size from 4-inch to 48-inch diameter pipes. The vast majority of sewer lines are 8-inch in diameter, which is not uncommon for a relatively small collection system. There are 4-inch and 6-inch diameter pipes throughout the collection system. Today, 6-inch diameter and smaller pipes are considered substandard and have been found to be more prone to operational failures than larger lines. Therefore, these small lines are rated relatively high for their risk of failure (see Exhibit 4A.1a to 1e – Pipe Diameter).

4.5.2.1.2 <u>*Pipe Material.*</u> The GWA collection system sewers are constructed predominately of PVC and ACP. Other materials, as identified in Section 4.2.2 were identified in the GIS data. Plastic materials, PVC and PEP, are not subject to corrosion, so these materials receive a low risk of failure rating. RCP, CIPC, PCP, CIP and DIP are subject to corrosion by sulfuric acid, a by-product of hydrogen sulfide gas that is generated in the wastewater. Therefore these materials receive a moderate risk of failure rating. ACP and clay pipes receive a high risk of failure rating. Asbestos pipe requires special procedures for repair and maintenance while clay pipes have been found to have a relatively high rate of structural deficiencies within the GWA collection system. Exhibit 4A.2a to 2e – Pipe Material, shows a graphical breakdown of the pipe materials. Listed below are the approximate quantities of each pipe material identified in the GIS (note: For ranking purposes CIPC, PCP and RCP were grouped together as concrete pipes; CIP and DIP were grouped together as iron pipes; PEP and PVC were grouped together as plastic pipes; and TCP and VCP were grouped together as clay pipes):

- ACP – approximately 460,000
- CIPC – approximately 2,400 feet
- PCP – approximately 200 feet
- RCP – approximately 11,000 feet
- CIP – approximately 5,400 feet
- DIP – approximately 800 feet
- PEP – approximately 600 feet
- PVC – approximately 580,000

- TCP – approximately 400 feet
- VCP – approximately 100 feet
- Unknown – approximately 360,000

4.5.2.1.3 *Forcemains*. Sewers located downstream of forcemains may be at risk of corrosion. Generally, there is a higher potential for hydrogen sulfide production in long forcemains, which for this analysis are those longer than 1,000 feet. Discharge from the force main to the sewer tends to cause turbulence that may increase the release of gas phase hydrogen sulfide (H_2S). Unlined concrete and metal sewers are subject to corrosion by sulfuric acid, a by-product of H_2S gas. Therefore sewer pipes composed of these materials and down stream of long forcemains received a high risk of failure rating.

4.5.2.1.4 *Construction Date.* The age of a sewer can be related to its risk of failure. The longer a sewer has been in service, the greater the potential for corrosion, erosion and other pipe degradation to occur. These pipes may therefore have a relatively high risk of failure and be more likely to require rehabilitation or replacement. However, it should be noted that old pipes may often be in excellent condition. Sewer pipes constructed before 1975 were given a high risk of failure rating while pipes constructed between 1975 and 1990 were given a moderate risk of failure rating (see Exhibit 4A.3a to 3e – Pipe Age).

4.5.2.1.5 *Pipe Invert Elevation.* The relative elevation of the invert of a sewer can be related to the risk of failure. The sewer invert elevation information was used to determine which sewer lines were constructed below the groundwater table. Defects in sewers constructed below the groundwater table can allow migration of surrounding soil or bedding material into the sewer. The remaining cavity could lead to structural problems for the sewer pipe, or a collapse of the road or other ground surface above the sewer. Sewers constructed below the groundwater table are also more susceptible to dry weather infiltration. Groundwater is assumed to be at sea level. Due to tidal variations, sewers with invert elevations 2.5 feet msl or below were assigned a high risk of failure rating. Approximately 91,300 feet, or about 6 percent, of the collection system sewer pipes are identified as having invert elevations below 2.5 feet msl. Exhibit 4A.4a to 4e – Pipe Invert Elevation, shows those sewer pipes below the groundwater table.

4.5.2.2 Spill Records

Spill records are helpful to identify repeat problem areas, or those at high risk of producing future overflows. Based on a review of the GWA spill record information that covered the period between February 2003 and June 2005, a great majority of the recorded spills occurred at pump stations (43 of the 48 records) and were related to a power outage or other pump failure condition. The recorded spills from the gravity portion of the collection system (5 of the 48 records) were difficult to relate to a specific point on the collection system due to a lack of information. It is recommended that GWA identify future spills from the collection system with the corresponding manhole number so they can be easily incorporated into the GIS for collection system evaluation.

4.5.3 Consequence of Failure

The consequence of failure rating was developed based on the relative consequence of one spill compared to another. Table 4-2 summarizes the consequence of failure ratings.

Table 4-2 - Consequence of Failure

Category	Numerical Rating		
	0	5	10
Difficulty of Repair	Other	Highway crossing (30 feet or less from centerline of highway)	Stream crossing or 2.5 feet below mean sea level
Spill Volume	Less than or equal to 8 inches	Greater than 8 inches and less than or equal to 15 inches	Greater than 15 inches
Spill Impact	Other locations	Public parks or docks	Near a school or beach (within 200 feet) or potable water well (within 1,000 feet) or within the ground water management zone

4.5.3.1 Sewer Size

Larger diameter sewer lines were considered to have a high consequence of failure because in most cases, larger sewer lines carry higher flow volumes. A failure on a large diameter sewer line is likely to be more catastrophic due to the larger potential spill volume and the difficulty involved in bypassing large flow volumes. Sewers, based on the distribution of pipe diameters in the GWA collection system, with a diameter greater than 15 inches were considered "large sewers". There are about 750 sewer reaches that meet the definition of a large sewer. These pipes were given a high consequence of failure rating. Sewers with a diameter greater than 8 inches and less than or equal to 15 inches were considered "medium sewers". Approximately 1,200 medium sewer reaches were given a moderate consequence of failure rating.

4.5.3.2 Spill Impacts

Another consideration for the consequence of a failure is the potential for a spill to damage sensitive areas. The locations of schools, swimming beaches, public parks, docks and potable water supply wells were considered when rating the consequence of failure. Sewer lines passing through or adjacent to school grounds, swimming beaches, within 1,000 feet of a potable water supply well, or within the ground water protection zone received high consequence of failure ratings due to the potential risk of wastewater contamination. Sewer lines passing through, or adjacent to, public parks or docks received moderate ratings for consequence of failure as they may put public health at risk due to wastewater contamination (see Exhibit 4A.5a to 5e – Potable Wells and Groundwater Protection Zone).

4.5.4 Ratings

Ratings are based on the information available in the September, 2006 GWA sewer database. Tables 4-1 and 4-2 summarize the risk and consequence of failure ratings and criteria. As a conservative approach, pipes with "unknown" data information were given medium ratings for the respective category.

4.5.5 Results of Critical Assessment

Exhibits 4A.6a to 6e – Critical Sewer Rating, shows the relative inspection priority assigned to each individual sewer reach based on the evaluation of its risk and consequence of failure. The priority rating values were arbitrary and the ranges were selected to identify a manageable footage of high and medium priority sewer lines for inspection in the first five years. These priority ratings are categorized into three classification ranges and color coded as follows:

- High priority – red (critical sewer rating > 40)
- Medium priority – yellow (critical sewer rating $\geq$ 30 and $\leq$40)
- Low priority – green (critical sewer rating <30)

The critical sewer ratings are intended to prioritize individual pipe segments for field inspection by manhole inspection, smoke testing, CCTV inspection, or a combination of these methods. Rehabilitation or replacement projects may be developed based on the findings of inspections. It is recommended that the entire system is inspected starting with the highest priority and eventually working through the lowest priority. Once the entire system has been inspected and the GIS updated to reflect any changes such as rehabilitation, pipe replacement, and data errors, the system is to be reevaluated with new critical sewer ratings developed so the inspection process may begin again. Based on GEPA regulations, all sewer lines within 1,000 feet of a water supply well or within the groundwater protection zone must be inspected every five years.

The majority of high priority sewer lines are within the ground water protection zone or are along the highways and coast of Guam; 656 sewer segments (approximately 10% by length) totaling approximately 147,200 feet were identified as high priority, and 1,859 sewer segments (approximately 31% by length) totaling approximately 436,200 feet were identified as medium priority. The remaining gravity sewers were identified as low priority. Of the low priority sewers, 1,400 segments (approximately 21% by length) totaling approximately 303,300 feet are within the ground water protection zone.

4.6 Condition Assessment

Assessment of the current condition of the collection system is integral to CIP project development and prioritization. However, since it is impractical and cost prohibitive to inspect the entire underground collection system all at once, spot inspections at key manholes and interviews with GWA field personnel were performed to provide a general overview of the current condition. As repair and rehabilitation work is performed and additional areas of the collection system are inspected, the new condition information will be incorporated into future project development and prioritization. Since the condition of the collection system is constantly changing, the assessment shall be an ongoing process.

4.6.1 Manhole Inspections

A comprehensive manhole inspection program was developed to provide an initial assessment of the integrity of GWA's large diameter sewer lines. The consultant team involved key GWA collection system staff members in this inspection program to pass on the skills and knowledge necessary to continue the inspection program. Manhole inspections were performed by MGD Technologies, Inc. to field verify the location and physical characteristics of the existing collection system as well as provide current condition information on various components of the collection system. The size of the system and the total number of manholes required the team to focus on key locations with a higher likelihood of problems along the large diameter ($\geq$10") portion of the collection system. Junction manholes and manholes at or near known problem areas were inspected, while in less crucial areas every third manhole was inspected. A total of 303 manhole inspections were completed. Exhibit 4B.1a to 1e – Manhole Inspections, shows the manholes which have been inspected to date. The complete file of manhole inspection data sheets and accompanying photographs was submitted to GWA by MGD Technologies, Inc. in 2005. The following bullets summarize the total number of manholes inspected by area.

- Yigo – 22 manholes inspected
- Dededo – 48 manholes inspected
- Mangilao – 12 manholes inspected
- Barrigada – 27 manholes inspected
- Piti – 10 manholes inspected
- Tamuning – 37 manholes inspected
- Agana – 21 manholes inspected
- Chalan Pago/Ordot – 21 manholes inspected
- Santa Rita – 2 manholes inspected
- Agat – 61 manholes inspected
- Yona – 14 manholes inspected
- Talofofo – 1 manhole inspected
- Merizo – 11 manholes inspected
- Other – 16 manholes inspected

The components of the manhole inspections included:

- Manhole GPS location
- Surface level visual inspection of the manhole interior and component condition
- Still photographs of the manhole and into each of the influent and effluent pipes
- Wastewater conductivity measurement

Field information was recorded on hard copy inspection report forms which were later input into an electronic database for integration with the GIS-based assessment tools. An example Field Inspection Report Form is included as Exhibit 4C.1 at the end of this chapter. The following paragraphs summarize the information collected.

4.6.1.1 GPS Location

As a method of field verifying the GIS collection system maps and to positively identify individual manholes, GPS coordinates were recorded for each of the manholes inspected. Two handheld GPS units were used by the field crews and the last five digits of the northing component of the location were marked on or near the manhole for identification purposes. At the beginning of the day each of the units was calibrated, then remained on for the duration of the day. Based on return visits to various manholes, field personnel estimated the accuracy of the GPS coordinates at approximately (+/-) 10 to 15 feet. This accuracy was sufficient to positively identify manholes during future visits and to confirm locations on the GIS maps.

4.6.1.2 Ground Surface

Information about surface conditions around the manhole were recorded to assist in characterization of items such as potential of rainwater inflow, traffic control requirements, and access for maintenance. Photos of the general area were taken and labeled for orientation.

4.6.1.3 Manhole Cover, Frame, and Rungs

Metallic components of the manholes were inspected for signs and extent of corrosion. The levels of pitting and flaking of the metal were evaluated to provide overall corrosion ratings. Generally, these corroded metal components tend to be of greater concern from a safety, as opposed to operational, standpoint. The manhole covers and frames and the frames and rings were also inspected for the condition of the seal which affects the potential of stormwater inflow. Photos were taken to document findings.

4.6.1.4 Manhole Cone, Barrel, Bench, and Channel

The manhole interior walls were evaluated for material of construction, condition, and the presence and level of infiltration. Since the evaluations were completed without entry into the manhole, the barrels, benches and channels were assessed based on what was visible from the surface. Scrape penetration tests were performed on the manhole cone to supplement the visual evaluation of the concrete condition. Photos were taken of the manhole interiors to document findings.

4.6.1.5 Flow Characteristics

Various parameters of the wastewater flow were observed and recorded. Flow velocity, and depth in relation to pipe diameter were visually estimated, as were the presence and amount of grease, silt and/or debris. Evidence of surcharge and an estimate of the surcharge depth was recorded when applicable. Conductivity, pH, and temperature were measured whenever possible. The conductivity readings were used to identify potential freshwater or saltwater infiltration, while temperature and pH are useful for estimating the potential of H_2S gas generation from the wastewater.

4.6.1.6 Pipes

The size, shape and material of each influent and effluent pipe was documented at every manhole and a plan view sketch of the pipe and manhole layout was produced. The sketches are helpful for organizing the pipe data, confirming manhole identification, and validating the GIS collection system layout. A special camera with a pole-mounted zoom lens was used to take photographs up each of the pipes wherever the free headspace above the water surface permitted. The photographs allowed for a visual assessment of a portion of the pipe and in some cases helped locate and identify structural defects or blockages.

4.6.1.7 Findings

In general, the majority of manholes inspected were in good structural condition and sulfide related corrosion was not identified as an issue in the collection system. The most commonly identified issues included grease, silt and debris, and collection system surcharging. Conductivity sampling did not seem to identify areas with unusually high or low readings, which would normally indicate active areas of either salt or fresh water infiltration, respectively. However other observations such as evidence of past infiltration, active infiltration, or structural defects that increase the potential of I/I were identified to support the assumption that I/I is an issue in certain areas. The subsections below summarize the key issues identified during inspections.

4.6.1.7.1 *Evidence of Collection System Surcharge.* The most common issue identified during the manhole inspections was the evidence of surcharge. While surcharge is not necessarily a problem in itself, it is an indication of an increased risk of spills in the area and potential downstream hydraulic limitations. Surcharge was identified by high water markings or stains on the manhole walls, debris deposited above the normal water surface elevation, or direct witness of the surcharged condition. More than 40% of the manholes inspected (129 of 303) showed evidence of surcharging. Surcharging was generally due to one or more of the following conditions: high I/I due to wet weather, debris or grease build-up, poor gravity collection system hydraulics, or pump station operation and limitations/failures. The following bullets summarize the areas with the highest concentration of the number of manholes with identified surcharge conditions:

- Dededo – 23 w/ evidence of surcharge (48%; 23 of 48)
- Barrigada – 13 w/ evidence of surcharge (48%; 13 of 27)
- Hagatna – 17 w/ evidence of surcharge (81%; 17 of 21)
- Piti – 7 w/ evidence of surcharge (70%; 7 of 10)
- Tamuning – 19 w/ evidence of surcharge (51%; 19 of 37)
- Agat – 27 w/ evidence of surcharge (44%; 27 of 61)

4.6.1.7.2 *Grease.* Two key negative impacts to a collection system caused by grease build-up include odor production and the reduction of flow capacity. There were 36 of the 303 manholes inspected (one percent of all inspected manholes) that were found to have medium to heavy grease accumulation at the time of inspection. The following areas were those identified to have the highest concentration of manholes with medium to heavy grease accumulation.

- Yigo – 3 w/ medium or heavy grease (14%; 3 of 22)
- Tamuning – 15 w/ medium or heavy grease (41%; 15 of 37)
- Yona – 3 w/ medium or heavy grease (21%; 3 of 14)
- Merizo – 2 w/ medium or heavy grease (18%; 2 of 11)

4.6.1.7.3 *Silt.* Deposits of silt in the collection system tend to indicate areas of low flow velocity and in some cases upstream structural defects that allow the introduction of dirt or sand into the wastewater flow. Inspections identified 26 of the manholes (<1 percent) where silt was present on the pipe inverts. All estimates of silt depth were at least 10% of the pipe diameter and in several locations 20% or more of the pipe diameter. The following areas were those identified to have the highest concentration of manholes where silt accumulation was visible.

- Agana – 4 w/ silt accumulation (20%; 4 of 21)
- Agat – 12 w/ silt accumulation (20%; 12 of 61)
- Merizo – 3 w/ silt accumulation (27%; 3 of 11)

4.6.1.7.4 *Manhole Barrel Infiltration.* Inspections found that 7 of the 303 manholes visited showed evidence or active infiltration from the manhole wall. All 4 of the observed active infiltration locations were in the Agat area. Infiltration at the manhole not only indicates specific structural defects, but also the potential for infiltration on other elements of the collection system, such as pipes, in the same vicinity. The following bullets summarize the findings.

- Yigo – 1 w/ evidence of infiltration (<1 percent; 1 of 22)
- Agat – 4 w/ active infiltration (<1 percent; 4 of 61)
- Chalan Pago – 2 w/ evidence of infiltration (10%; 2 of 21)

4.6.1.7.5 *Manhole Frame to Ring Seal.* One of the easily identifiable construction defects that may increase the potential of wet weather inflow to the collection system is the lack of a good seal between the manhole cover frame and the manhole ring or cone. The amount of wet weather inflow that may occur at a poor manhole frame to ring seal is highly dependent upon the specific soil characteristics and surface topography. However, since mitigation of this condition is relatively easy, all of the identified occurrences are listed as issues that should be addressed. Of the manholes inspected, approximately 24% (72 of 303) were found to have no seal between the frame and ring. The following bullets summarize the areas with the highest concentration:

- Yigo – 5 w/ no frame to ring seal (23%; 5 of 22)
- Agana – 4 w/ no frame to ring seal (19%; 4 of 21)
- Agat – 53 w/ no frame to ring seal (87%; 53 of 61)

4.6.2 Forcemain Inspections

Due to various constraints, the scope of the initial collection system condition assessment focused primarily on the gravity collection system, however it is important to assess the condition of GWA's forcemains as well. The following section describes the recommended methodology for ongoing data collection on the condition of the various forcemains.

In most cases, a comprehensive, direct inspection of the forcemains would require putting the pipelines out of service, allowing either CCTV inspection of the interior, or man entry in larger diameter lines. Exterior inspection of the entire reach would be impractical, and in many cases, such as water crossings, not possible. To minimize excavation and system shut-down time, the following procedures are recommended for the initial force main condition inspection.

- Reconnaissance/Inspection of Fittings
- Inspection of Force Main Discharge Pipe and Manhole
- Liquid Sulfide Sampling

Those forcemains found to be in the worst condition based on the initial inspections should be programmed for additional, more comprehensive interior and exterior pipe inspection. The following sections present a detailed description of each of the elements of the recommended initial force main condition inspection listed above.

4.6.2.1 Reconnaissance/Inspection of Fittings

This effort will provide a general condition assessment of the force main and most of its critical appurtenances, without physically entering the pipe, or exposing and potentially damaging buried sections of the forcemains. The objective of this effort is to identify and catalog the type and location of each fitting, and to perform a visual condition assessment.

A brief outline of the reconnaissance assessment survey procedures is provided below.

- Begin assessment at WWPS
- Traverse to each fitting site utilizing GPS coordinates or other location information
- Assess whether fitting is operable or not
- Estimate the corrosion condition of the fitting (None, Moderate, Severe)
- If visible, make a similar assessment of the exterior of the force main pipe
- Take a digital photo of fitting and pipe
- Take a field GPS reading to verify location
- Record data on a field inspection form including any other comments or sketches
- Proceed to next fitting, and repeat the procedure

There are various types of fittings which may be found on the force main. Below is a summary description of some of these fittings.

<u>Air Release Valve (ARV).</u> Air release valves manually or automatically vent trapped gases. Gases trapped at these locations increase the head against which the pump must operate, provide an opportunity for internal pipe corrosion and increase the potential for high-pressure transients (water hammer) and cavitation in the pipeline. Trapped gases can also disrupt the operation of the flow tubes. ARVs are typically located at the beginning of the forcemains near the flow tubes and at intermediate high points where gas can accumulate.

<u>Air Vacuum Valve (AVV).</u> Air vacuum valves are installed at high points in the force main to allow air to enter the system when it is draining. These valves will break a vacuum that can form in a force main and prevent the pipe from collapsing.

Combination Air Valve (CAV). Combination air valves combine the function of an ARV and AVV into one unit.

Air Bleeder (AB). Air bleeders have the same function as an ARV except the valve is operated manually. Air bleeders may also be identified as manual ARVs.

Blow-off Valve (BOV). A blow-off valve is usually installed at low points in the force main system where debris can accumulate. This valve is utilized to drain wastewater and debris out of the force main. Debris that is trapped at these locations increases the head against which the pump must operate and provides an opportunity for corrosion at the invert of the pipe.

Gate Valve (GV). A gate valve is usually installed on either side of a flow tube or ARV so that they can be isolated from wastewater flow.

Check Valve (CV). A check valve is usually installed at the discharge end of each pump to provide a positive shutoff from the force main pressure when the pump is not running. It also prevents the force main from draining back into the wet well when the pump is not running.

Cathodic Protection Systems. Cathodic protection systems are designed to protect metallic pipelines from galvanic corrosion.

Cathodic Corrosion Test Site (TST). Cathodic corrosion test sites are utilized to determine if the cathodic protection system is properly functioning.

Flow Tube (FT). Flow tubes are utilized to measure the flow rate in the force main with a Venturi meter mounted outside of the pump station.

Other Items (OT). Other items include pressure manholes and cleanouts. These items are installed to facilitate maintenance activities.

4.6.2.2 Inspection of Forcemain Discharge Pipe and Manhole

The condition of the discharge end of the force main pipe and the condition of the discharge manhole itself will give an indication of the potential for interior corrosion in other areas of the force main. This information can be used in conjunction with results of liquid and gas sampling to identify the potential of the presence of hydrogen sulfide (H_2S) gas in the force main.

If possible, a visual inspection of the discharge end of the force main pipe and the discharge manhole should be conducted. To conduct a manned entry inspection it would be necessary to temporarily take the upstream pump station off line. If this is not feasible, a surface level visual inspection would still provide useful information.

The inspection should try to identify/quantify some of the following:

- Confirm/identify force main pipe material
- Force main discharge pipe corrosion condition
- Manhole corrosion condition (cover, rungs, walls, etc)

4.6.2.3 Liquid Sulfide Sampling

Liquid sulfide sampling will help to quantify the presence and/or the generation potential of sulfides and H_2S gas in the force main. High sulfide concentration in the force main increases the potential of sulfide related corrosion in air pockets that may form at high points along the force main alignment.

Wastewater grab samples should be collected at the pump station influent wet well and the force main discharge point. Several samples should be collected at each location at various times of the day over a 2-day sample period. Samples should be collected while the force main is actively discharging and ideally at the beginning of the pumping cycle to catch the flows that are likely to have the highest sulfide concentrations. Samples must be analyzed in the field within 1 minute of collection to minimize off-gassing of liquid sulfide to H_2S gas. Samples will be analyzed for total sulfide concentration using the LaMotte Pomeroy methylene blue titration technique.

Wastewater temperature and pH measurements should be taken in conjunction with each grab sample collected for liquid sulfide analysis.

4.6.3 GWA/GEPA Staff Interviews

GWA and GEPA personnel familiar with their wastewater collection system have knowledge of various issues that may be undocumented and not easily identified during inspections. Therefore, in addition to manhole inspections, which provide a snap-shot point in time an idea of the condition of a portion of the collection system, interviews were conducted with GWA collection systems maintenance personnel and GEPA personnel to document this institutional knowledge of the system. The key issues, based on the knowledge and experience of the GWA and GEPA personnel are summarized below by area. This information is incorporated into recommendations for additional inspection and project development as defined in Sections 4.8.1, 4.8.2, and 4.8.3.

Dededo

- 8-inch line west of the elementary school on Y-Sengsong Road between East San Antonio Avenue and East Santa Monica Avenue is believed to have sags that cause grease issues.
- 10-inch line on Delores Street is believed to have broken sections of AC pipe.
- 10-inch line at the Marine Drive and Harmon Loop Road intersection is prone to wet and dry weather spills due to heavy grease.
- Collector line west of residential area (just west of Marine Drive and south of school) that connects to 14-inch line on Harmon Loop Road is prone to blockage and back-ups due to grease.
- 8-inch collector line south of South Lemai Court/South Mariposa Court/South Melindes Court is prone to grease blockage.
- 18-inch line on Adrian Sanchez Street that flows west from the Route 16 intersection is prone to overflow when the Route 16 pump station is down and flow bypasses to this line.

- Manhole on Route 16 near the Mendiola intersection (northwest of Harmon Coral Pit) is believed to surcharge due to downstream pipe alignment. The area near the school is prone to wet and dry weather spills.
- 8-inch line on the east side of the Santa Ana subdivision at the Route 3 and Route 9 junction that carries flow to 30-inch line has heavy grease issues.
- 36-inch line through the golf course on Route 3 surcharges, possibly due to connection from the adjacent housing development.

Barrigada

- 8-inch line on Jalaguac Way is prone to spills due to layout.

Hagatna

- 8-inch line on Mendiola Lane east of Tutujan Drive is suspected of having sags.
- 8-inch line on Paasan Drive west of Tutujan Drive is suspected of having sags.
- Lateral connections to the 24-inch/27-inch line on Marine Drive between 6th Street and 10th Street are made at the pipe invert. Laterals back up and as the mainline pipe can flow ¾ full at high peak.
- Suspected storm drain cross connections to wastewater collection system in this area.

Tamuning

- Influent lines to pump station along Pale San Vitores Road (10-inch line from south and 24-inch line from north) surcharge due to possible undersized pumps.
- Ypao Beach Pump Station has bar screen blockage issues (manual bar screen cleaning).
- 6-inch line south of Route 3 (near Numero Uno) has grease issues.
- 10-inch line along the coast that feeds the Tamuning Bayside Pump Station is always surcharged because the minimum water level for the pump must be kept high to keep the pump cool.
- Manhole at the Marine Drive and Sereno Avenue intersection has a 90-degree connection that restricts flow in the main line.
- The Marine Drive inverted siphon near the Route 30 junction may be undersized as it backs flow up.

Piti

- The Tepungan pump station seems undersized.
- 8-inch line on J. M. Tuncap Street has grease issues.
- The manhole at the junction of Route 1 and J. M. Tuncap Street has a pipe running through it making maintenance difficult.

Agat

- The residential development bounded by San Francisco Street to the south and Erskin Drive to the north is suspected of having high I/I. Clay pipes are believed to be damaged and stub outs plugged with tar may be failing.

- Finile Drive housing development is suspected of having high I/I. PVC piping believed to have poor bedding leading to possible sags.
- Inverted siphon on Route 2 across the Togcha River causes grease build-up.
- Agat STP influent pump station seems undersized and backs flow up in upstream lines.
- 8-inch line on South Perino Street connects to the invert of the 16-inch/18-inch main line which causes flow to back up in wet weather.

Yona

- 14-inch line on Route 4 between the two entrances to Sister Mary Encarita Drive (loop) has grease issues.

Asan

- 8-inch line adjacent to Nino Perdido Church that connects to 16-inch/18-inch main line on Marine Drive has grease issues.
- 6-inch line on North San Carlos has grease issues.

4.7 Capacity Assessment

The capacity of the collection system has been assessed using a sewer model that identifies hydraulic deficiencies and potential spill points based on current and predicted future loading. GWA's wastewater collection system is comprised of 6 independent service areas, each service area discharging to a different sewage treatment plant; therefore six separate sewer hydraulic models were created. The models were developed in H_2OMap Sewer, a product of MWH Soft, Inc. The model network was created using information from the collection system GIS. Data needed for model development that are not in the current GIS, such as sewers found on the GWA 1968 USGS maps (USGS maps on which sewer and water lines have been hand drawn) or village parcel maps (hand drawn maps showing ownership parcels by village including some sewer lines) that were not found in the as-built drawings, confirmation of recent developments, verification of pipeline connectivity, and GPS verification of pump station locations, were researched to complete the model with best available data.

4.7.1 Flow/Rain Data Collection

Due to the size of the collection system, the initial modeling effort included all of the gravity lines that are 10 inches in diameter and greater. Calibration of the model was performed using rainfall, depth and flow data collected at strategic points in the gravity collection system.

4.7.1.1 Approach

The rainfall and flow metering program was divided into two parts; an initial short-term metering program that would provide rainfall and flow information for initial flow model calibration, and future monitoring to confirm findings and fill gaps in system understanding.

4.7.1.1.1 Short-term Metering Program. MGD Technologies, Inc. performed short-term rainfall and flow monitoring of the collection system during August and early September 2005. This intensive program simultaneously distributed flow meters in 37 strategic locations throughout the collection system. The short-term metering program divided the island's collection system into key sub-basins with a flow meter at the downstream end of each sub-basin. Rain gages were set up in nine locations around the island to help quantify the total rainfall and delineate which regions of the island were subjected to rainfall from a given storm. The goal was to perform at least 28-days of short-term metering with a minimum requirement of capturing two significant rainfall events and the corresponding wastewater flow data for each metering site.

4.7.1.1.2 *Focused Metering Program*. The details of the long-term flow metering program were adjusted from the original scope. The initial suggestion was to install a single long-term flow meter at the downstream point of each collection basin as none of the STPs have influent flow meters that continuously record data. Due to the comprehensive coverage with the short-term meters during the monitoring period and the recommendation to install SCADA monitored influent flow meters on all the STPs, it became unnecessary to install six long-term meters which will require ongoing maintenance and provide much the same information as the future STP influent meters. Therefore the decision was made to change the direction of this program and develop the means for GWA to create an ongoing, focused metering program. Under the focused metering program, GWA will have six portable flow meters that can be deployed in a known I/I, surcharge, or other problem area to gather specific information that will be helpful to pinpoint I/I sources and in the design of upgrades. Currently GWA has received the meters and are in the process of scheduling training for their use.

4.7.1.2 Data

The final flow and rain gauge data from MGD was imported into Brown and Caldwell's Capacity Assessment Planning Environment (CAPE) software to be reviewed and used for model calibration. The base flow in the model was developed using flow monitoring periods without significant rainfall activity. Base flows were projected based on the sum of residential and commercial employment.

4.7.2 I/I Factor Development

Wet weather calibration was performed using the large storm events that were captured during the flow monitoring period. I/I models developed in CAPE were used to extrapolate flow monitoring results to represent five and 10-year events. The flows measured at the monitors or extrapolated with the I/I models were distributed to upstream input nodes based on tributary area.

4.7.3 Hydraulic Modeling

As noted above, the sewer model network was developed using GIS sewer data supplemented by information from the 1968 USGS sewer maps, village parcel maps and field confirmations. Flows to load the model were developed using the flow and rainfall data collected in August 2005. The following subsections describe the approach and findings.

4.7.3.1 Model Sewer Network

4.7.3.1.1 *Pipe Network*. GIS data was used to begin the network construction. The GIS data were reviewed for connectivity and consistency in diameter and slope. Modifications were made in some areas to correct some pipe slopes, diameters and connections from review of the as-built drawings, field confirmation or the 1968 USGS maps.

Due to a lack of available as-built drawings in some areas, the 1968 USGS maps and village parcel maps were reviewed to fill in gaps in the GIS coverage. Because the USGS and parcel maps do not have invert elevations for manholes, the necessary invert data were developed by extrapolation between known points or by assuming slopes based on contour information. Missing rim elevations were estimated from the available contour information. The network resulting from this effort is shown on Figures 4-1 through 4-4.

Figure 4-1 – Northern District STP Sewer Network

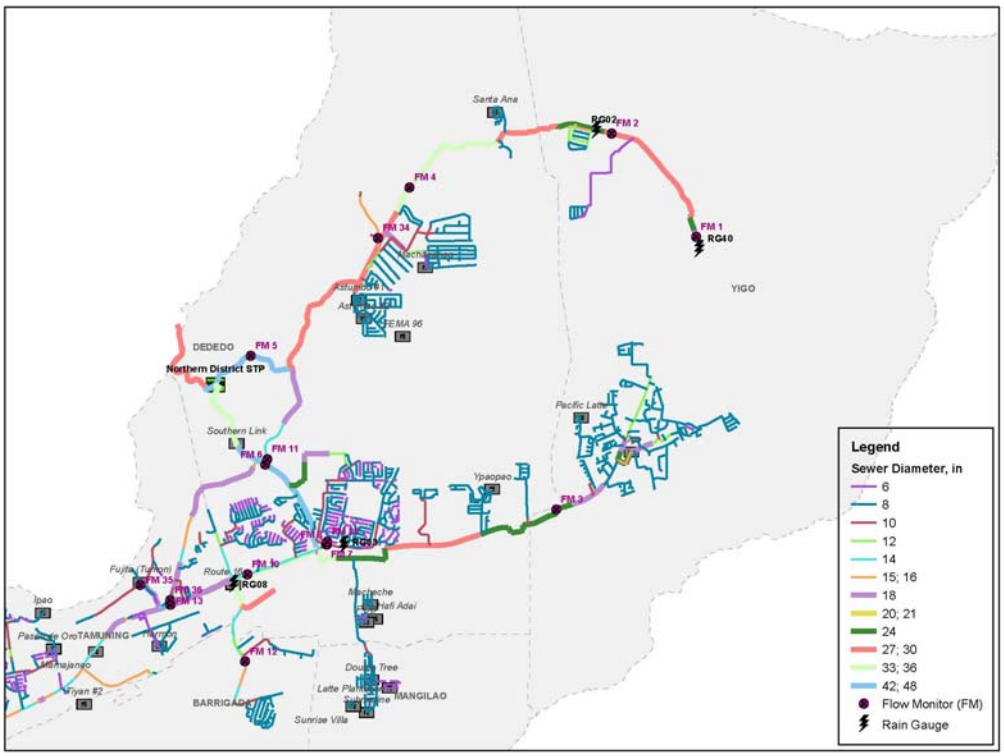


Figure 4-2 – Hagatna STP Sewer Network

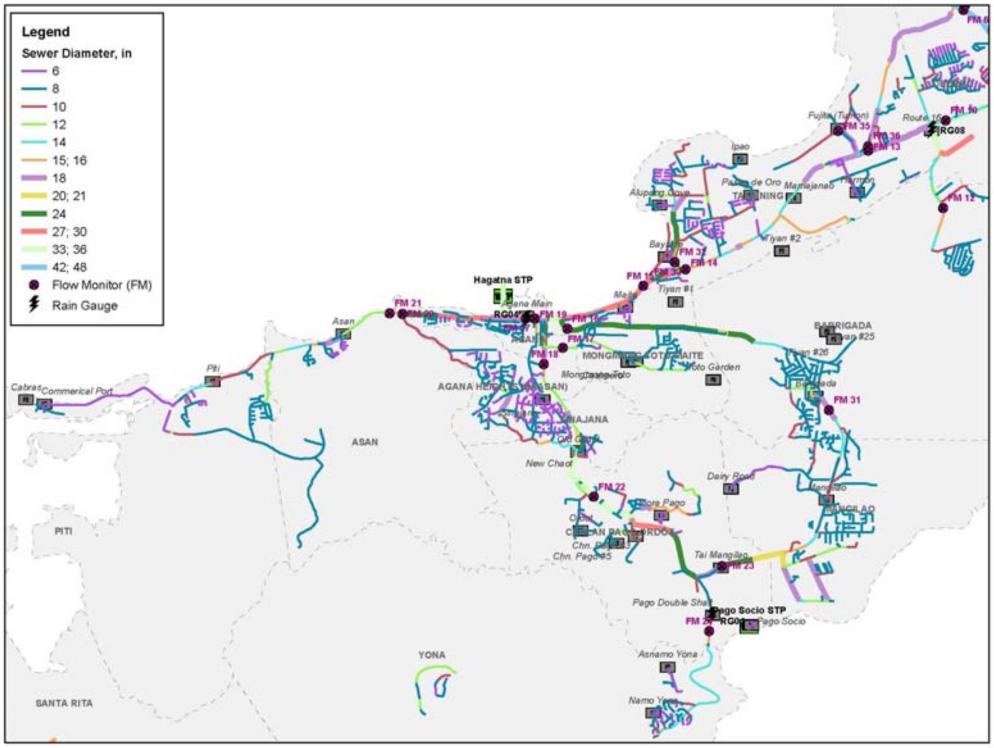


Figure 4-3 – Agat-Santa Rita and Baza Gardens Sewer Networks

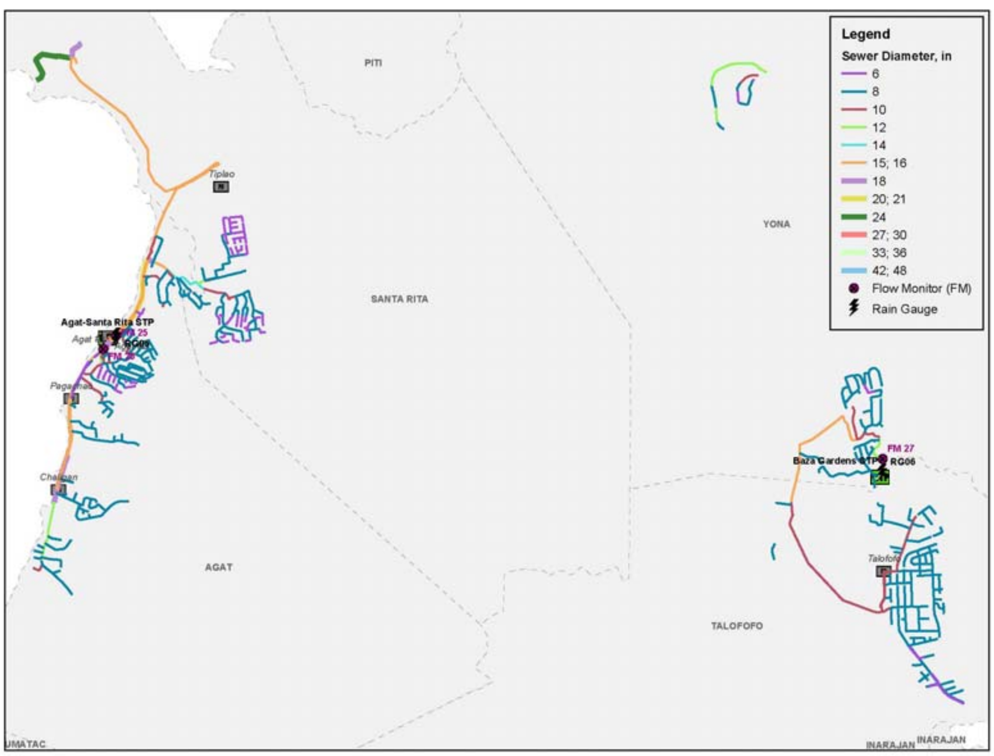
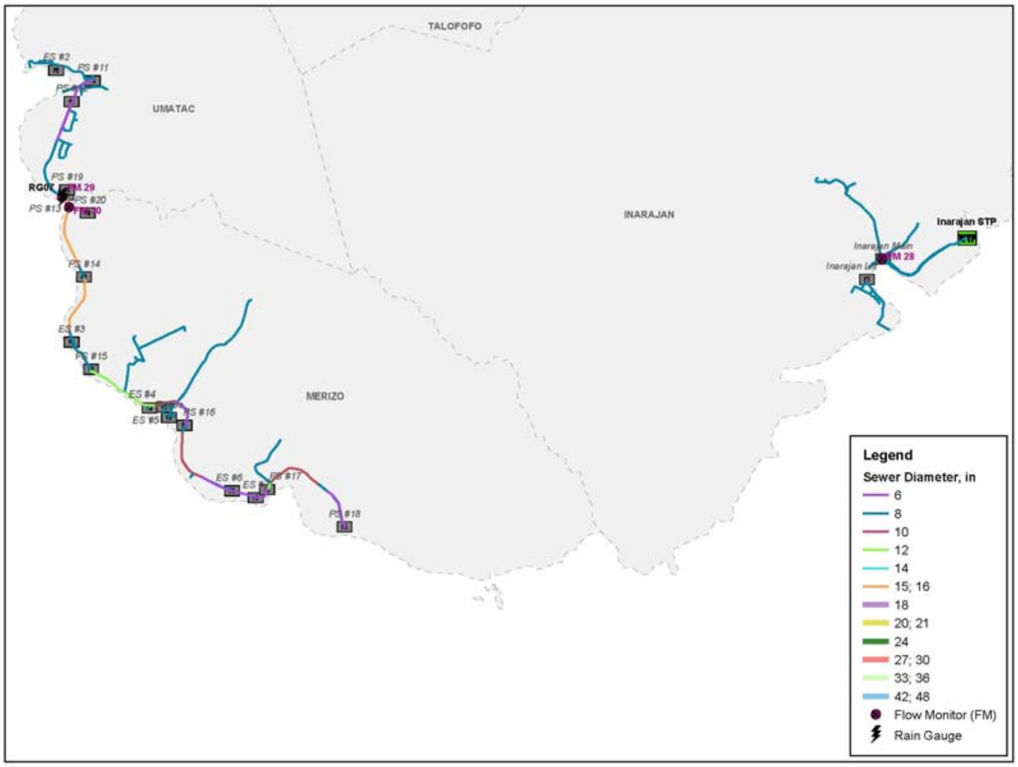


Figure 4-4 – Umatac-Merizo and Inarajan Sewer Networks



Once the pipe network was constructed using best available information, all pipes with diameter 10 inches and greater were imported to H_2O map Sewer. This software was further used to locate inconsistencies in the pipe data such as pipe segments where the invert elevations did not match immediately upstream and downstream segments.

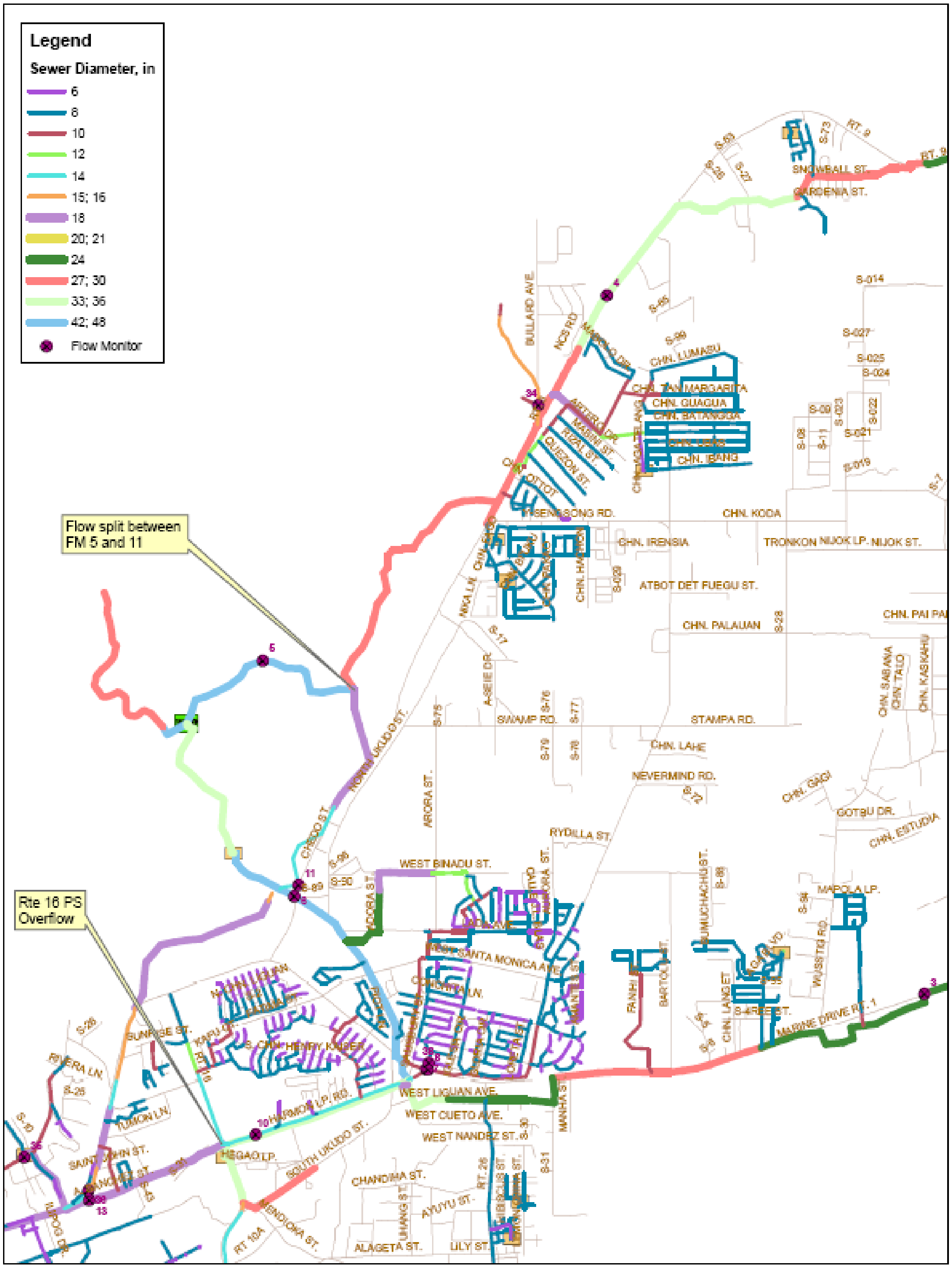
4.7.3.1.2 *Pump Stations*. All pump stations were located in the field with GPS. It was found that the GIS data included pump stations that not be verified by other records. These were reviewed with GWA staff and it was determined that these were planned as part of development, but have not yet been constructed. In some cases (in the Baza Gardens treatment plant tributary area for example), sewers have been constructed by developers leading to the future pump station locations. GWA currently collects sewage from users of these sewers via pumper trucks several times per week. These systems will need to be added to the model when GWA makes the determination that the pump stations will be constructed. Appendix 3A to Volume 3, Chapter 3 – Wastewater Facilities Condition Assessment, provides a detailed list of the existing pump stations evaluated during the condition assessment.

The pump stations were added to the model. Because actual pump curves are not available, the pumps are represented by a default head-capacity curve using the nameplate data as the centroidal point.

4.7.3.1.3 *Special Structures*. Two special structures exist in the Dededo area of the Northern District STP service area. Locations are shown on Figure 4-5. An emergency overflow exists just upstream of the Route 16 pump station which will re-direct flows to the Hagatna STP when the pump station is out of service. We also suspect based on flow monitoring results, that this overflow is activated in large wet weather events.

The other special structure splits flow between two lines to the east of the NDSTP. Part of the flow is diverted to the 42-inch line leading to the treatment plant via flow meter 5. The remainder proceeds to the Southern Link Pump Station (SLPS) in the 18-inch line via flow meter 11. The structure was constructed in such a way that most of the dry weather flow proceeds to the SLPS while wet weather flows are more evenly split. Based on photographs of the structure, it is apparent that a significant flow enters this junction from the east in an apparent 30-inch diameter sewer that has not been found to date on any data source. Elimination of this split would reduce power usage at the SLPS and increase system reliability. This split is planned to be eliminated-therefore, the model has been constructed as if it did not exist.

Figure 4-5 – Northern District Special Structures



4.7.3.2 Current Dry Weather Flows

Dry weather flows (DWF) and associated diurnal patterns were estimated from the flow monitoring results during a week's period with minimal rainfall. Unit flow factors (gallons per resident - employee per day) were developed by estimation of the connected residential and employment population tributary to each flow meter. These flow factors formed the basis for flow projections. The flow factors are listed by flow meter in Table 4-3, Flow Factors Developed from Flow Monitoring Study. Assignment of population to each flow meter was performed in the following steps:

- Aerial photographs of the island were used as a GIS background and polygons were drawn around areas with surface developments.
- The development polygons were intersected in the GIS with the census block groups described elsewhere. Residential population and commercial employment from the census block coverage were assigned to the development polygons based on relative area. Since the census block groups provide data only for the planning years 2005, 2020, 2050 and 2100, interpolation was used to estimate corresponding data in 2025.
- The development polygons were intersected with the sewer coverage described above to assign areas as sewered or non-sewered. Development polygons containing sewers and adjacent to sewers were assigned as sewered. The resulting sewered area coverage was checked against coverage of sewered and non-sewered accounts created in the WERI study. In general, this coverage validated the assignment. Because the sewer coverage developed for the model may be incomplete, the assignment of sewered areas may contain errors in some places. The aerials used for the polygon development are likely out of date, so that there may be additional development not yet recognized.

4.7.3.3 Future Dry Weather Flows

Future dry weather flows on identified existing sewered areas were estimated by applying the dry weather flow factors found for the current condition to the estimated 2025 residential and commercial employee population in the developed polygons. In addition, new areas were identified that have a high probability of being sewered in the future. Development polygons selected for potential future sewering include those with population densities greater than 10 people per acre (which is estimated to translate to approximately two to three dwelling units per acre), and or those development polygons that surround or are up-gradient from existing water wells. Figures 4-6 through 4-9 show development polygons assumed to be sewered in the current condition (2005), polygons assumed to be sewered by 2025, and those assumed to be not sewered. The estimated areas, populations and flows associated with these assumptions are shown in Table 4-4, New Areas Assumed Sewered by 2025.

Table 4-3 – Flow Factors Developed from Flow Monitoring Study

Flow Meter	Sewered Area, Acres	Sewered Residential		Sewered Employment		Average Flows, mgd(a)		Peak Wet Weather Flow, mgd(a)		DWF, gpcd	PWW I/I, gpad
		2005	2025	2005	2025	2005	2025	2005	2025		
North District STP											
FM 01 - AAFB	1457	4274	6565	1258	1551	0.45	0.66	3.2	3.4	81	1887
FM 02	204	456	641	0	0	0.05	0.07	3.5	3.5	110	1806
FM 03	1046	6176	7504	715	867	0.63	0.77	2.0	2.1	91	1309
FM 04	562	1870	2332	0	0	0.20	0.25	5.2	5.2	107	2024
FM 05	961	8125	9422	86	107	0.20	0.23	2.8	2.8	198	2224
FM 06	1537	12455	14597	4594	5619	2.20	2.67	11.2	11.7	132	2904
Unmetered	17	189	232	0	0	0.02	0.02	NA	NA	93	NA
FM 07	136	1592	1934	22	28	0.15	0.18	0.4	0.4	93	1843
FM 08	318	4438	4836	916	1128	0.38	0.42	1.2	1.2	71	2577
FM 10	199	2797	3331	361	485	0.73	0.88	1.7	1.8	231	4620
FM 11	34	68	84	0	0	1.44	1.78	6.7	7.0	198	2224
FM 12	359	1813	2232	6	8	0.26	0.32	0.6	0.7	143	948
FM 34 - NCTAMS	279	495	611	0	0	0.06	0.07	1.5	1.5	121	5164
FM 35	357	1185	1269	7694	9480	0.89	1.08	2.7	2.9	100	5068
FM 38	85	1350	1421	330	407	0.10	0.11	0.4	0.4	60	3186
NDSTP Total	7551	47283	57011	15982	19680	7.8	9.5	18.0	19.8	164	1356
Hagatna STP											
FM 13	141	1353	1427	1655	1988	0.12	(b) ---	2.5	(b) ---	(b) ---	16910
FM 14	1194	4703	5363	12714	15671	0.54	(b) ---	2.3	(b) ---	(b) ---	1228
FM 15	19	89	113	125	155	0.26	1.10	5.7	6.4	44.6	3529
FM 16	837	7663	9286	1126	1395	0.94	1.14	2.3	2.6	107.0	923
FM 17	35	271	333	16	21	0.03	0.04	0.4	0.4	104.5	10457
FM 18	522	5487	6592	540	671	0.54	0.65	7.0	7.8	89.6	2999
FM 19	196	788	969	2285	2813	0.50	0.62	10.2	11.3	162.7	3284
FM 20	154	1223	1486	1956	2415	NA	NA	NA	NA	NA	NA
FM 21	673	2710	3955	363	446	0.35	0.50	2.1	2.4	113.9	2599
FM 22	680	3289	4191	196	245	0.10	0.13	3.0	3.3	28.7	1695
FM 23	503	4363	4956	784	970	0.30	0.35	1.6	1.8	58.3	2586
FM 24	269	2221	2671	97	114	0.14	0.17	0.7	0.7	60.4	1896
FM 31	496	2854	3519	642	791	0.13	0.16	1.1	1.2	37.2	1956
FM 32	697	7806	9397	5048	6227	1.00	1.22	2.9	3.3	77.8	2727
FM 33	89	505	669	574	707	1.00	1.28	1.2	1.4	926.8	1680
FM 36	262	3161	3024	1390	1574	0.29	0.29	0.9	1.0	63.7	2328
FM 37 (includes 20)	176	459	566	2283	2817	1.10	1.36	6.0	6.7	201.8	997
Unmetered	78	179	220	868	1070	0.12	0.14	0.4	0.4	110.0	3284
Hagatna Total	7022	49124	58737	32662	40090	7.5	9.1	25.0	28.4	91.2	2498
Umatac-Merizo STP											
FM 29 - Umatac	120	609	749	23	28	0.05	0.06	0.6	0.6	82.1	4345
FM 30 - Merizo	545	2327	2872	54	65	0.23	0.28	0.9	0.9	98.8	1155
Umatac-Merizo Total	665	2936	3621	77	93	0.28	0.35	1.4	1.5	95.4	1729
Baza Gardens											
FM 27	454	2609	3696	38	47	0.16	0.23	1.4	1.5	62.5	2725
Inarajan											
FM 28	267	632	710	92	74	0.07	0.08	1.3	1.5	110.8	4600
Agat-Santa Rita											
FM 25	478	4232	5220	619	765	0.57	0.70	3.1	3.2	134.1	5298
FM 26	501	3599	4435	66	79	0.48	0.59	0.8	0.9	134.1	673
Unmetered	47	593	729	71	88	0.08	0.10	NA	NA	134.1	NA
Agat-Santa Rita Total	1026	8424	10384	756	932	1.13	1.39	4.2	4.5	134.1	3015

(a) Average flows at monitors during a week with little rain and peak flows measured at the monitors.

(b) Flows included at flow meter 15

Table 4-4 – New Areas Assumed Sewered by 2025

New Area Assumed to be Sewered by 2025			Potential Flow. 2025 including unsewered area (a)	
Acres	Residents	Employees	Average	Peak
North District STP				
130	375	0	0.69	3.60
0	0	0	0.07	3.52
255	1471	170	0.92	2.59
241	1041	0	0.36	5.65
1341	5351	0	1.29	5.50
514	3304	320	3.15	12.76
84	886	0	0.10	NA
16	332	0	0.21	0.48
1	8	0	0.42	1.24
0	0	0	0.88	1.80
17	229	0	1.82	7.10
91	345	0	0.37	0.82
0	0	0	0.07	1.51
0	0	0	1.08	2.89
0	0	0	0.11	0.38
2690	13342	490	11.6	25.0
Hagatna STP				
19	419	87	(b) ---	(b) ---
0	0	0	(b) ---	(b) ---
0	0	0	1.12	6.4
967	1004	2213	1.49	5.4
0	0	0	0.04	0.4
100	1111	53	0.76	8.1
0	0	0	0.62	13.7
NA	NA	NA	NA	NA
0	0	0	0.50	2.4
0	0	0	0.13	3.4
0	0	0	0.35	1.8
14	273	6	0.20	0.8
15	50	0	0.17	1.3
0	0	0	1.22	3.3
0	0	0	1.28	1.4
17	320	100	0.34	1.1
2	27	2	1.36	6.8
0	0	0	0.14	0.4
1132	3204	2461	9.7	31.8
Umatac-Merizo STP				
0	0	0	0.06	0.57
0	0	0	0.28	0.86
0	0	0	0.35	1.43
Baza Gardens				
287	1752	0	0.34	2.4
Inarajan				
0	0	0	0.08	1.46
0	0	0	0.70	3.2
0	0	0	0.59	0.9
0	0	0	0.10	NA
0	0	0	1.39	4.5

(a) Includes flows from areas with high density or that impact wells
(b) Flows included at flow meter 15

The above procedure to estimate potential future flows was used to compute the column labeled "Potential Flow 2005 including unsewered area" in Table 4-3. This estimate was prepared prior to completion of the WERI location of water account customers without sewer accounts (apparent unsewered properties) discussed in Volume 3, Chapter 6 – Septic Systems and Unsewered Areas. A comparison of the two approaches (Table 4-4 compared to Tables 6-6 and 6-7 in Volume 3, Chapter 6 assuming four people per intercepted property) indicates that the assumed new sewered population shown it Table 4-4 is about 6000 higher than implied in the recommendations in Volume 3, Chapter 6 in the Hagatna and NDSTP areas. This provides a buffer in the estimated treatment plant flows for the sewering of additional properties.

4.7.3.4 Wet Weather Flows

Wet weather flow estimates were derived from the flow and rainfall monitoring program. The flows that occurred during rains associated with typhoon Nabi that passed north of the island at the end of August 2005 were used for development of wet weather flows. The estimated I/I flows (total flow less base flow) that occurred at the flow monitors on the 31st of August were extracted from the monitoring records and used for capacity assessment. I/I models developed in Capacity Assurance Planning Environment (CAPE) were used to estimate I/I for this event at monitors where the record did not include this date. Wet weather flows were also extrapolated to events with higher or lower rainfall than actually occurred using the CAPE I/I models. Figure 4-10 shows an example of the calibration.

Rainfall in Guam is dominated by the breakdown of the trade winds that bring heavy showers and sometimes torrential rains. Typhoons occasionally occur with very large rains. Daily rainfall totals of 10-inches or more occur at a frequency of about once in 10 years. Often, the records show that these large daily volumes are made up principally by high intensities in a single hour.

Long term rainfall data is available from the National Climatic Data Center. Daily rainfall totals are available spanning from 1953 through 2001. Hourly rainfall data are available only from 1984 through 1999. Figure 4-11 shows an occurrence frequency chart of daily rainfall from this data. It is noted that the 10-year daily depth is only 13% higher than the five-year depth. During the monitoring period, approximately five inches of rain fell on the north end of the island on August 31, 2005 with peak hourly intensities up to six inches per hour. Over eight inches fell on the south end of the island with peak intensities over nine inches per hour. Sewer flows in Guam respond significantly to peak hourly intensities, but also depend on antecedent rainfall over the previous 24-hours.

To put the measured flows in context of expected recurrence, the calibrated I/I models were used to compute the I/I sequence that would occur using the 1984-1999 hourly rainfall data set. The available data set is too short to make firm estimates of actual recurrence frequencies; however, it was estimated that the once in five-year peak hourly I/I flow is approximately 20% higher than the two-year flow, and that the 10-year peak I/I flow is approximately 30% higher than the two-year flow. Based on these analyses, the peak I/I flows that occurred in the north end of the island are estimated to be representative of a two- to five-year recurrence while those that occurred in the south are representative of a 5- to 10-year recurrence. To provide a capacity assessment on a similar basis, the measured I/I flows in the north were increased by 25% to give them a comparable occurrence frequency as those in the south. Pipe upgrades were projected on this basis.

To provide prioritization, the I/I flows in the south were reduced by 25%. Pipes that were overloaded in the south at the lower flows, and those in the north overloaded with the existing flows were prioritized for attention first. The upgraded pipes sizes were computed for the higher flows. The remaining pipes that required upgrades at the higher flows were given a second priority.

To assess capacity in the 2025 condition, the measured I/I from estimated current sewered areas was allowed to increase by 10% to account for continued degradation of the sewers. For areas that are assumed to be newly sewered by 2025, a conservative I/I allowance of 2500 gallons per acre per day (gpad) was assumed. If new sewers are constructed to modern standards, the actual rate should be half the assumed amount or less.

Figure 4-6 – Northern District Developed Areas

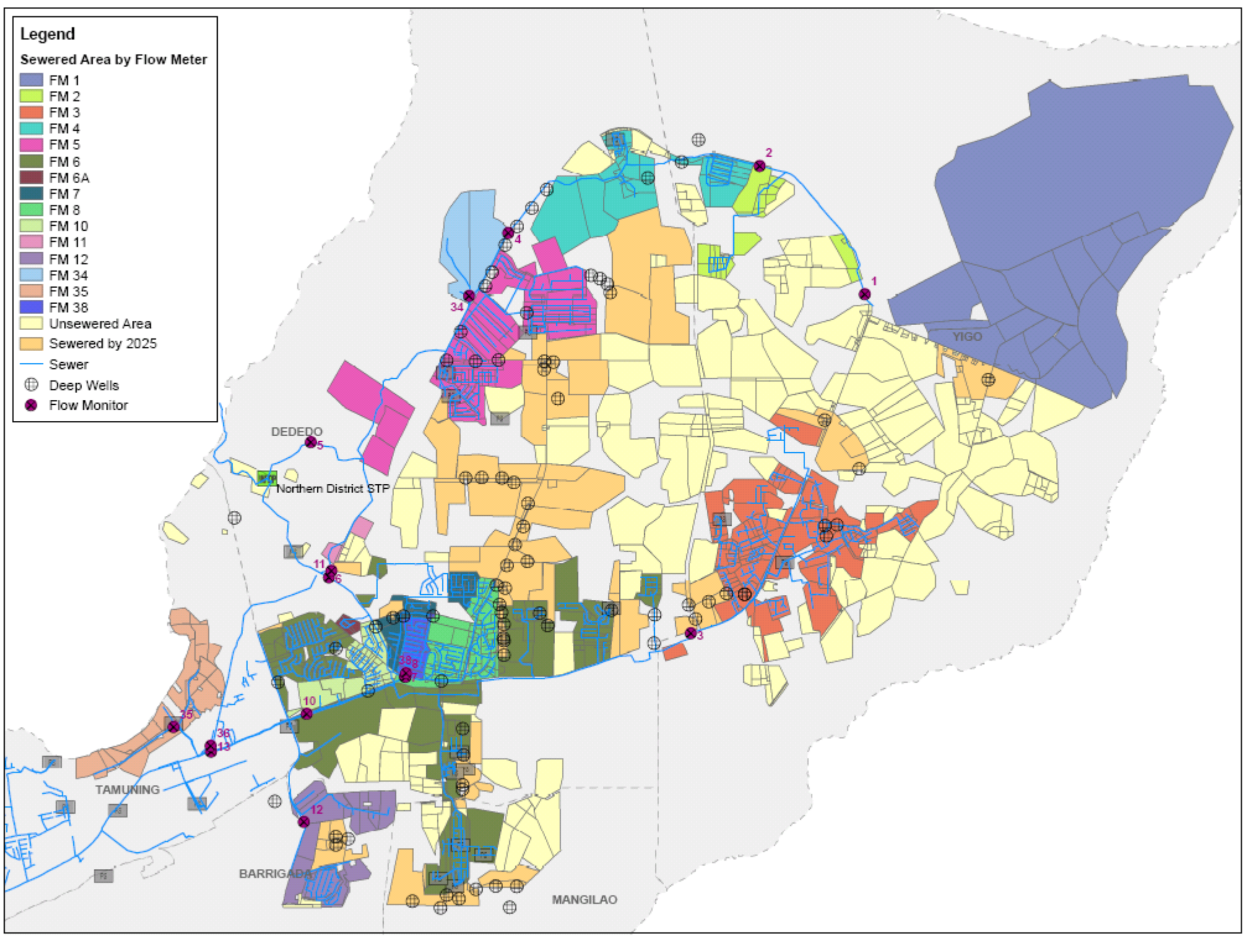


Figure 4-7 – Hagatna Developed Areas

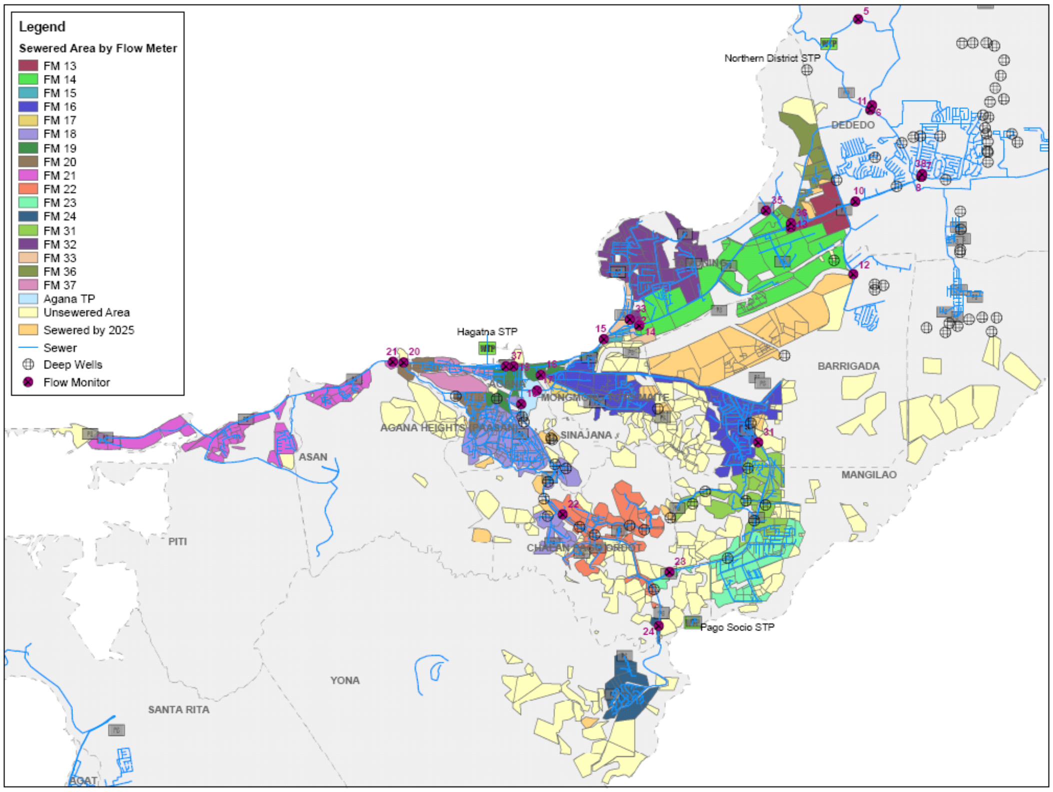


Figure 4-8 – Agat-Santa Rita and Baza Gardens Developed Areas

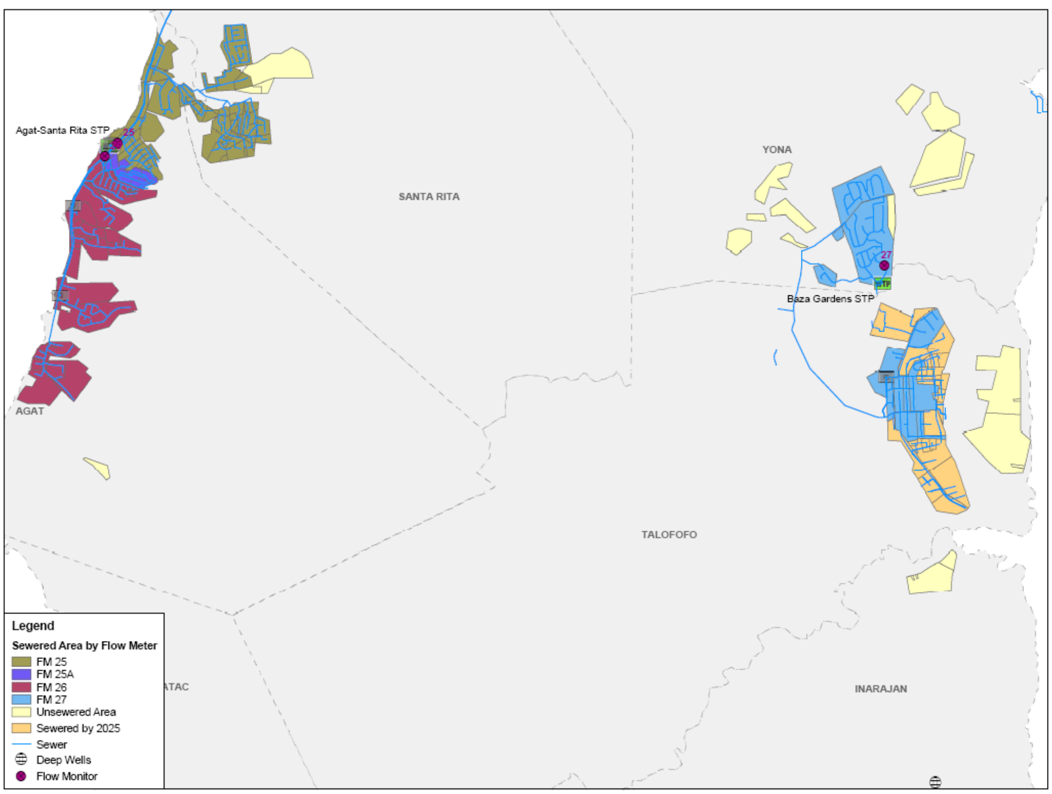


Figure 4-9 – Umatac-Merizo – Inarajan Developed Areas

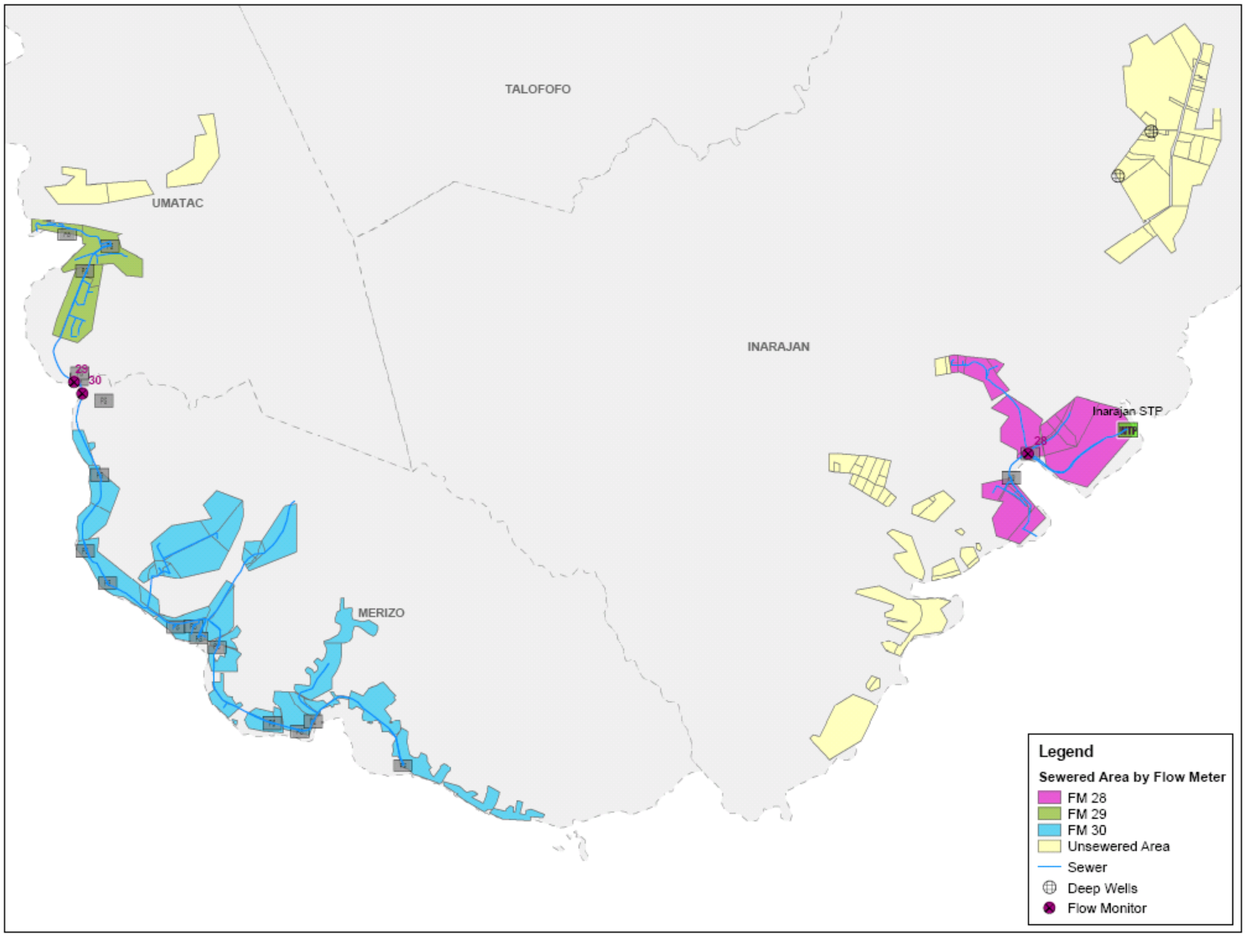


Figure 4-10 – I/I Model Calibration Example, Meter 8

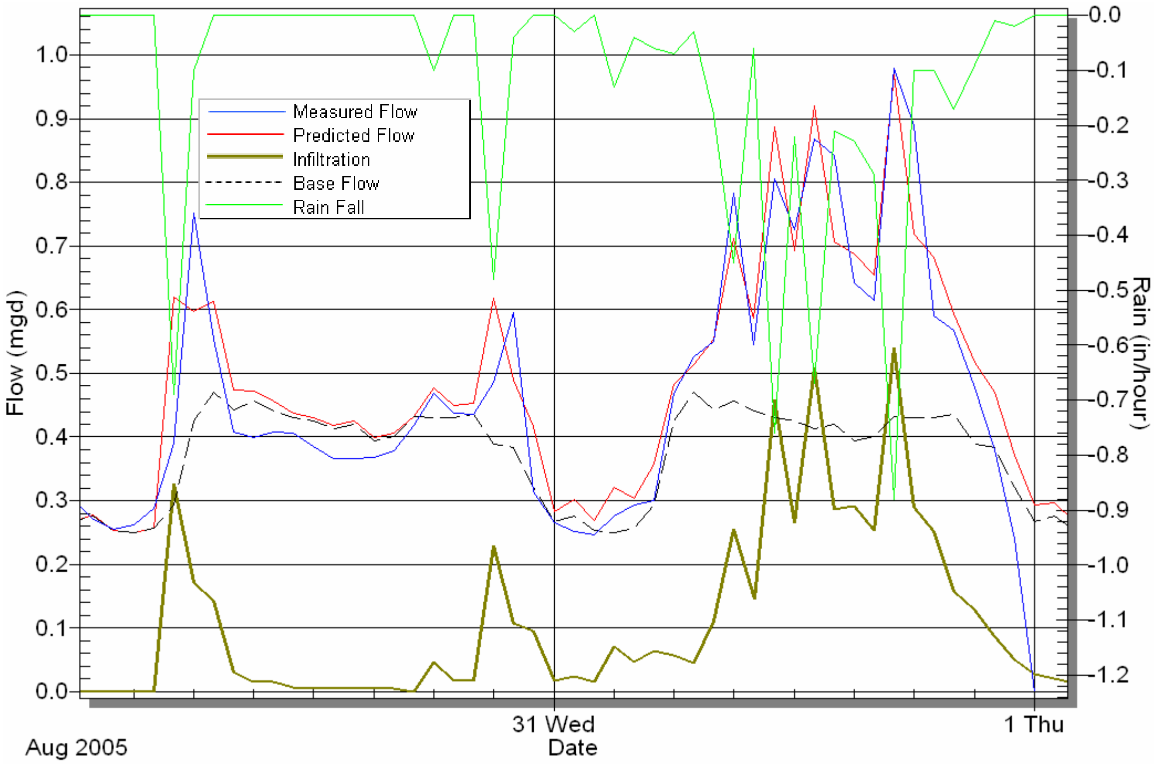
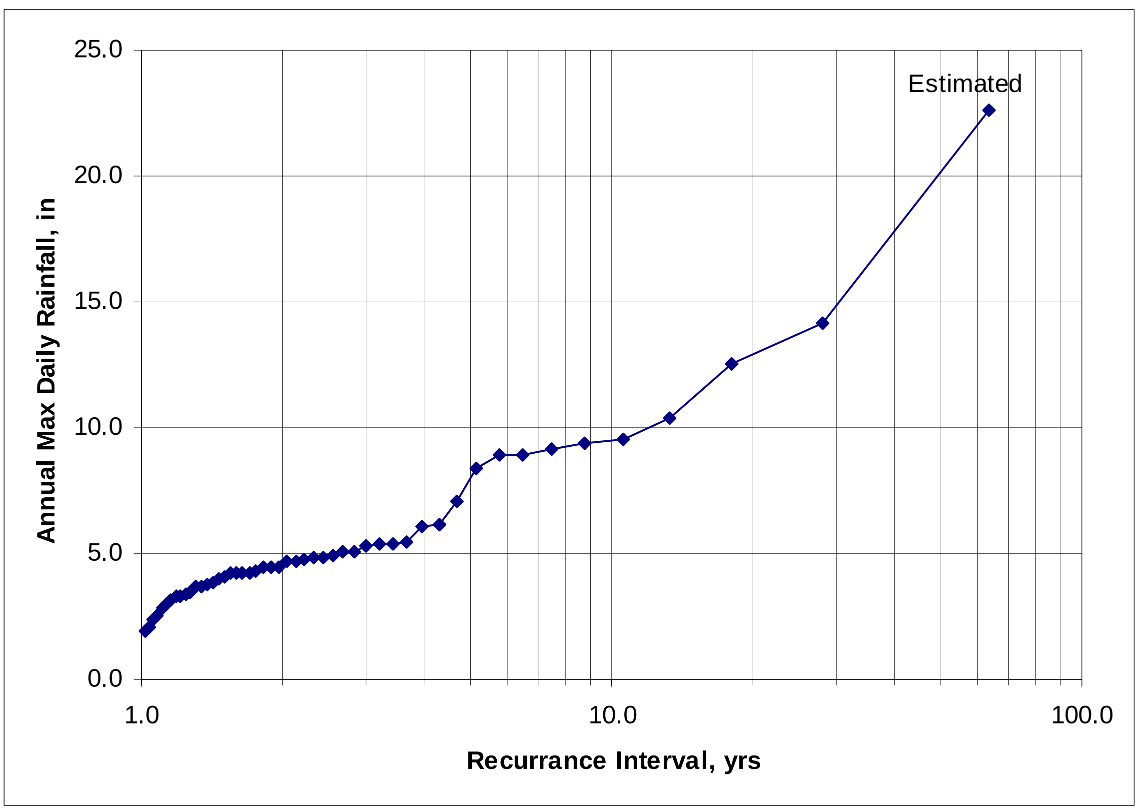


Figure 4-11 – Occurrence Frequency of Daily Total Rainfall for Guam



4.7.3.5 Review of Flow Metering Results

This section discusses observations made from review of the flow metering data.

4.7.3.5.1 *Northern District STP Service Area*. For the most part, the flow meters in the NDSTP service area indicated that the sewers at the flow monitor locations were not surcharged through out the monitoring period. Generally the flow depths were less than half the sewer diameter indicating that the pipes at the monitor locations could carry twice as much flow as measured without surcharge.

Exceptions to the lack of surcharge were FM 07, 08, and 38. These three meters measure flow from approximately 540 acres—flows from these meters (combined peak of two mgd) combine into a single 10-inch sewer that joins the old 36-inch sewer paralleling the main 46-inch influent to the Southern Link Pump Station. It is understood that the 36-inch line is lower than the 46-inch they connect just upstream of the Southern Link Pump Station. Depths at these three monitors ranged up to 48 inches. Although data on the depth of the specific manhole where the meters were installed is missing, it is expected to be about 10-feet based on the surrounding manholes. The surcharge may be due to the small line accepting the combined flows, or due to backup from the 36-inch line downstream. It is recommended that the cause of the surcharge be researched and appropriate modifications be made to eliminate it. This may involve enlargement of the 10-inch line connecting to the 36-inch, or modification of the 36-inch junction to the 46-inch line (36 or 48-inch line) to better take advantage of its capacity.

In addition, flow meter 35 upstream of the Fujita pump station reported maximum depths up to 65 inches. Manhole depths in this area are sufficient that overflows are not expected. However, it is recommended that the pump station operations be examined with the goal of eliminating the excessive surcharge.

The diurnal pattern of dry weather flow at most of the Northern District flow meters exhibited minimum night time flows of 60 to 70% of the daily average, and peak daily flows of 120% of daily average or less. It is expected that these patterns indicate high influx of groundwater infiltration. In a relatively tight system, minimum night time flows of 25% or less of average are expected and diurnal peaks are normally 150% of average or more.

4.7.3.5.2 *Hagatna STP Service Area.* Flow meters that exhibited significant surcharge in the Hagatna STP service area are discussed below:

- Flow meter 24 upstream of the Pago Double Shaft pump station exhibited maximum depths of 82 inches. The maximum elevation is about 1.5 feet below the rim of the second manhole upstream. The maximum reported flow rate at the meter (1.1 mgd) is the approximate capacity of one of the two installed pumps at the station. This data suggests that only one pump was operated or that the combined capacity of both pumps is less than the inflows at the station causing the backup at the meter. It is recommended that the station operation be modified to allow both pumps to operate or that the capacity be increased.

- Flow meter 20 in the 27-inch line on Route 1 near 9th Street exhibited depths up to 75 inches in a 108 inch deep manhole. Increases in depth were not always associated with rainfall. The cause of the high depths at this location is not clear. The manhole is high enough that it should be relatively unaffected by the Hagatna main pump station. This was a difficult location to monitor, so that the data may be in error. It is recommended that the sewer downstream be examined for blockages.
- Flow meter 31 upstream of the Barrigada STP reported a maximum depth of 47 inches. The maximum water surface elevation is less than one foot below the rim elevation of the manhole immediately downstream so that overflows are a possibility. The maximum reported flow is less than the identified capacity of one of the two installed pumps in the station and less than the capacity of the sewer. The cause of the backup is unclear. It is recommended that the station operation and capacity be examined.
- Flow meter 15 indicated surcharge from 10 a.m. to midnight on August 31st. Because the meter was provided only with an upward looking ultrasonic depth meter, it is not possible to determine the total depth of surcharge.
- Meter 17 exhibited surcharge up to 70 inches in a 12-inch sewer. The maximum water surface elevation is essentially at the rim of the manhole suggesting the possibility of overflows. It is believed this depth was a result of surcharge in the line downstream.
- Meter 18 reported a surcharge of over 48 inches in an 18-inch sewer. The manhole depth is six feet. This surcharge is apparently due to flows exceeding the capacity of the sewers downstream of the meter.
- Meter 37 on the influent line to the STP from Piti exhibited surcharge through out the monitoring period. The total depth of surcharge is not available because the meter was not provided with a pressure sensor. It is recommended that the pump station operation be examined to reduce this surcharge to help keep the sewer clean and possibly to reduce surcharge at the Meter 20 location.

Other meters in the Hagatna service area did not exhibit excessive surcharge.

4.7.3.5.3 Agat-Santa Rita STP Service Area. Both meters 25 and 26 on influent lines near the STP reported maximum depths of eight to nine feet on three occasions during the monitoring period. Nearby manholes are 12-feet to 14-feet deep and the maximum water surface would have been approximately 4 feet below the ground surface. The backup and restriction to flow is expected to be due to the influent pump station not having sufficient capacity. Peak I/I rates have been projected using the I/I models that exceed the maximum reported flows indicating that the full peak flow was not pumped into the STP.

4.7.3.5.4 Umatac-Merizo STP Service Area. No surcharges were reported at either Meter 29 or 30 in this service area.

4.7.3.5.5 *Inarajan STP Service Area*. During the high flows on August 31, 2005, meter 28 just upstream of the influent pump station reported surcharge up to nine feet. The peak flow measured during this period was less than the reported capacity of the pump station suggesting a possible problem with the power or plugging of the pumps with debris. The surcharge elevation exceeds the rim elevation of manholes south of the pump station along Chagamin Avenue suggesting an overflow would have occurred. It is recommended that the pump station be examined for reliability and upgraded if necessary. It is also recommended that the low lying portions of the sewer along Chagamin Avenue be converted to a pressure system to avoid overflows.

The metered flows at this location indicate a significant influence from groundwater infiltration. Based on the I/I model calibration, peak flows on any given day are impacted by the rainfall that falls over the preceding seven days. Because of the restriction by the pump station and the probable failure of the meter velocity sensor due to debris fouling during the August 31st event, it is not possible to accurately estimate the peak flow that may have occurred. Further monitoring is recommended after review of the station capacity and reliability.

4.7.3.5.6 *Baza Gardens STP*. No surcharge was reported at meter 27 on the STP influent sewer.

4.7.3.6 Modeling Results

Infiltration/Inflow and dry weather sewage flows developed as described above were loaded into the H_2Omap Sewer software to assess the capacity of the sewers and pump stations in each STP service area. The results are discussed in the following paragraphs.

4.7.3.6.1 *NDSTP Service Area*. Figures 4-12 and 4-13 show the pipes which the models predict to be surcharged (water surface above the crown) and the estimated depth the maximum water surface is below the rim elevation at the manholes. These figures were constructed from the model results for the 2025 condition with assumed new sewered areas as described above and with the I/I increased by 25% to represent a 5- to 10-year event.

Significant surcharges with estimated water surface elevations at or close to the ground surface occur in three areas: the area around Chalan Batangga Street east of flow meter 34; the Buena Vista area tributary to flow meters 07, 08 and 38; and the lines tributary to the Fujita pump station (flow meter 35).

Chalan Batangga: The results in this area are uncertain. The GIS data base in this area was incomplete and connectivity, manhole rim elevations and pipe sizes have been taken from the USGS maps. The wet weather flows assigned to this area may also be over estimated due to the large un-metered flow that enters the split manhole where flow splits between meters 05 and 11. It is recommended that the connectivity and rim elevations be verified and that the flow entering the split manhole be monitored to improve the model predictions. It is considered unlikely that manholes are overflowing as suggested.

Figure 4-12 – Surcharged Sewers in the Northern District STP Service Area

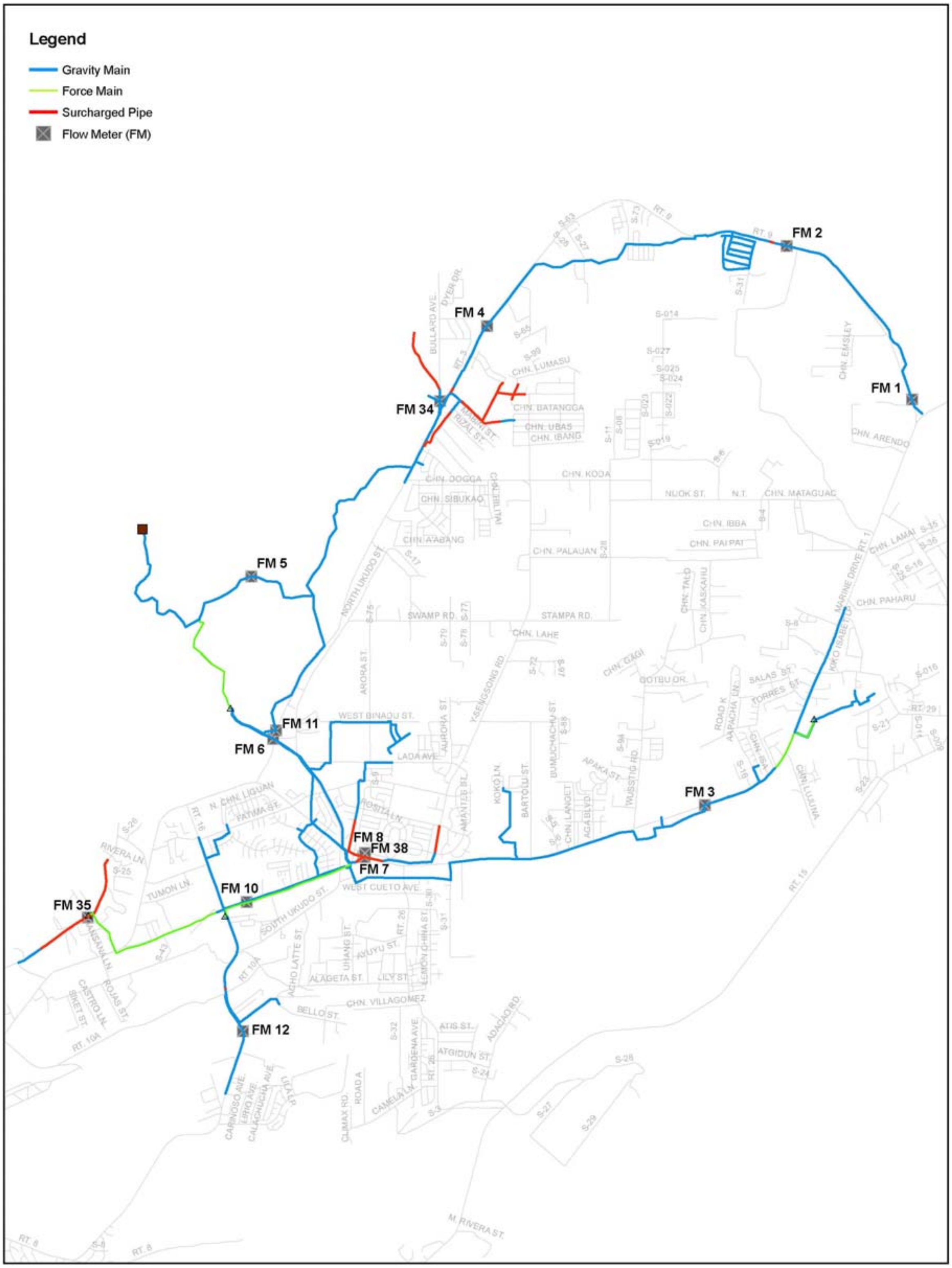
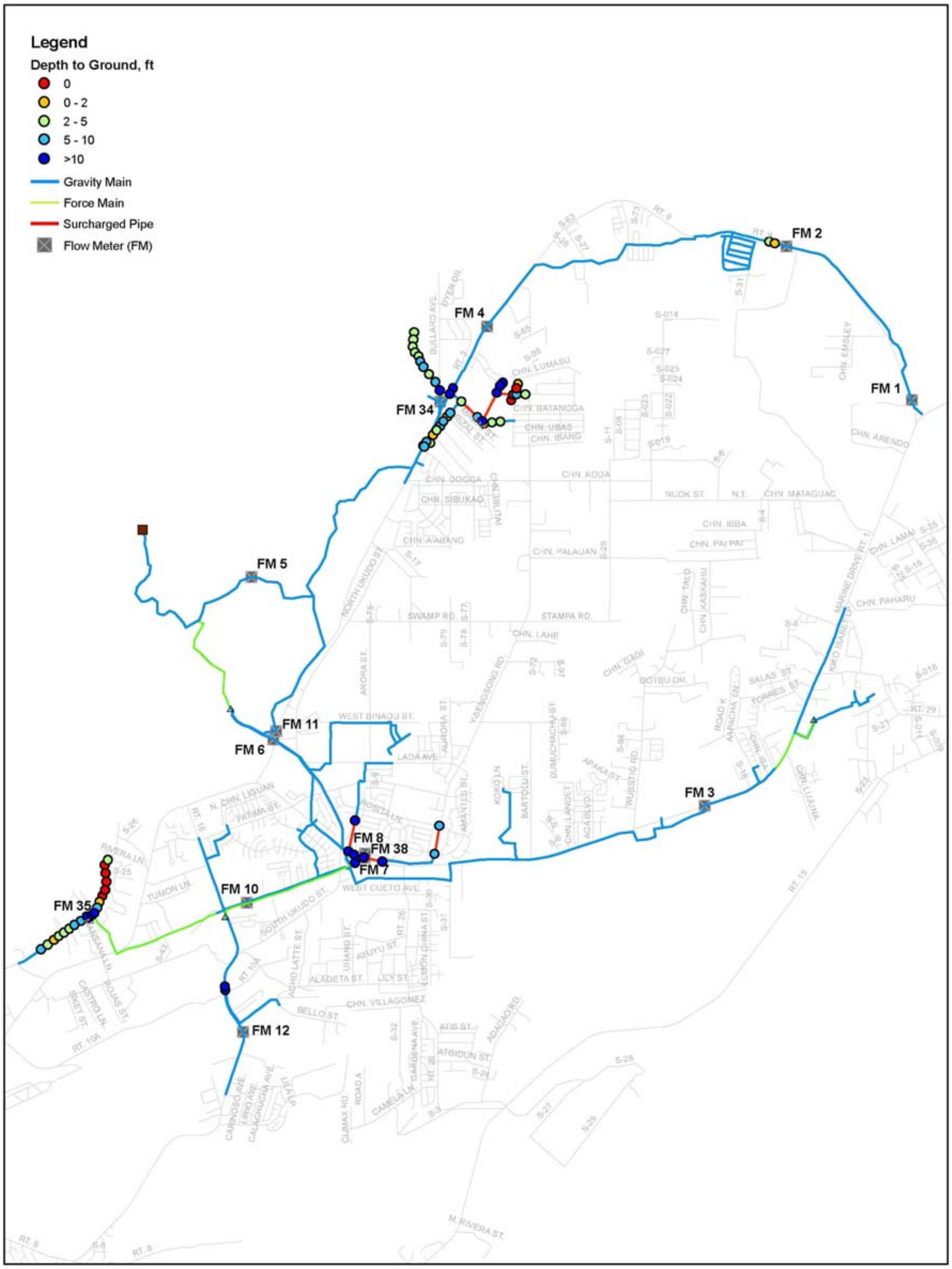


Figure 4-13 – Predicted Minimum Distance from MH Rim to Water Surface
for Surcharged Sewers in the Northern District STP Service Area



<u>Buena Vista</u>: This area was noted as surcharging during the flow monitoring period due to the restricted line that connects it to the main line sewer down stream. The manhole depths are such that overflows in the vicinity of monitor locations. The line connecting this area to the main line should be enlarged to relieve the surcharge, however. The model also suggests that the 10-inch line in Y-Seng Song Road is surcharged-this line was not in the GIS data base and was taken from the 1968 USGS maps and inverts and rim elevations estimated. Because the predicted water surface elevation is well below the ground surface, it is recommended that the line parameters be verified, and the line be observed for surcharge evidence before a correction project is undertaken.

<u>Fujita Pump Station</u>: This pump station serves the hotel area on the beach. Surcharges were noted at the flow meter during the monitoring period. Flows at this location respond strongly to intense rainfall, producing about 1.5 mgd of peak I/I from rain at one inch per hour, but the maximum diurnal peak flow in dry weather was higher than any flow reported during wet weather. The response to rainfall suggests an inflow source. The pipes leading to the pump station found in the GIS database are undersized for the dry weather flow. If field confirmation indicates the GIS pipe sizes are correct, they will need to be enlarged in the near future.

Replacement pipe sizes were computed to relieve the surcharges shown on Figure 4-13. These were prioritized based on severity of the existing problem, response to growth, and confidence in the underlying network data.

4.7.3.6.2 <u>Hagatna STP Service Area</u>. Figures 4-14 and 4-15 show pipes which the model predicts to be surcharged (water surface above the crown) and the estimated depth the maximum water surface is below the rim elevation for the Hagatna STP service area. Results are for the 2025 loading condition. Major problem areas are noted along Marine Drive, Route 4, Route 33, East O'Brian Drive, and the lines draining Agana Heights to the Chaot River pump station. The line is Route 33 from the Mongmong-Toto lift station to flow meter 16 is presumed and should be verified. Flows in the line draining Agana Heights to the Chaot River pump station should be metered to confirm the model projections. Some of the surcharges shown are due to down stream conditions. For example, the surcharges shown in the line draining the Tamuning area tributary to meters 32 and 33 is caused by high water levels in the line in Route 1. Likewise, the surcharges in the line on East O'Brian Drive are due to high water levels in the line Route 4.

It should be noted that the model software does not allow water to leave the system at manholes where it predicts the water surface is at the rim elevation. In the actual system, overflows up upstream manholes might relieve the system downstream so that overflows might not occur at every manhole shown with the predicted water surface at the rim. However, the model is conservative in that it predicts the impact of maintaining the flows in the system so that pipe enlargements to convey the flow to the treatment plant can be computed.

Figure 4-14 – Surcharged Sewers in the Hagatna STP Service Area

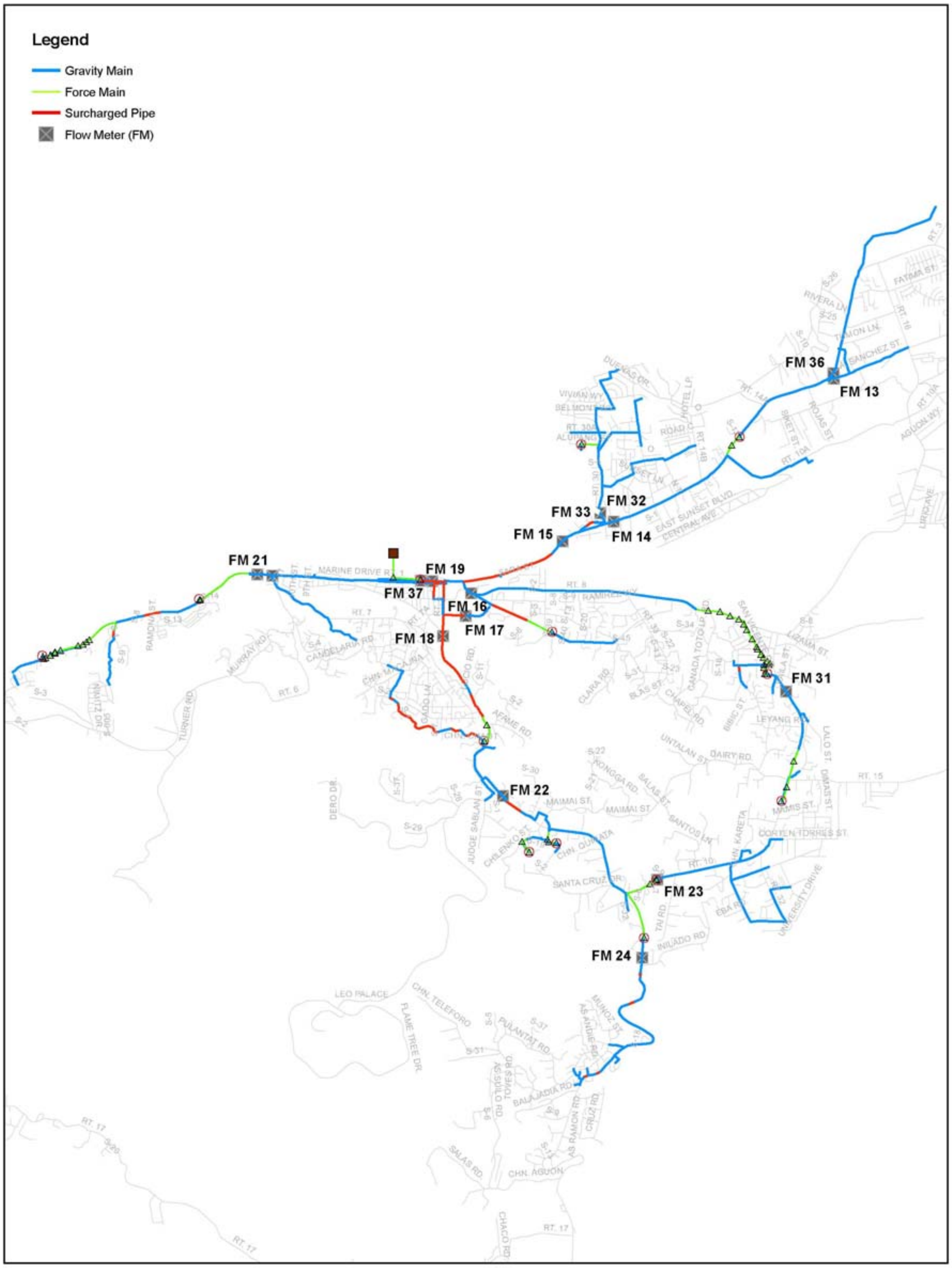
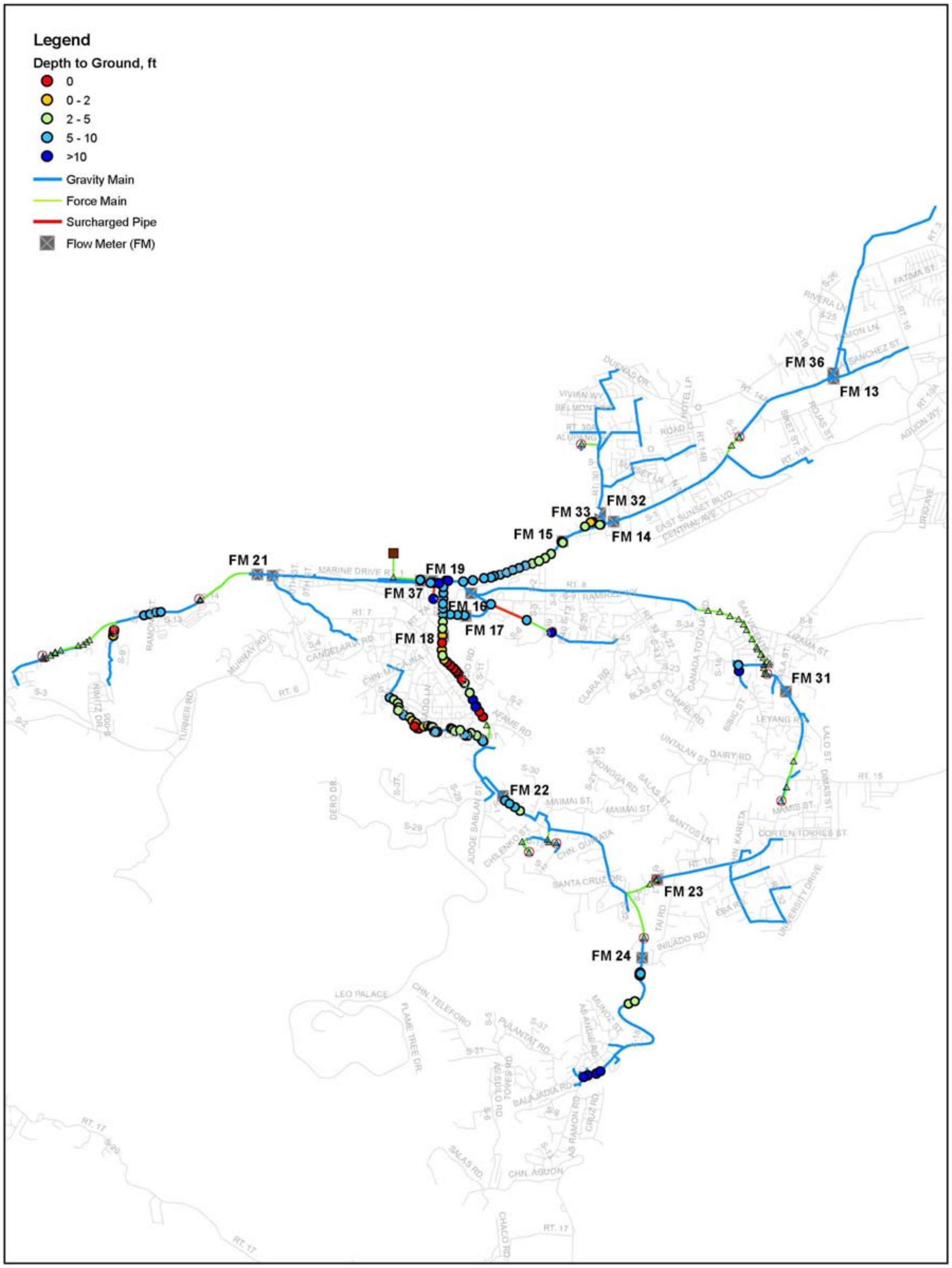


Figure 4-15 – Predicted Minimum Distance from MH Rim to Water Surface for Surcharged Sewers in the Hagatna STP Service Area



The number of pipes that the model indicates would require upgrade using the smaller storm parameters discussed above is about one-third of those for the larger storm. These have been prioritized at level 1 or action in the near-term. The remaining pipes have been given priority 2 unless they require confirmation by further analysis, pipe verification or the necessary increase in size is no more than one standard pipe diameter, in which case they have been given priority 3. Pump stations whose capacity is less than the model predicts for the larger storm have also been given a priority 1 for upgrade.

4.7.3.6.3 *Agat-Santa Rita STP Service Area*. Figure 4-16 shows surcharged pipes and estimated depth the maximum water surface is below the rim for the Agat-Santa Rita STP service area. The lines tributary to flow meter 25 are shown as surcharged with the water surface near or at the surface in the area around Route 12. During the flow monitoring, both meters 25 and 26 indicated significant surcharge. It is believed this is due to the plant influent pump station not having capacity to pump all the flow. The results shown on Figure 4-16 were prepared assuming the influent pump station was upgraded to handle the flow. However, the model still predicts surcharge and potential overflow upstream of the meter 25 site. Pipe size upgrades to relieve the surcharge were computed for this area.

4.7.3.6.4 *Baza Gardens STP Service Area*. Figure 4-17 shows surcharged pipes and estimated depth the maximum water surface is below the rim in the Baza Gardens STP service area. Pipe sizes necessary to relive these surcharges have been calculated. The pipes leading the plant in Flores Rosa Street will have to be addressed when the developed areas not yet connected to the system are added.

Figure 4-16 – Surcharged Sewers in the Agat-Santa Rita STP Service Area

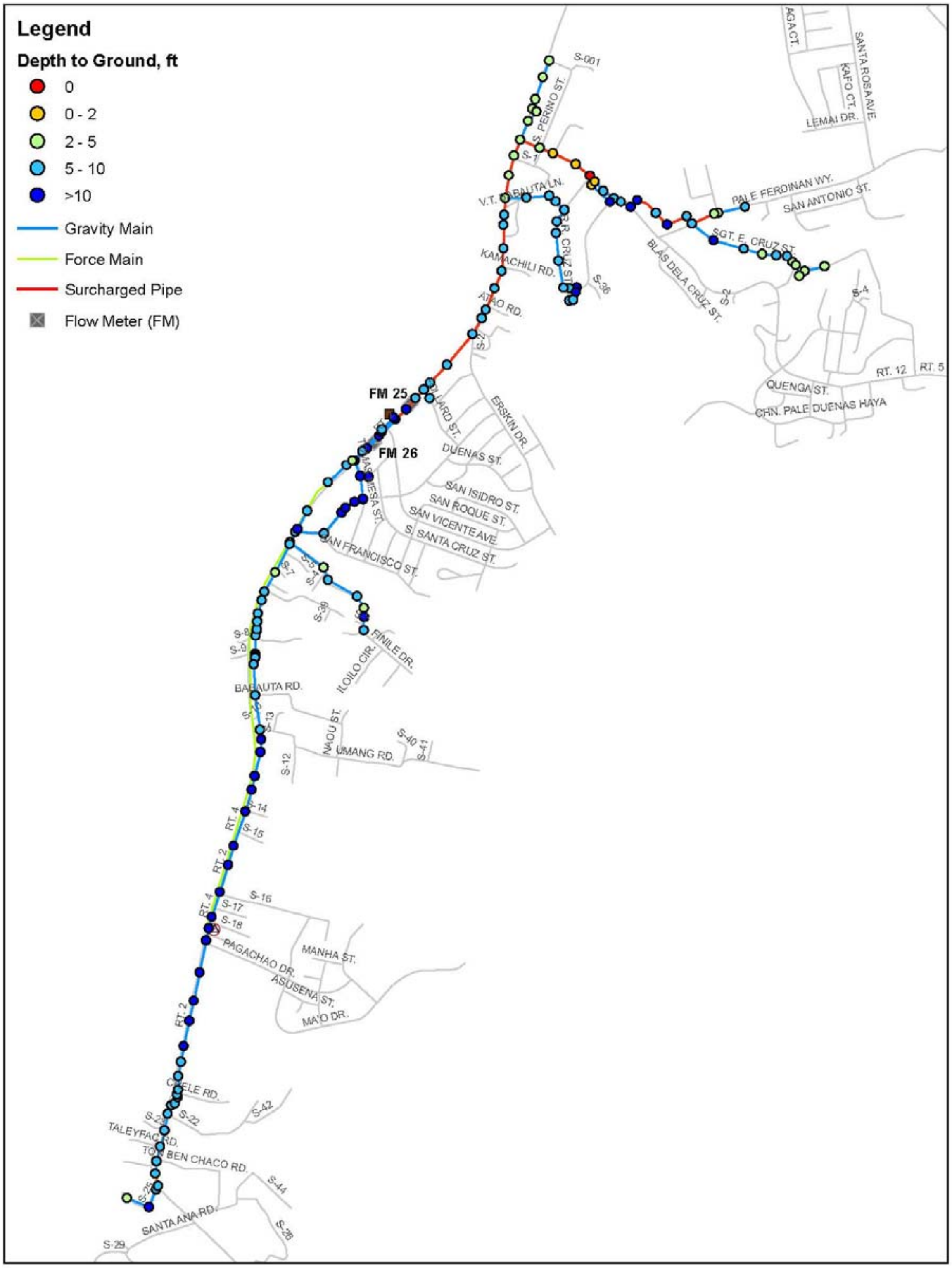
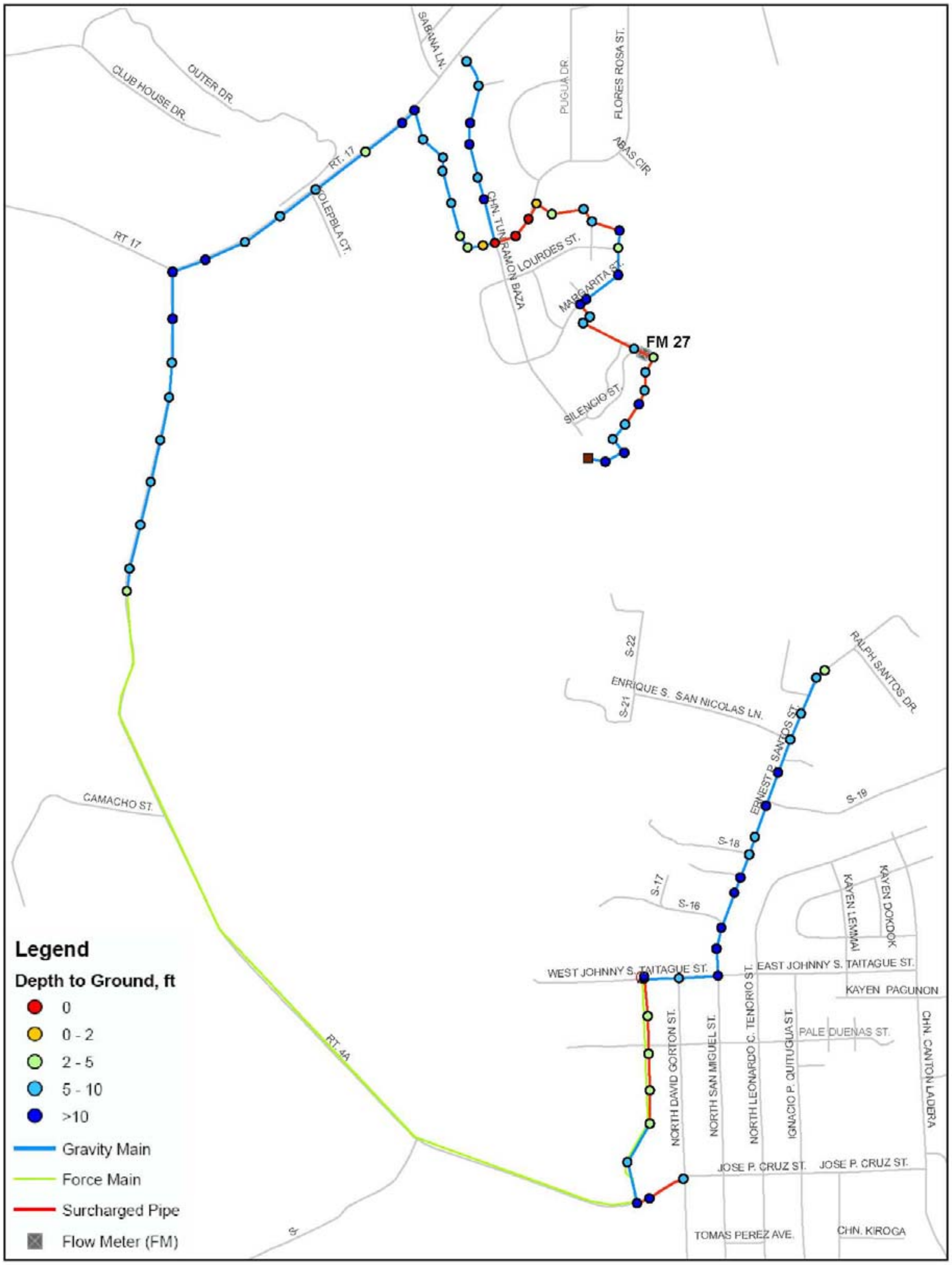


Figure 4-17 – Surcharged Sewers in the Baza Gardens STP Service Area



4.8 Conclusions, Recommendations and CIP Projects

4.8.1 Conclusions

Major activities for this portion of the WRMP centered on determining the basic layout of the sewer system and performing critical sewer and general condition and capacity assessment. This information was then used to provide recommendations and the proposed CIP project summarized below.

4.8.2 Recommendations for Preventive Maintenance

Regularly scheduled periodic flushing is recommended for the areas on the gravity collection system identified with dry weather spills, sags, and/or the potential for grease build-up. In the future, areas that are found to have similar issues based on the prioritized inspection results are recommended to be added to the preventive maintenance schedule. In lieu of an existing program, it is recommended that areas identified for additional preventive maintenance due to spills be put on a weekly flushing schedule until it is determined that less frequent maintenance is required or until the area has been inspected by CCTV and the cause of the spill identified and/or mitigated. Those areas that are found to require ongoing excessive preventive maintenance to prevent potential spills should be programmed for rehabilitation. Areas identified for additional preventive maintenance due to debris or grease accumulation, but do not spill should be put on a monthly flushing schedule. The frequency of flushing for these areas may be reevaluated upon completion of additional field inspection. Initial areas recommended for preventive maintenance are listed below:

- 8-inch line on Mendiola Lane east of Tutujan Drive – suspected of having sags.
- 8-inch line on Paasan Drive west of Tutujan Drive – suspected of having sags.
- Finile Drive housing development PVC piping believed to have poor bedding leading to possible sags.
- Inverted siphon on Route 2 across the Togcha River causes grease build-up.
- 14-inch line on Route 4 between the two entrances to Sister Mary Encarita Drive (loop) has grease issues.
- 8-inch line on J. M. Tuncap Street has grease issues.
- 8-inch line adjacent to Nino Perdido Church that connects to 16-inch/18-inch main line on Marine Drive has grease issues.
- 6-inch line on North San Carlos has grease issues.
- 6-inch line south of Route 3 (near Numero Uno) has grease issues.
- 8-inch line west of the elementary school on Y-Sengsong Road between East San Antonio Avenue and East Santa Monica Avenue is believed to have sags that cause grease issues.
- 10-inch line at the Marine Drive and Harmon Loop Road intersection is prone to wet and dry weather spills due to heavy grease.
- Collector line west of residential area (just west of Marine Drive and south of school) that connects to 14-inch line on Harmon Loop Road is prone to blockage and back-ups due to grease.

- 8-inch collector line south of South Lemai Court/South Mariposa Court/South Melindes Court is prone to grease blockage.
- 8-inch line on the east side of the Santa Ana subdivision at the Route 3 and Route 9 junction that carries flow to 30-inch line has heavy grease issues.

4.8.3 Recommendations for Prioritized Inspection/Ongoing Data Collection

Results from the critical sewer assessment rating prioritized the entire gravity collection system into one of three priority ratings: high (>40, red); medium (≥30 and ≤40, yellow); and low (<30, green). Approximately 150,000 feet, or about 10% of the collection system sewers were assigned a high priority, while approximately 436,200 feet, or about 31% of the collection system sewers, were assigned a medium priority rating using the numerical rating scale described in Tables 4-1 and 4-2. The remainder of the pipes were assigned a low priority rating, however approximately 300,000 feet of the low priority sewers, or about 21% of the collection system sewers, are located within the groundwater protection zone. Exhibits 4A.6a-6e – Critical Sewer Rating, shows the results of the collection system rating.

It is recommended that the high and medium priority lines and all the low priority lines in the groundwater protection zone or within 1,000 feet of a potable water supply well be inspected by CCTV, or manhole inspection with photographs documenting the condition of the influent and effluent sewer pipes, over the next five years. This corresponds to slightly over 180,000 feet of sewers that are recommended for inspection per year. Due to the large number of lateral connections in the system, inspection priority ratings were not provided. However, the intention is that during ongoing inspection the condition of laterals associated with the main line should be noted with additional, targeted inspection scheduled for those laterals that are identified with potential problems. Other specific areas recommended for additional data collection are listed below:

- Agat Focused I/I Investigation – perform focused flow monitoring, smoke testing and CCTV to identify specific high I/I areas for rehabilitation in the area east of Route 2 between Finale Drive on the south and Atao Road on the north.
- Agana Marine Corps Drive Smoke Testing – perform smoke testing along Marine Corps Drive for possible cross connections.
- Merizo Smoke Testing – perform smoke testing to identify whether abandoned laterals (identified in the 1991 Umatac-Merizo Sewer System Evaluation Survey), near the Mannell River channel are potential I/I points.
- Review operations of the Fujita Pump Station to avoid surcharges in the upstream pipe network.
- Complete development of GIS pipe database and verify model parameters.
- Collect additional flow data to fill gaps in the temporary program and improve model predictions. High priority areas are the line from Piti to the Hagatna STP, the line draining Agana Heights to the Chaot River Pump Station, the 14-inch line in Route 16 leading to the Route 16 Pump Station, and focused metering in the Agat-Santa Rita STP service area.
- Upon completion of the GIS database and additional metering, re-run models to confirm predictions.

- Perform force main daylight manhole and external fitting inspections on all forcemains to prioritize additional inspection on the worst condition forcemains as described in Section 4.6.2.

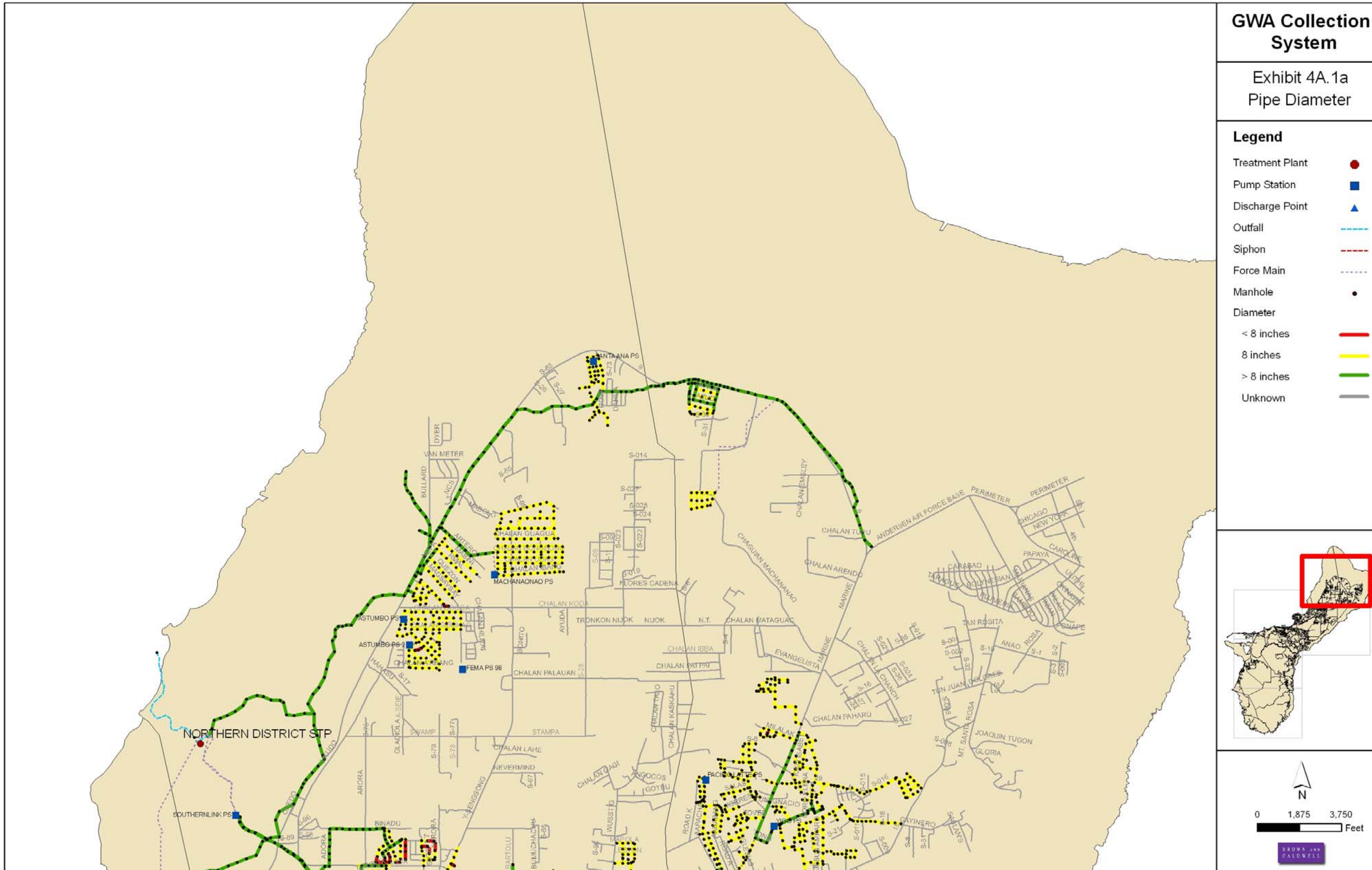
4.8.4 CIP Projects

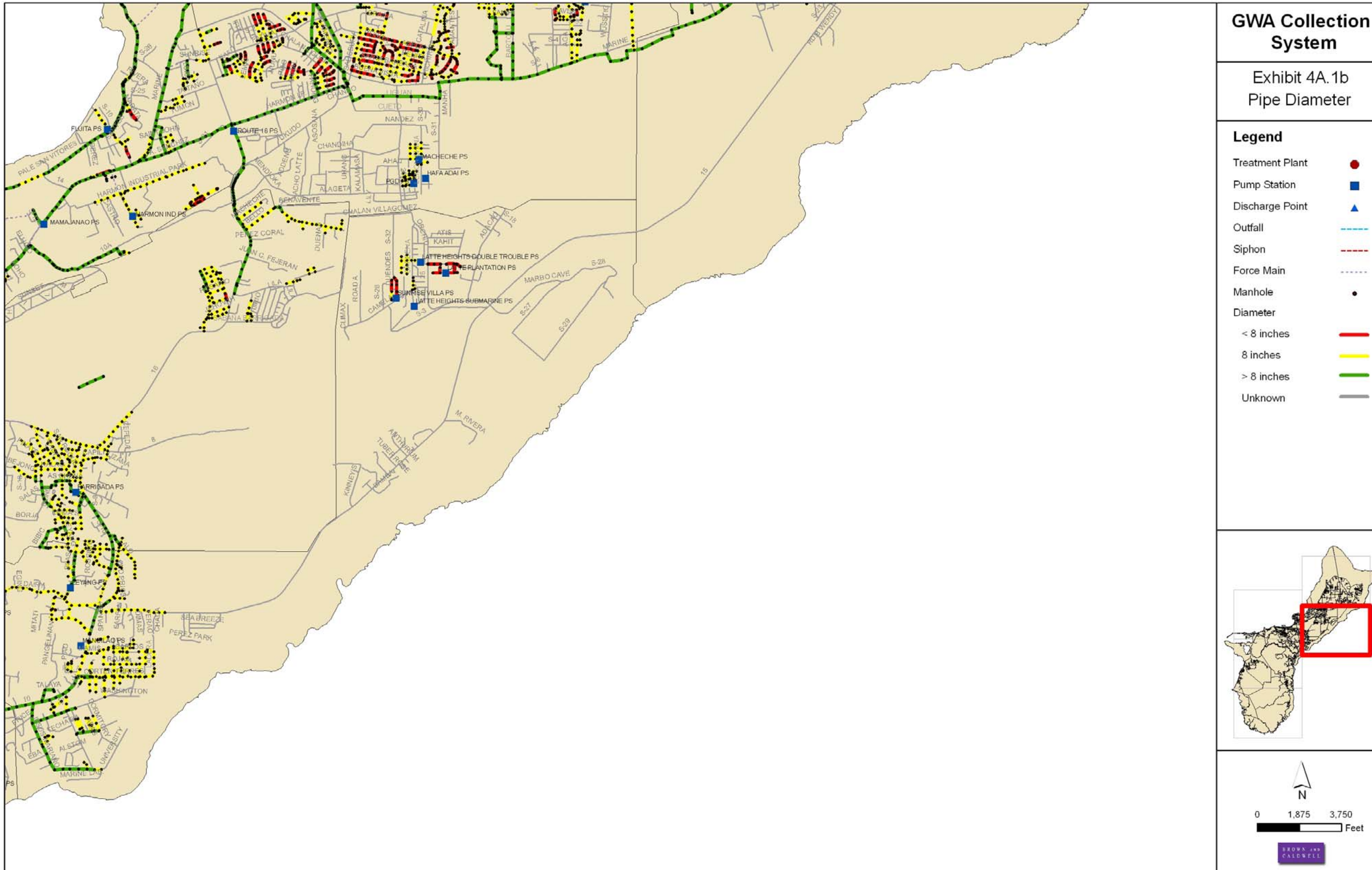
CIP projects are detailed in the WRMP Proposed CIP Projects listing in Volume 1, Chapter 15. Following is a summary of major items recommended in the program:

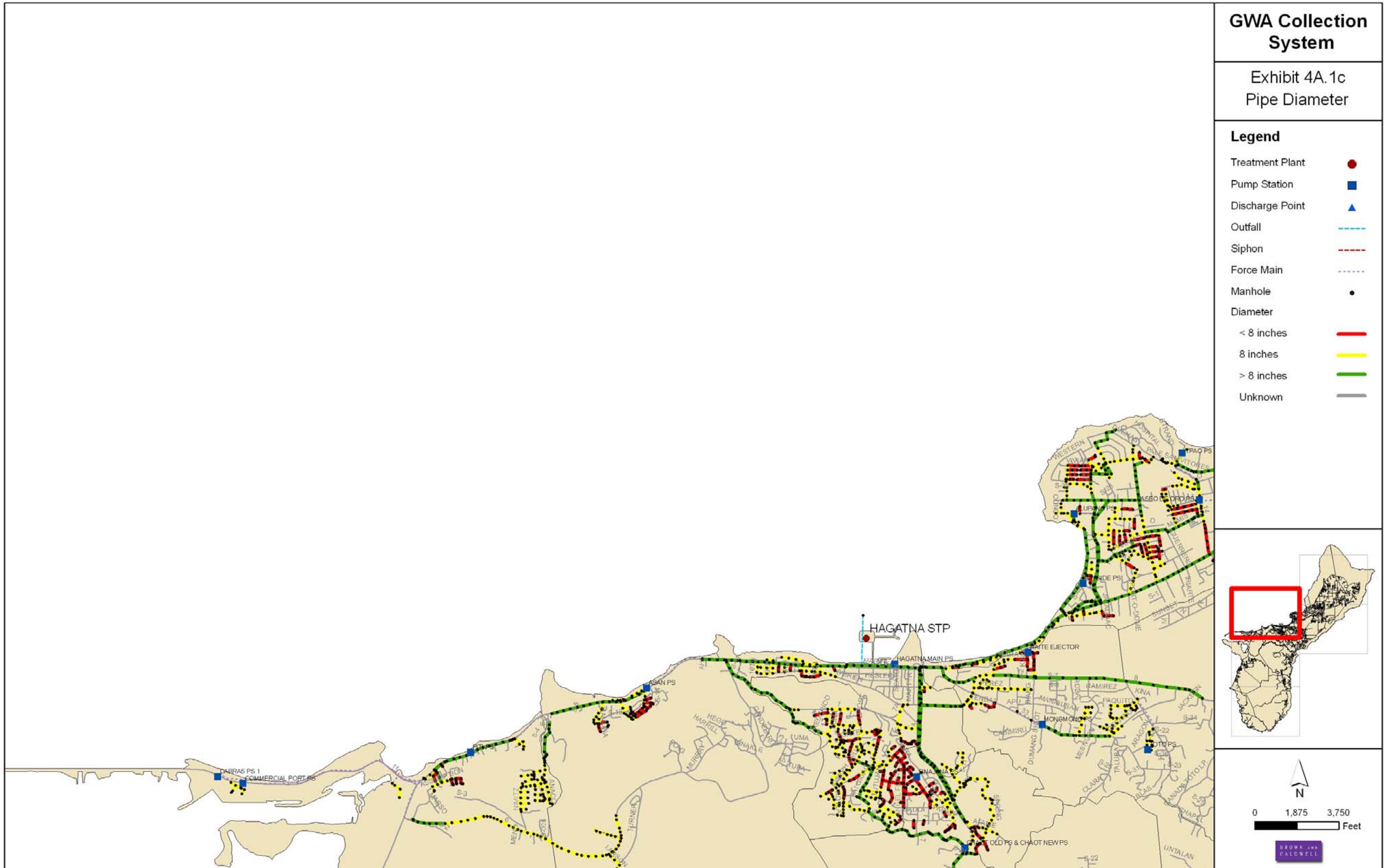
- Dededo Manhole Modification – this project proposes modification to one manhole to divert 100% of flow to 42-inch gravity line which flows directly to the NDSTP instead of the 18-inch line that flows to the Southern Link PS.
- General Manhole Frame Seal Repair – this project recommends repairs to seal the manhole cover frame to the barrel/cone at approximately 62 manholes identified by the initial manhole inspections.
- Agat Manhole Rehabilitation – this project recommends rehabilitation of four manholes that were identified by manhole inspections to have active infiltration.
- Upgrade pipes and pump stations in tributary areas of each STP to provide needed conveyance capacity. The specific pipes and pump stations are listed in the project summaries provided in Chapter 9 of this volume.
    - NDSTP Rte 16 PS Overflow Study
    - NDSTP Priority sewer upgrades
    - Hagatna STP Priority sewer upgrades
    - Agat-Santa Rita STP Priority sewer upgrades
    - Baza Gardens STP Priority sewer upgrades
    - Inarajan STP pressure sewer upgrades
- Design and construct new sewers tributary to the following STP's:
    - NDSTP
    - Umatac-Merizo STP
    - Baza Gardens STP
    - Inarajan STP
- Design and construct new sewer connections.
- Ongoing replacement of approximately ¾ percent of the worst condition gravity sewers per year (~8,600 feet/year in addition to hydraulic upgrade recommendations). Based on the estimated footages of the recommended hydraulic sewer upgrades, the additional ongoing replacement program would bring the total estimated annual pipe replacement to about one percent per year of the entire gravity sewer system.

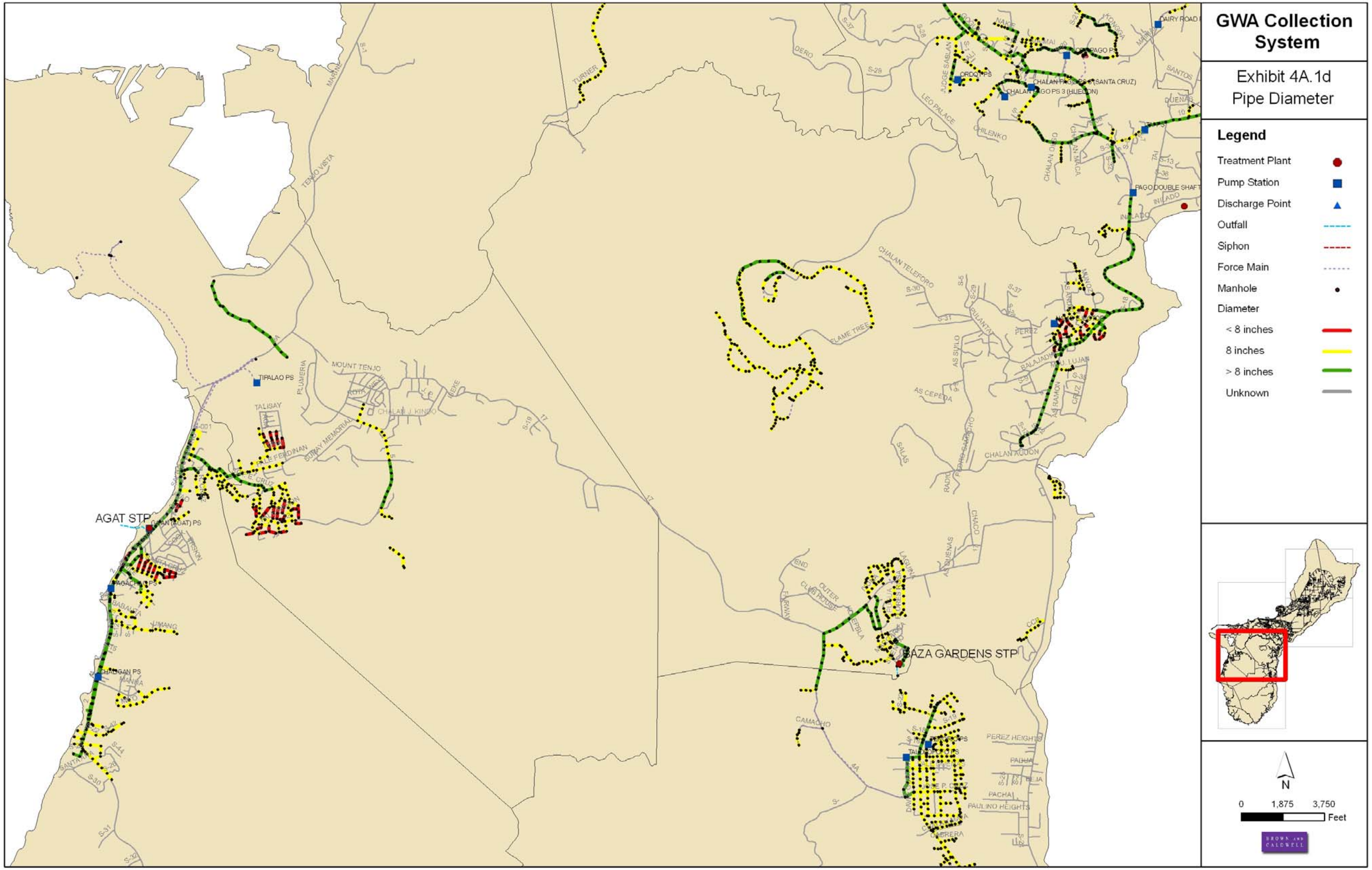
4.8.5 Spill Response Plan

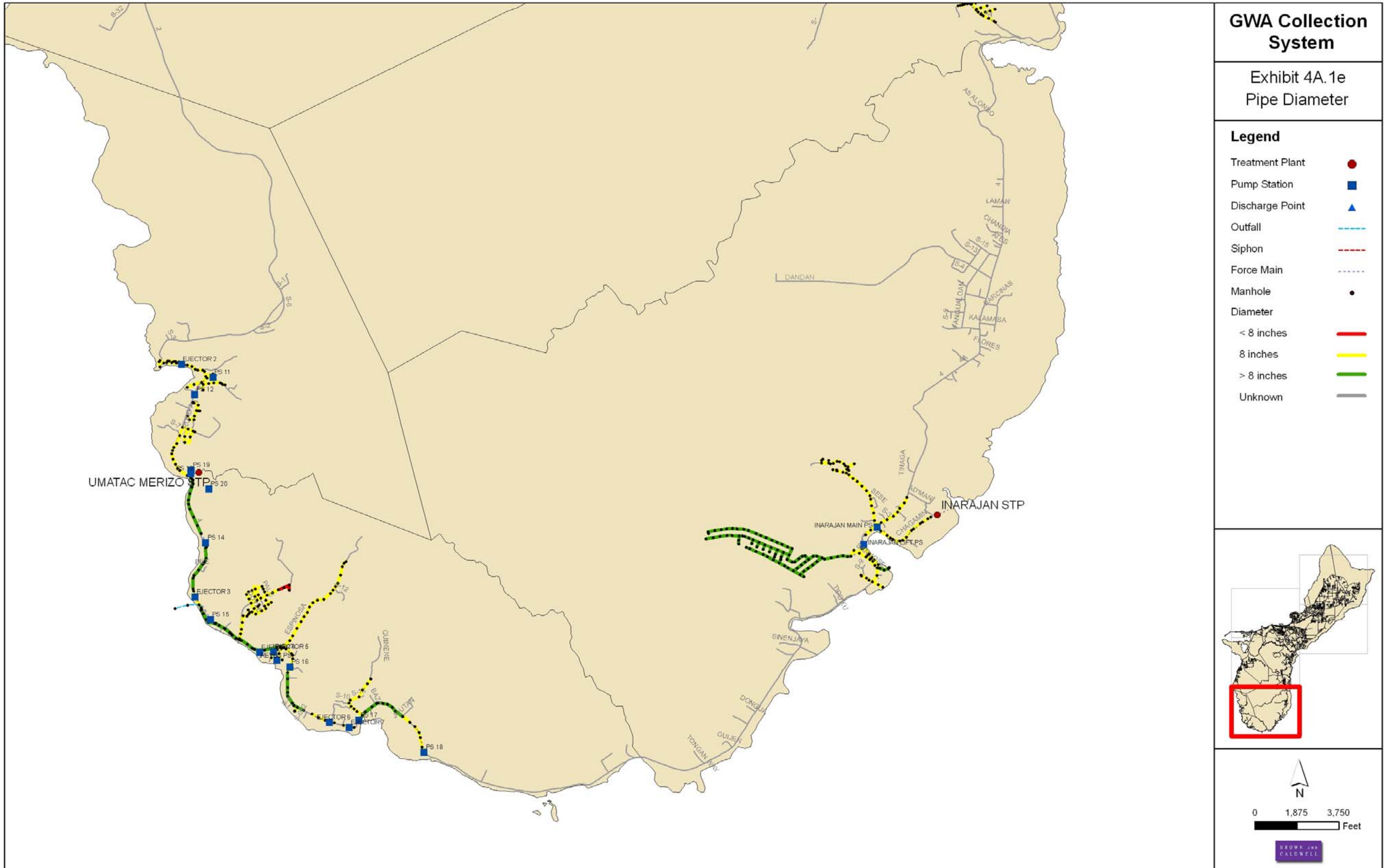
In addition to the above recommendations, GWA will develop a spill response plan that will identify procedures to contain, mitigate and document spills as well as define the local and federal agencies that should be contacted in the event of a spill. The plan should require automatic preventive maintenance programming for sewers that may be related to the spill.

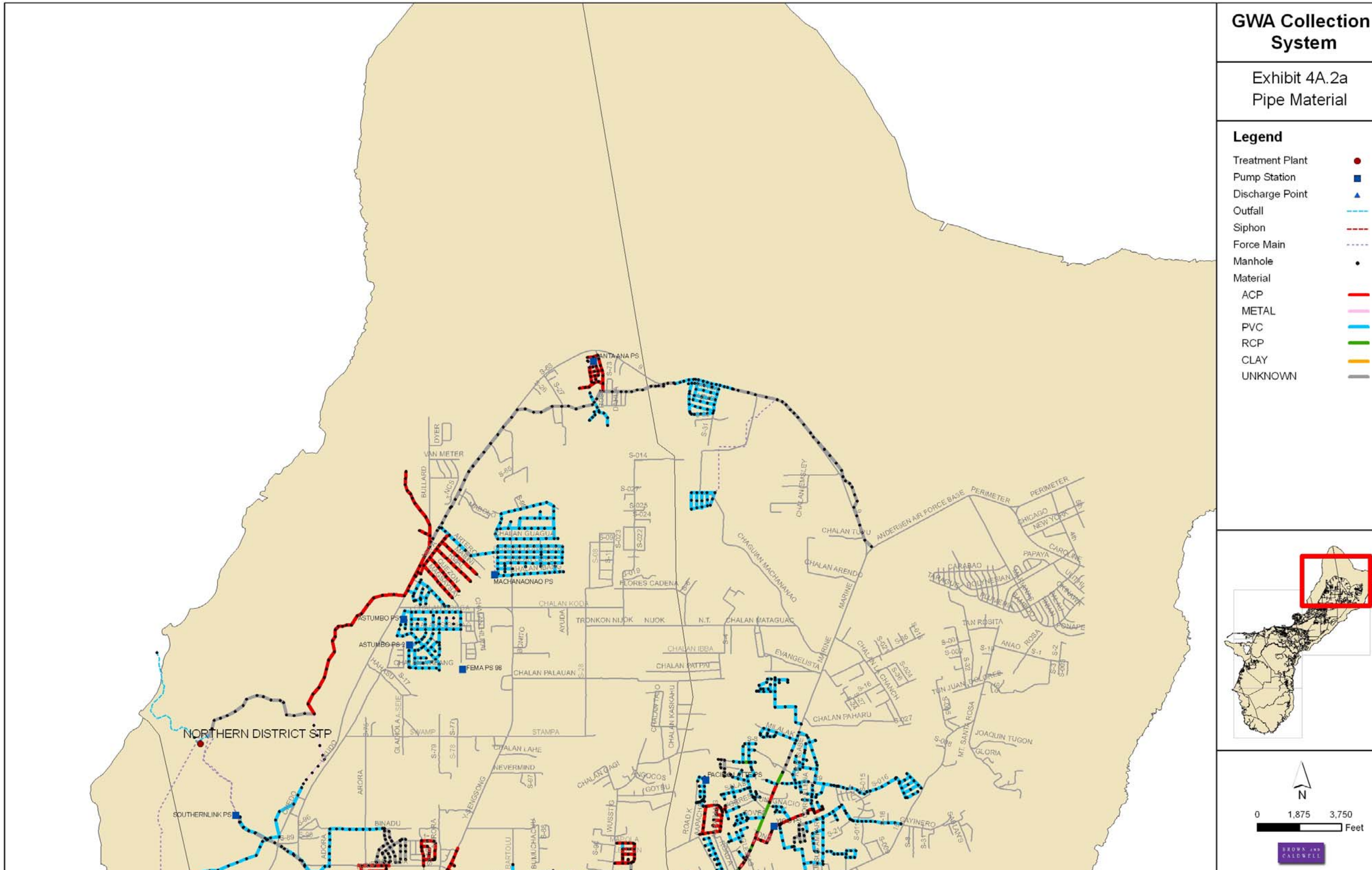

GWA Collection System
Exhibit 4A.1a
Pipe Diameter
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Diameter
< 8 inches
8 inches
> 8 inches
Unknown
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
ASTUMBO PS
MACHANAONAO PS
FEMA PS 98
SOUTHERNLINK PS
ANDERSEN AIR FORCE BASE
PERIMETER
CHALAN PALAUAN
STAMPA
JOAQUIN TUGON

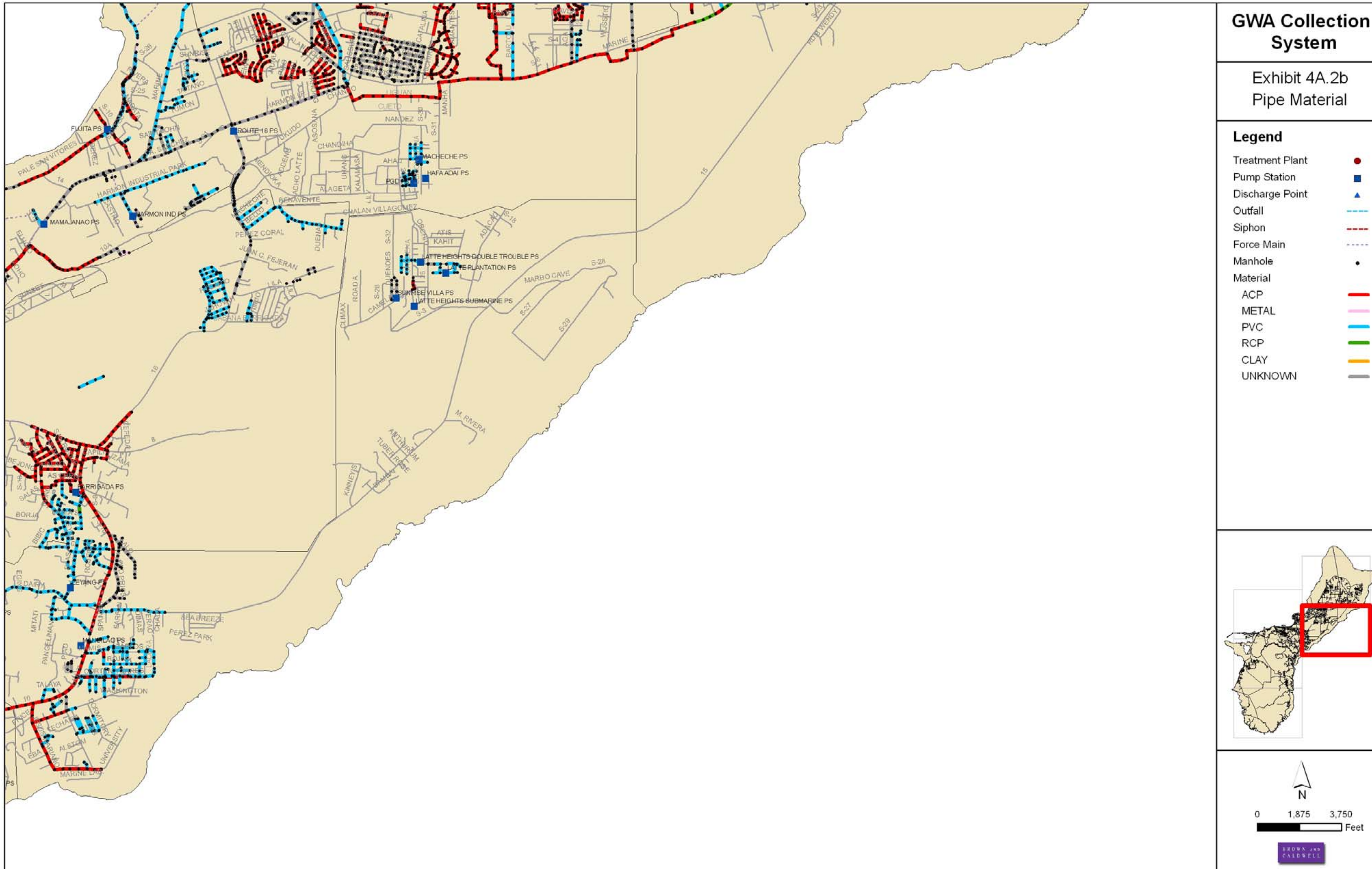

GWA Collection System
Exhibit 4A.1b
Pipe Diameter
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Diameter
< 8 inches
8 inches
> 8 inches
Unknown
N
0
1,875
3,750
Feet
FLUITA PS
ROUTE 16 PS
MACHECHE PS
HAFA ADAI PS
MAMAJANAO PS
HARMON IND PS
LATTE HEIGHTS DOUBLE TROUBLE PS
LATTE PLANTATION PS
SUNRISE VILLA PS
LATTE HEIGHTS SUBMARINE PS
BARRIGADA PS
MARBO CAVE
M. RIVERA
SEA BREEZE
PEREZ PARK
HARMON INDUSTRIAL PARK

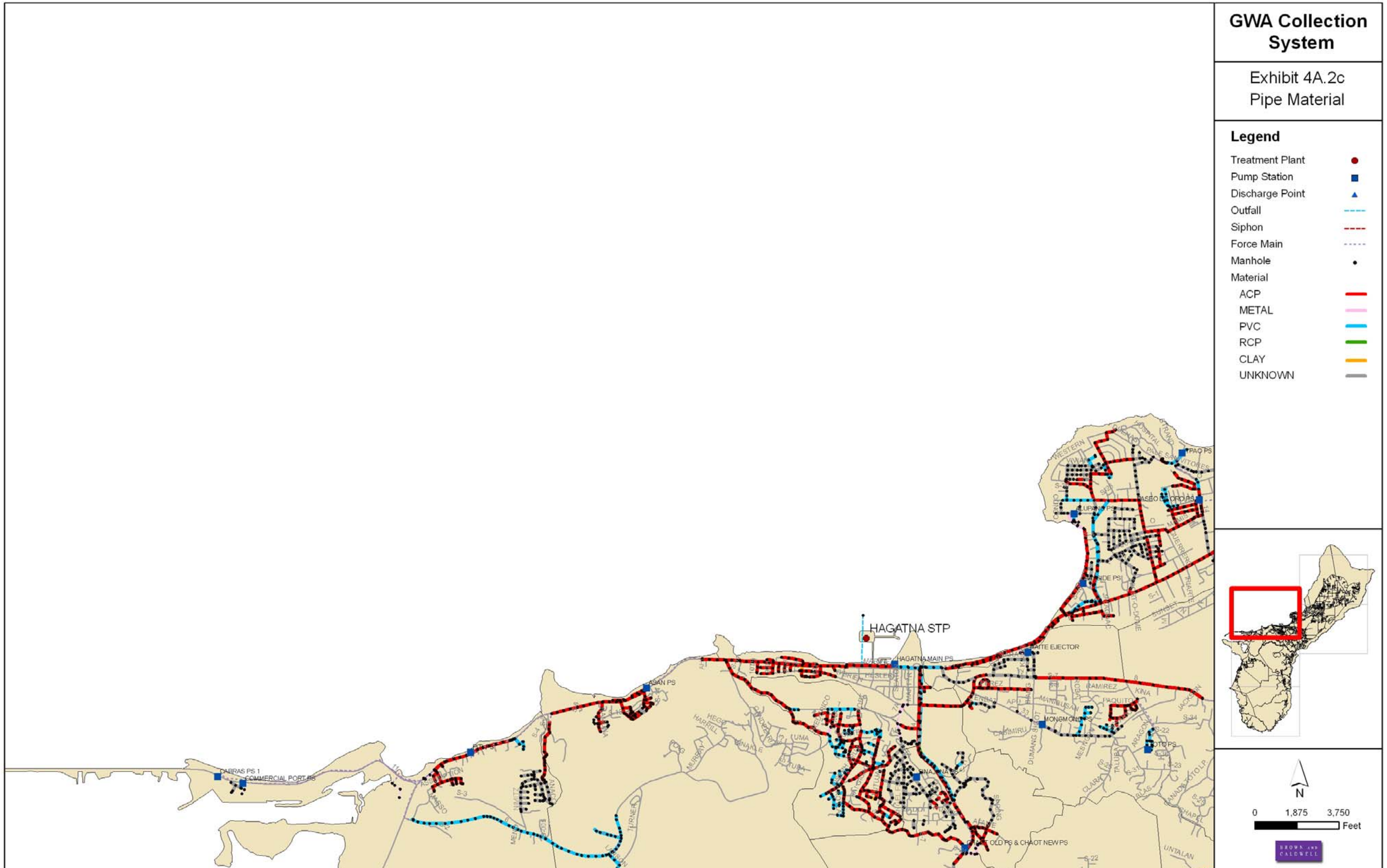

GWA Collection System
Exhibit 4A.1c
Pipe Diameter
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Diameter
< 8 inches
8 inches
> 8 inches
Unknown
N
0 1,875 3,750
Feet
HAGATNA STP
HAGATNA MAIN PS
CABRAS PS 1
COMMERCIAL PORT PS
MONGMONG PS
OLD PS & CHAOT NEW PS
PAO PS

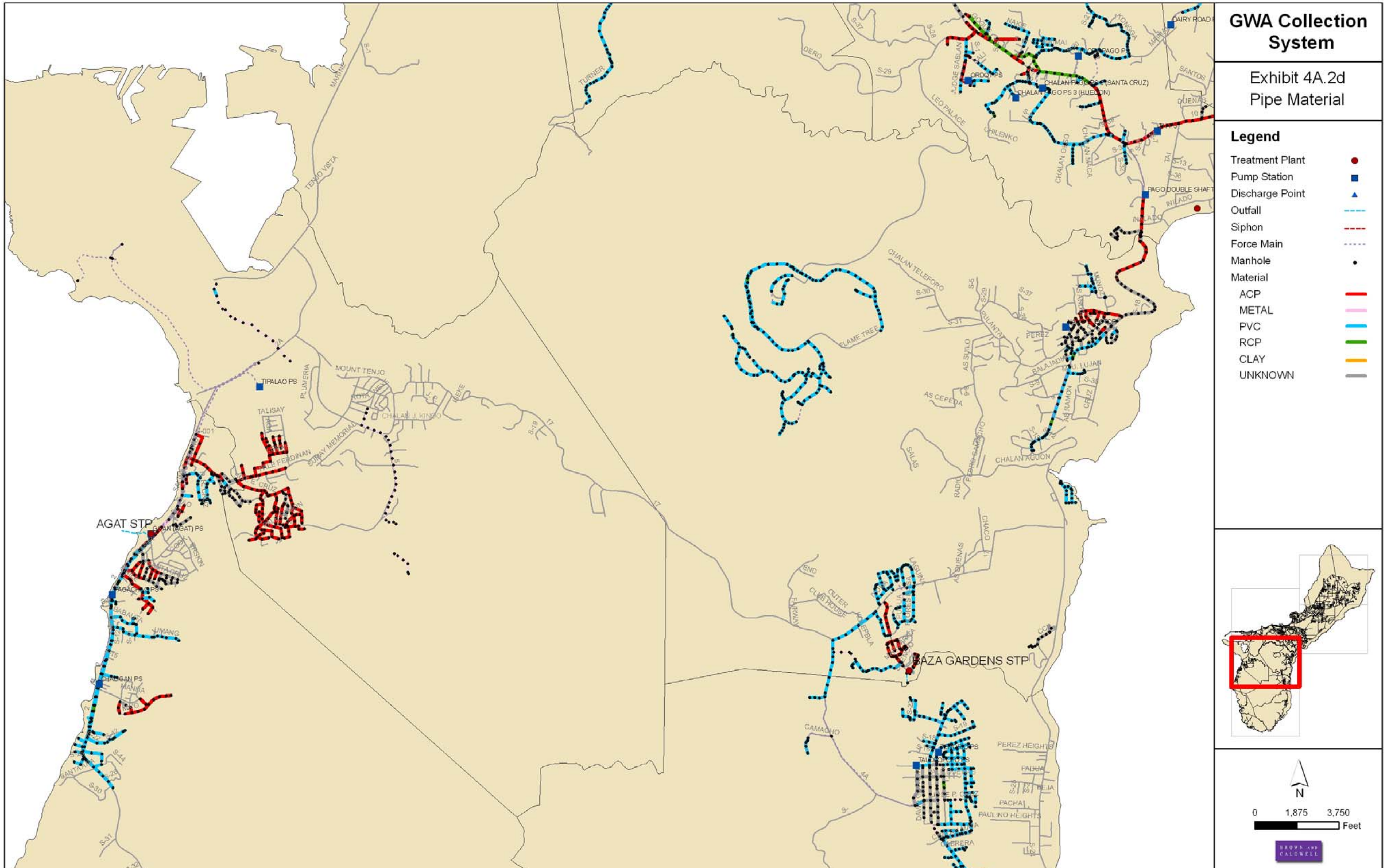

GWA Collection System
Exhibit 4A.1d
Pipe Diameter
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Diameter
< 8 inches
8 inches
> 8 inches
Unknown
AGAT STP
BAZA GARDENS STP
TIPALAO PS
N
0
1,875
3,750
Feet

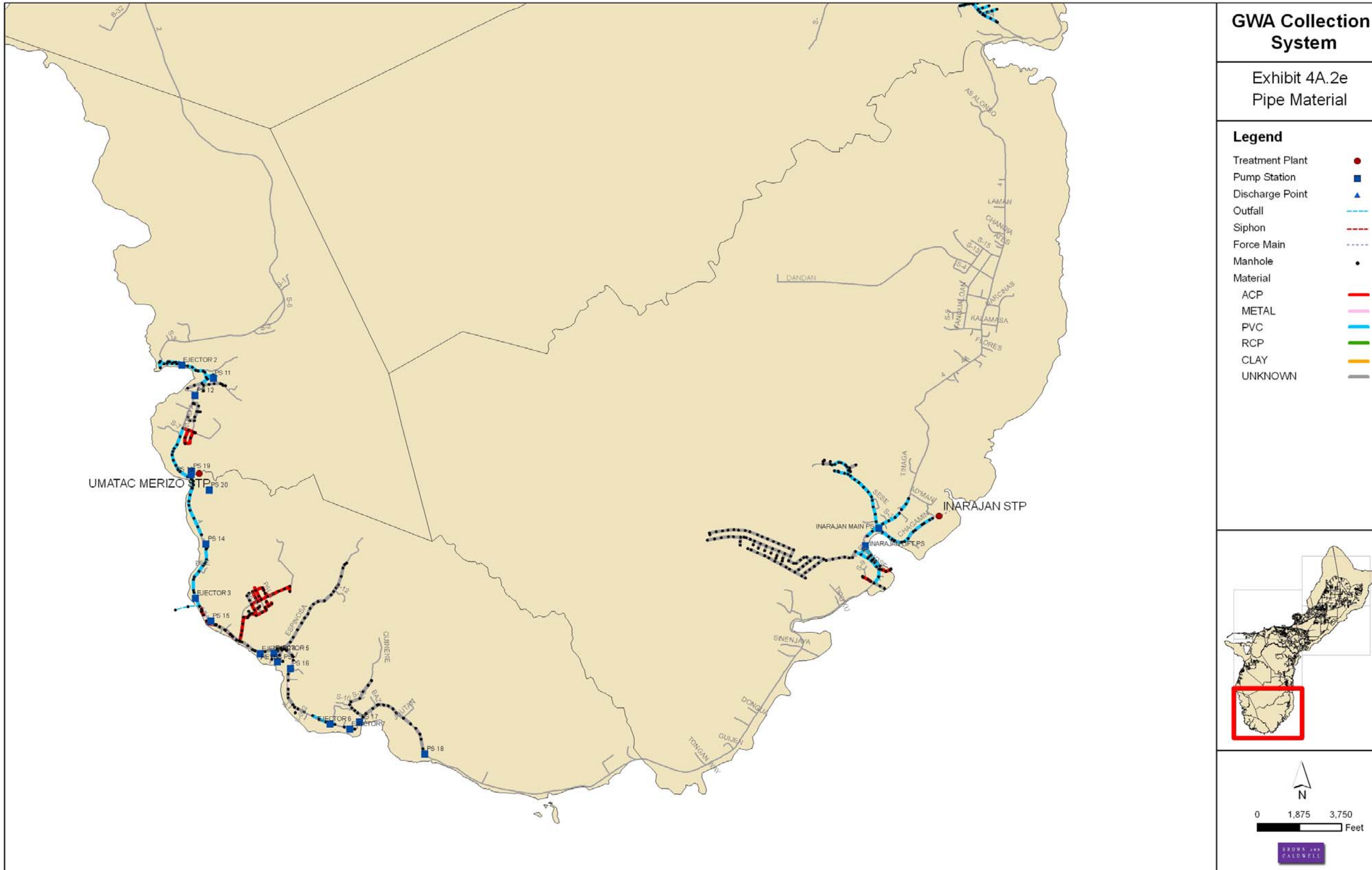

GWA Collection System
Exhibit 4A.1e
Pipe Diameter
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Diameter
< 8 inches
8 inches
> 8 inches
Unknown
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
PS 11
PS 12
PS 19
PS 20
PS 14
EJECTOR 3
PS 15
PS 16
EJECTOR 6
PS 17
PS 18
DANDAN
0 1,875 3,750
Feet

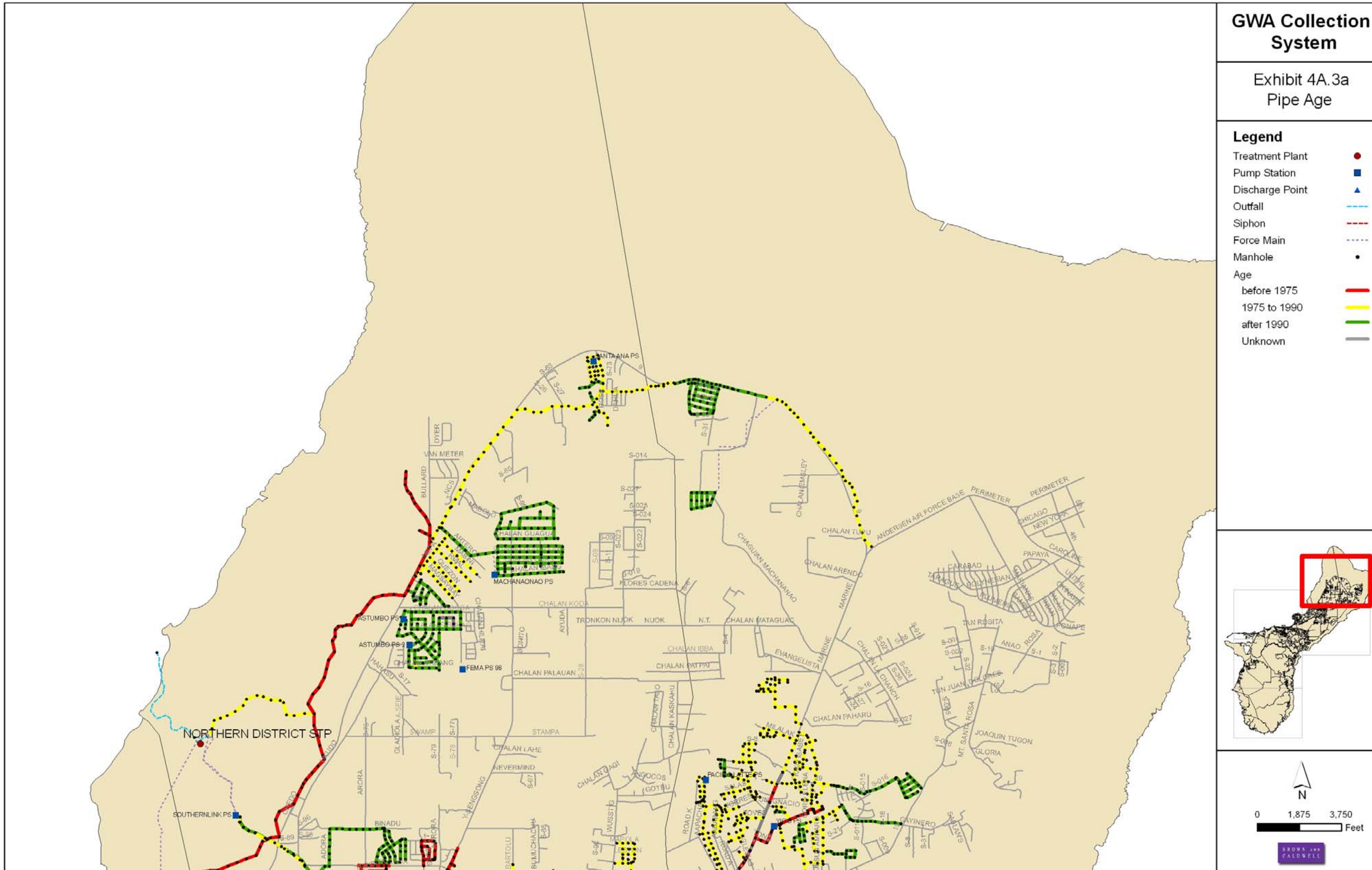

GWA Collection System
Exhibit 4A.2a
Pipe Material
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Material
ACP
METAL
PVC
RCP
CLAY
UNKNOWN
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
SOUTHERNLINK PS
MACHANAONAO PS
ASTUMBO PS
FEMA PS 98
SANTA ANA PS
ANDERSEN AIR FORCE BASE

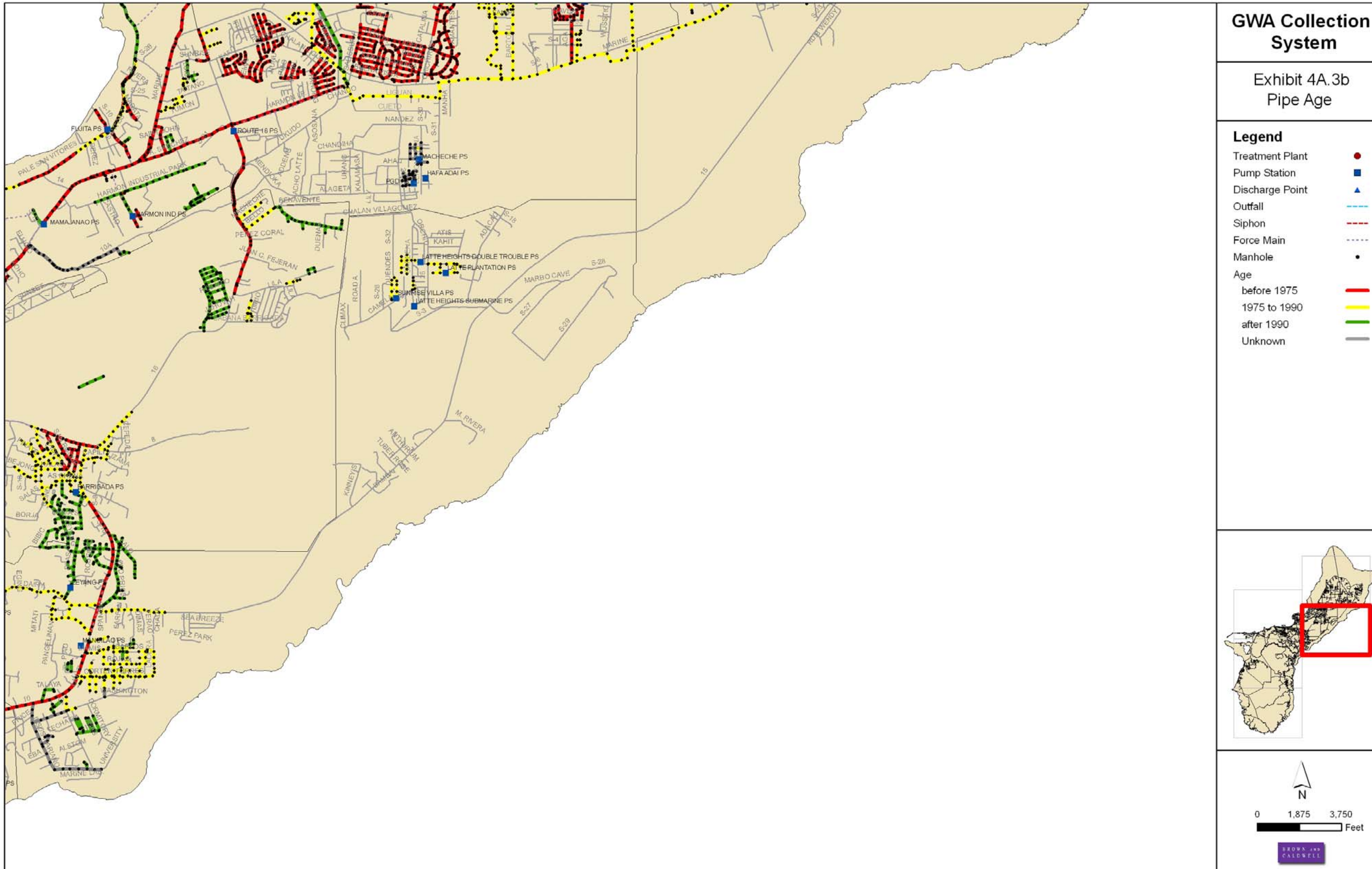

GWA Collection System
Exhibit 4A.2b
Pipe Material
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Material
ACP
METAL
PVC
RCP
CLAY
UNKNOWN
N
0
1,875
3,750
Feet

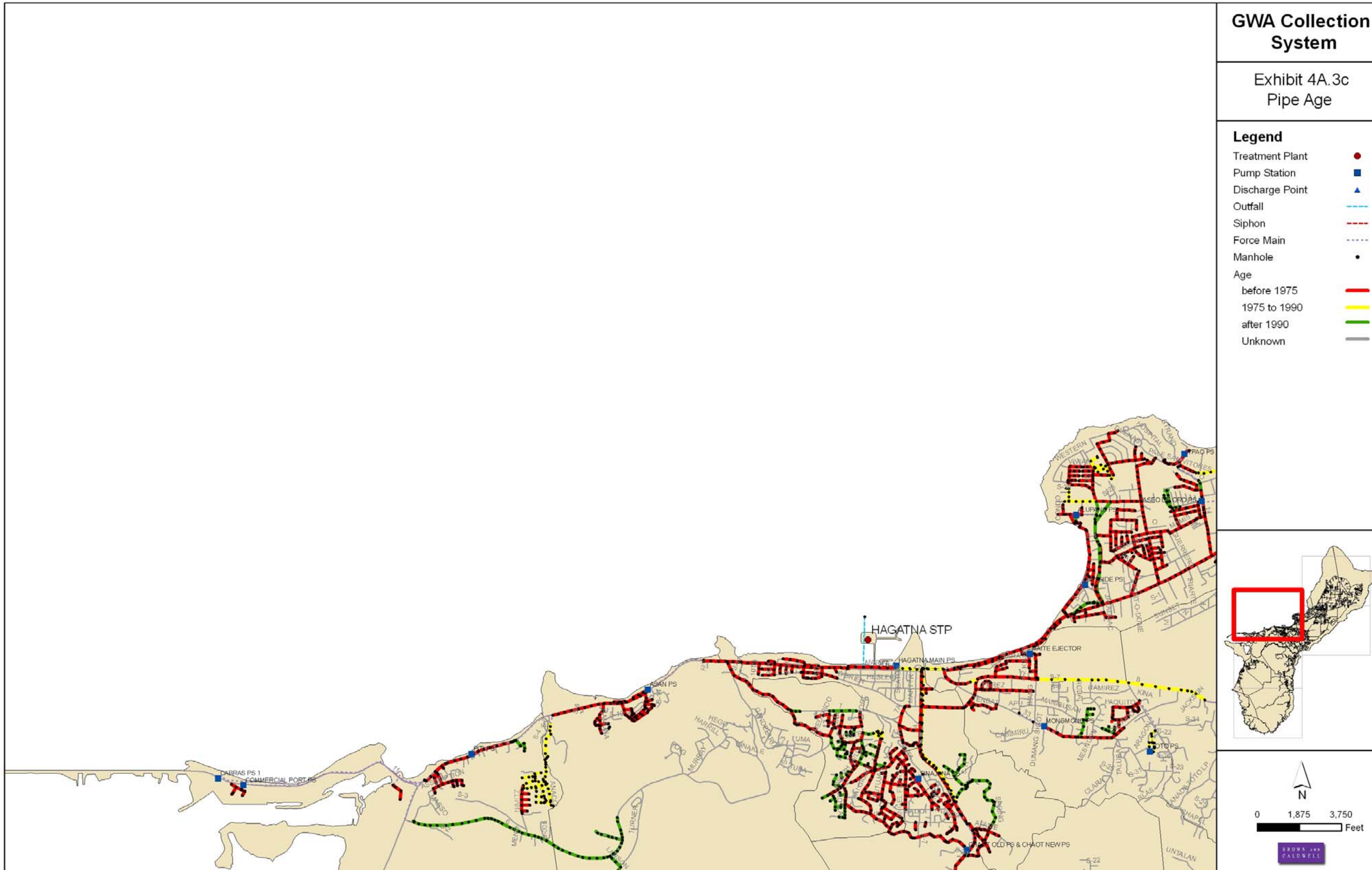

GWA Collection System
Exhibit 4A.2c
Pipe Material
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Material
ACP
METAL
PVC
RCP
CLAY
UNKNOWN
HAGATNA STP
HAGATNA MAIN PS
N
0
1,875
3,750
Feet

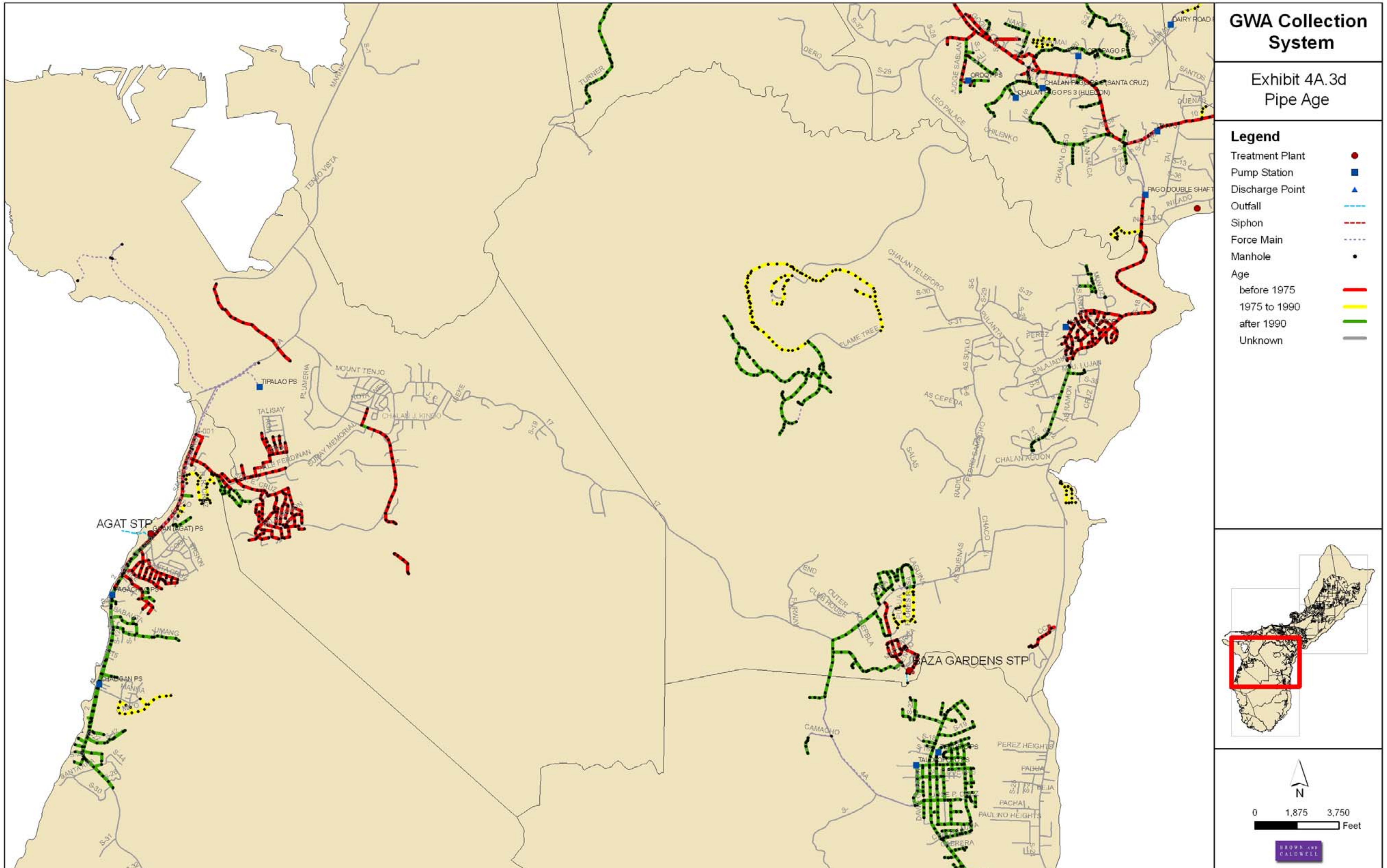

GWA Collection System
Exhibit 4A.2d
Pipe Material
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Material
ACP
METAL
PVC
RCP
CLAY
UNKNOWN
N
0
1,875
3,750
Feet
BROWN AND CALDWELL
AGAT STP
BAZA GARDENS STP
TIPALAO PS
MOUNT TENJO
TALISAY
CHALAN TELEFORO
CHALAN AGOON
PEREZ HEIGHTS
PAULINO HEIGHTS
PAGO DOUBLE SHAFT
DAIRY ROAD
CAMACHO
FLAME TREE
AS CEPEDA

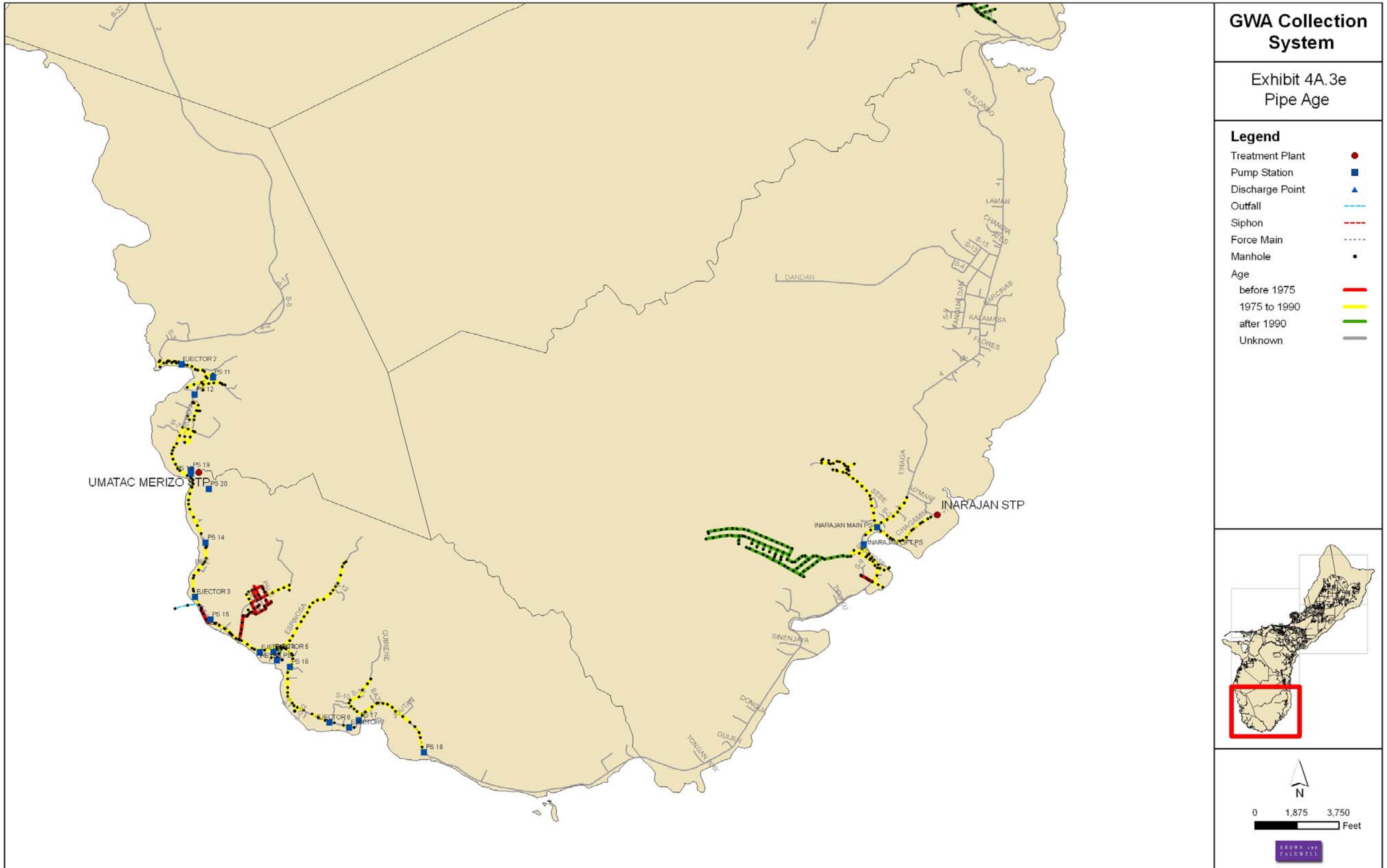

GWA Collection System
Exhibit 4A.2e
Pipe Material
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Material
ACP
METAL
PVC
RCP
CLAY
UNKNOWN
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
N
0
1,875
3,750
Feet

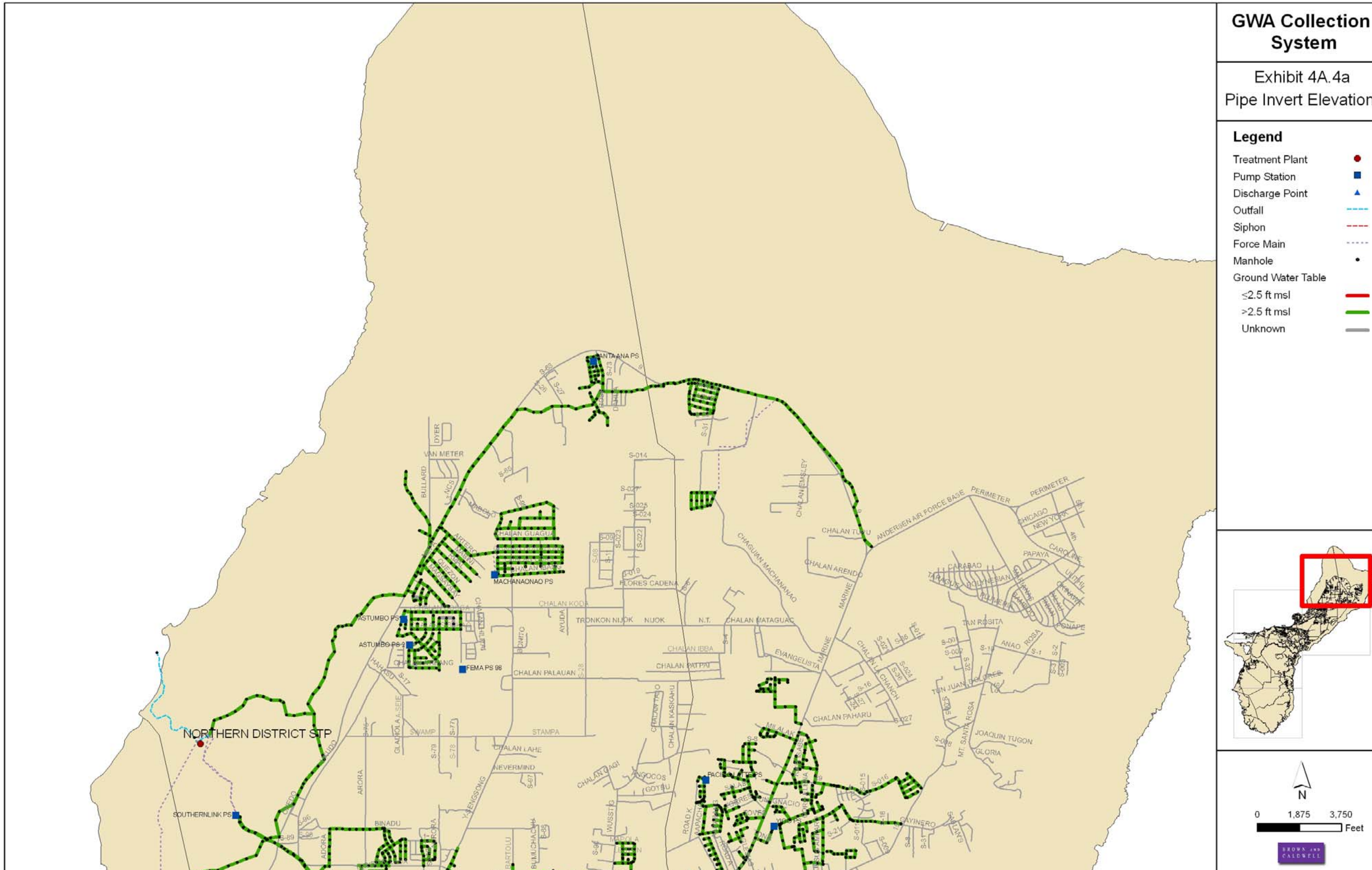

GWA Collection System
Exhibit 4A.3a
Pipe Age
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Age
before 1975
1975 to 1990
after 1990
Unknown
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
SOUTHERNLINK PS
ASTUMBO PS
ASTUMBO PS 2
MACHANAONAO PS
FEMA PS 98
SANTA ANA PS
CHALAN PALAUAN
ANDERSEN AIR FORCE BASE
PERIMETER
CHALAN TUPU
MARINE
STAMPA
TRONKON NIJOK
NIJOK
CHALAN MATAGUAC
EVANGELISTA
FLORES CADENA
VAN METER
CHALAN LAHE
NEVERMIND
CHALAN PAHARU
JOAQUIN TUGON
GLORIA
TUN ROSITA
TUN JUAN DOLORES
MT. SANTA ROSA
CHICAGO
NEW YORK
PAPAYA
CAROLINE
ANAO
CHALAN AREN
BINADU
ARORA
SWAMP
DYER
BULLARD

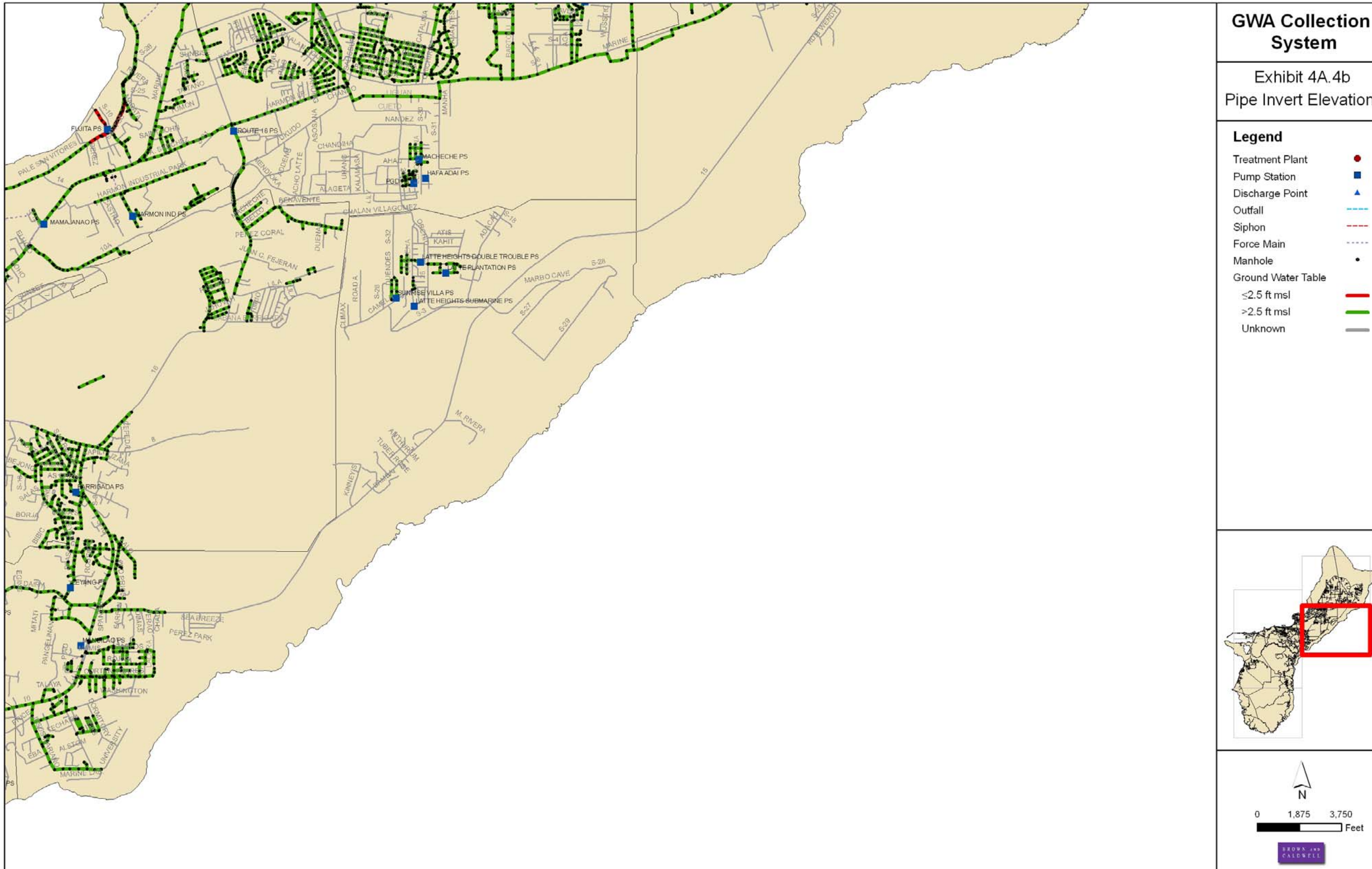

GWA Collection System
Exhibit 4A.3b
Pipe Age
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Age
before 1975
1975 to 1990
after 1990
Unknown
N
0
1,875
3,750
Feet

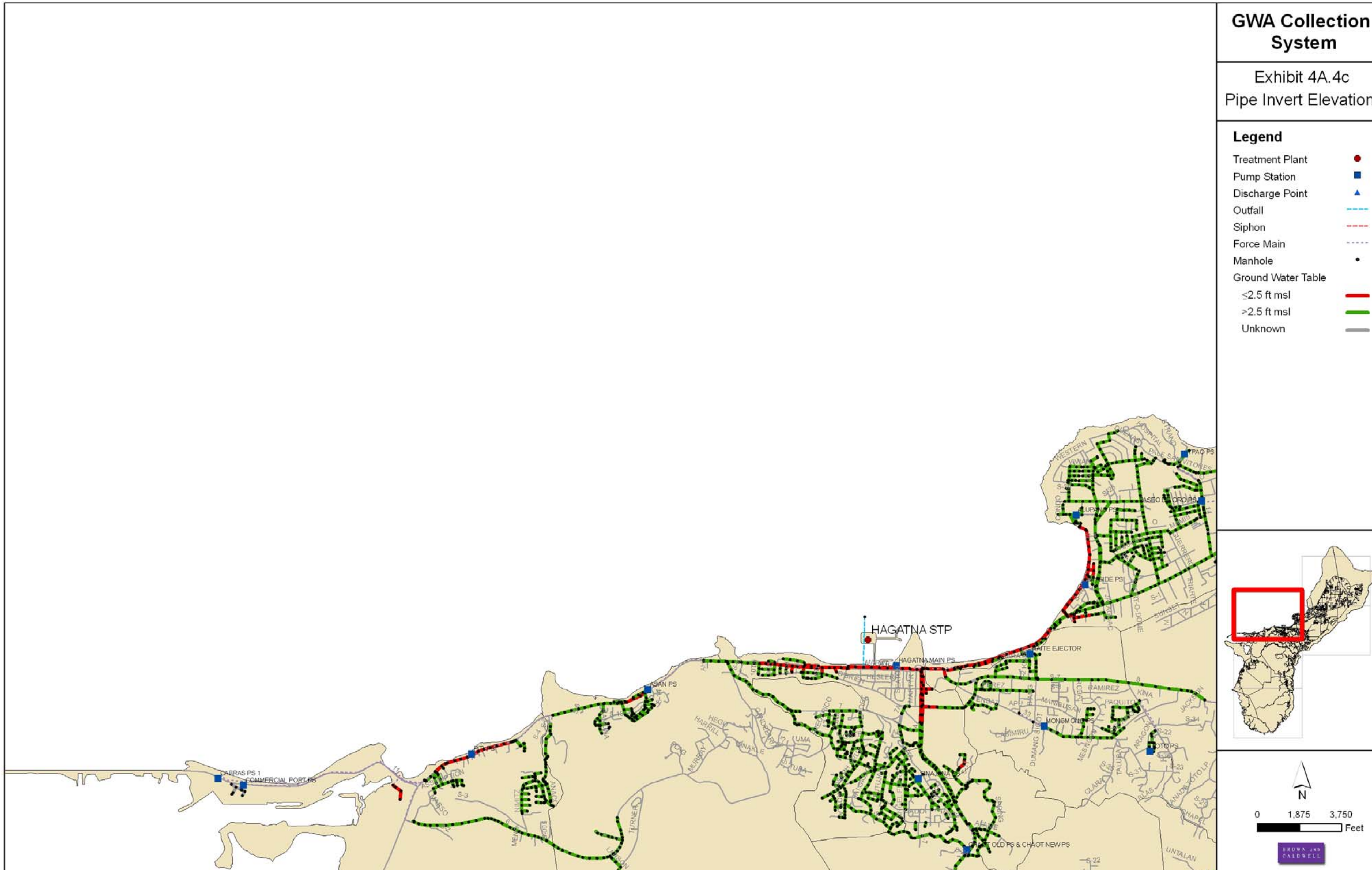

GWA Collection System
Exhibit 4A.3c
Pipe Age
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Age
before 1975
1975 to 1990
after 1990
Unknown
HAGATNA STP
HAGATNA MAIN PS
CABRAS PS 1
COMMERCIAL PORT PS
OLD PS & CHAOT NEW PS
N
0
1,875
3,750
Feet

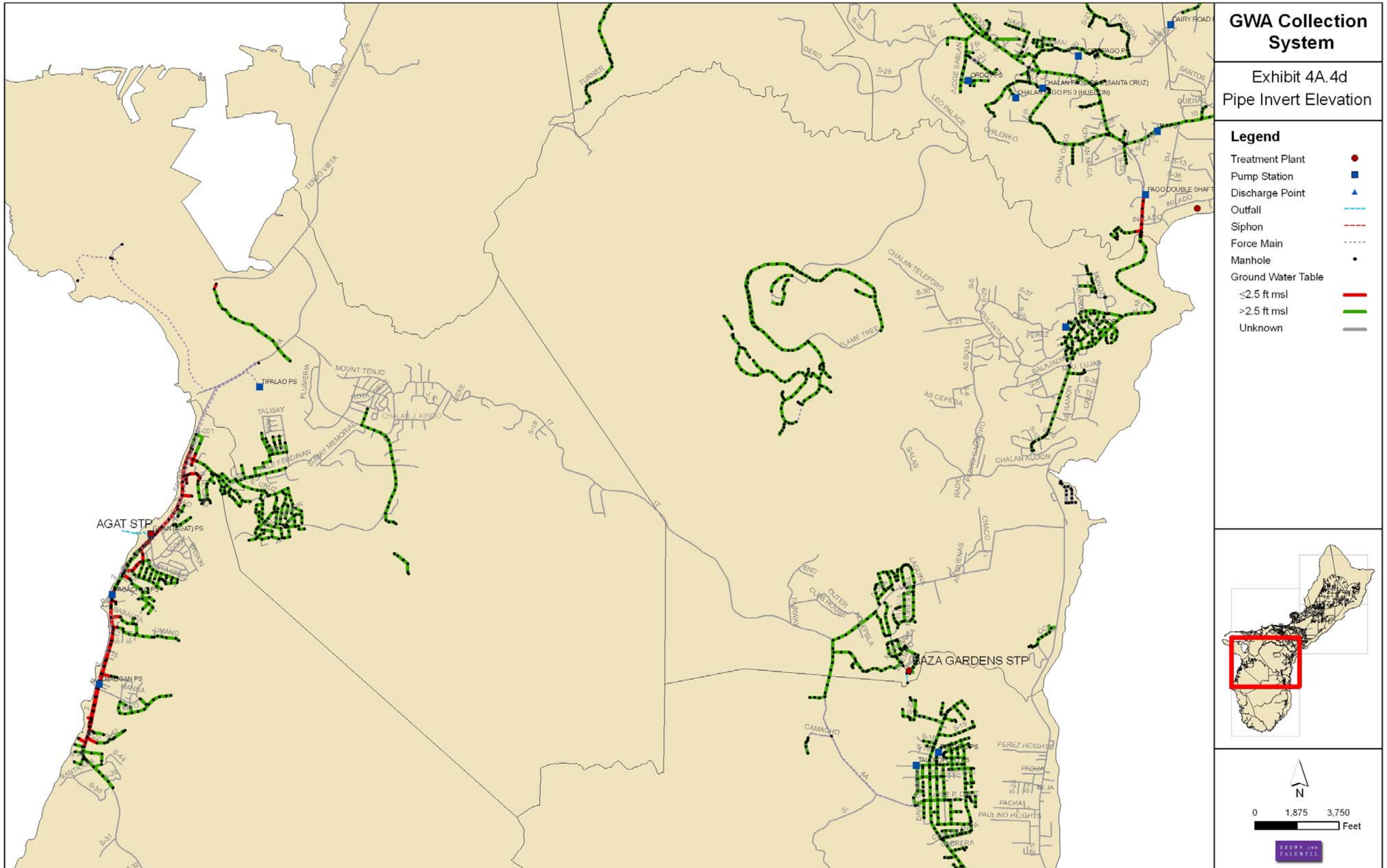

GWA Collection System
Exhibit 4A.3d
Pipe Age
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Age
before 1975
1975 to 1990
after 1990
Unknown
N
0
1,875
3,750
Feet
AGAT STP
BAZA GARDENS STP
TIPALAO PS
MOUNT TENJO
TALISAY
PLUMERIA
TENJO VISTA
CHALAN TELEFORO
FLAME TREE
AS CEPEDA
CHALAN AGUON
PEREZ HEIGHTS
PAULINO HEIGHTS
CAMACHO
PAGO DOUBLE SHAFT
DAIRY ROAD

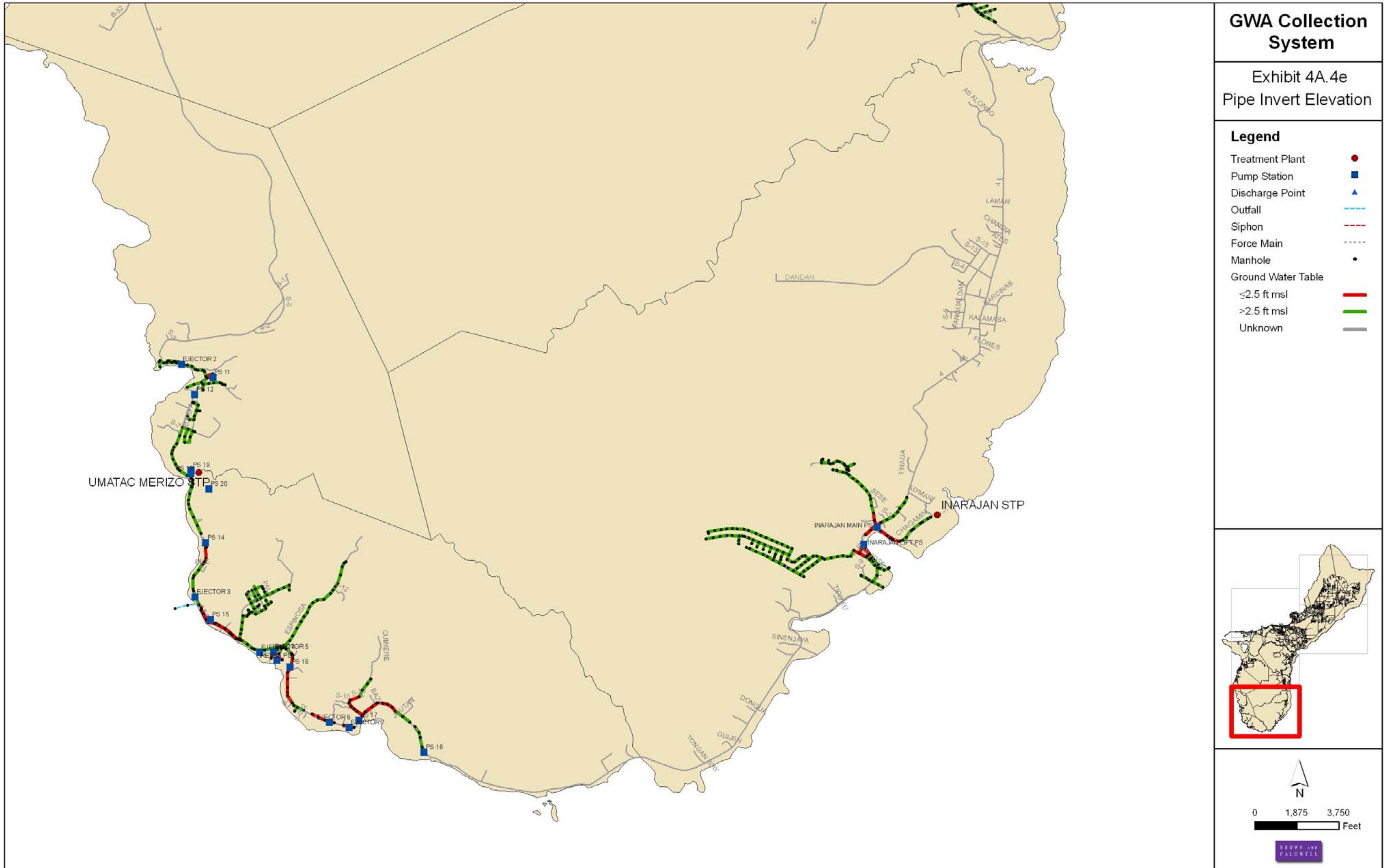

GWA Collection System
Exhibit 4A.3e
Pipe Age
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Age
before 1975
1975 to 1990
after 1990
Unknown
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
PS 11
PS 19
PS 20
PS 14
EJECTOR 3
PS 15
PS 16
PS 18
DANDAN
N
0
1,875
3,750
Feet

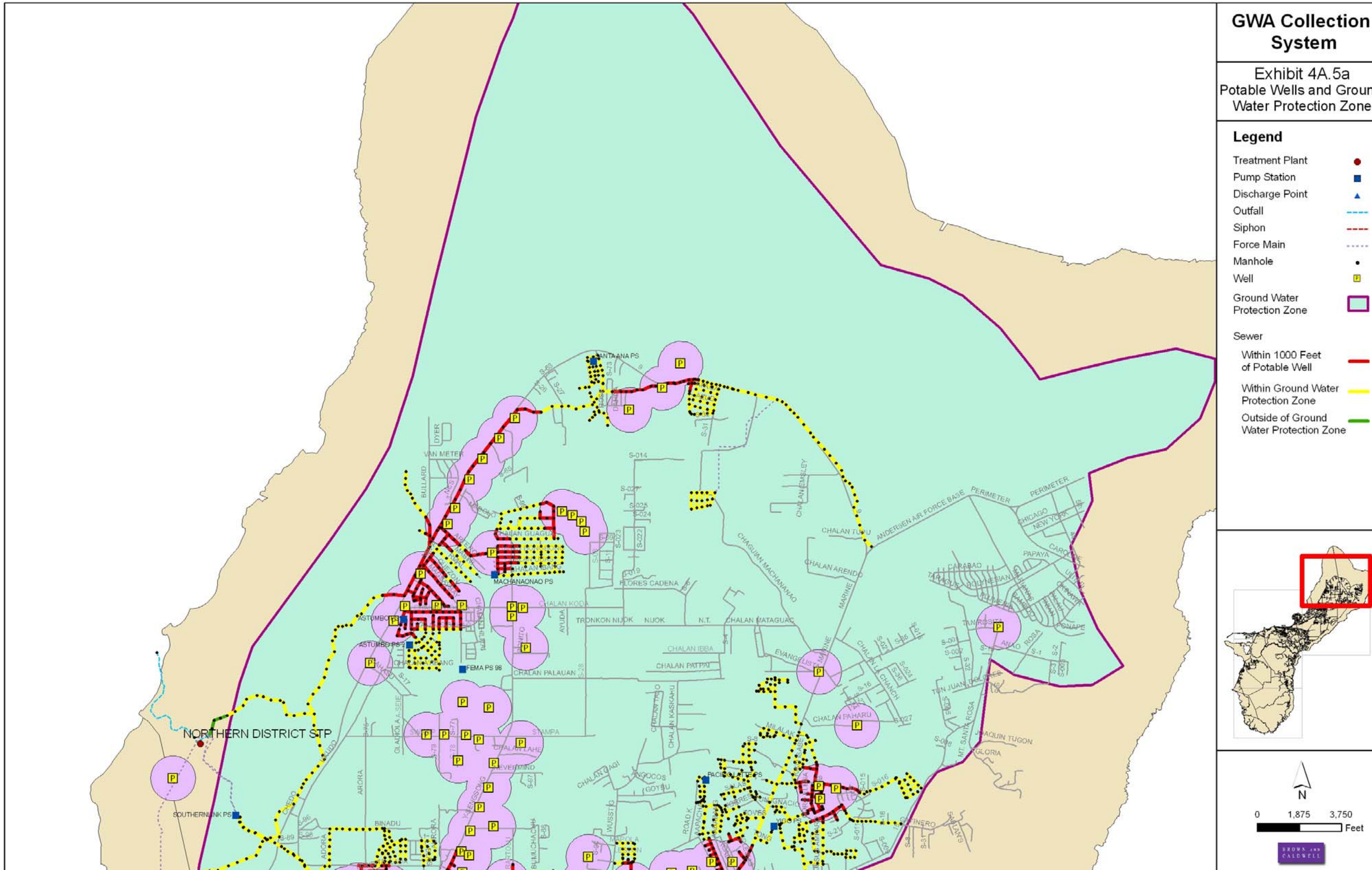

GWA Collection System
Exhibit 4A.4a
Pipe Invert Elevation
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Table
≤2.5 ft msl
>2.5 ft msl
Unknown
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
SOUTHERNLINK PS
ASTUMBO PS
ASTUMBO PS 2
FEMA PS 98
MACHANAONAO PS
SANTA ANA PS
PAOPAO PS
CHALAN PALAUAN
CHALAN PAHARU
ANDERSEN AIR FORCE BASE
PERIMETER
JOAQUIN TUGON
TRONKON NIJOK
NIJOK
CHALAN MATAGUAC
FLORES CADENA
VAN METER
STAMPA
CHALAN LAHE
NEVERMIND
BINADU

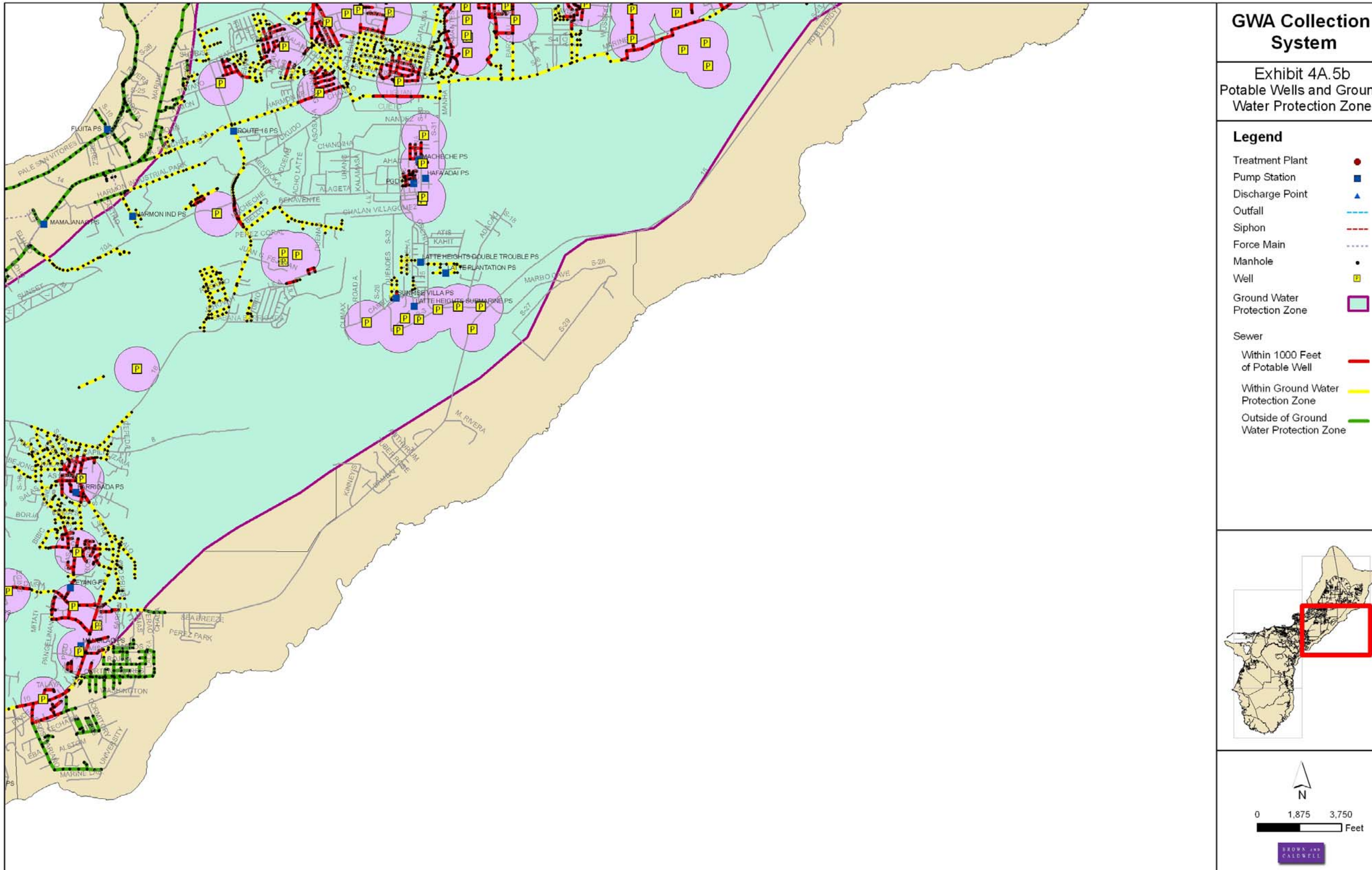

GWA Collection System
Exhibit 4A.4b
Pipe Invert Elevation
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Table
≤2.5 ft msl
>2.5 ft msl
Unknown
N
0
1,875
3,750
Feet
FUJITA PS
ROUTE 16 PS
MAMAJANAO PS
HARMON IND PS
MACHECHE PS
HAFA ADAI PS
LATTE HEIGHTS DOUBLE TROUBLE PS
LATTE PLANTATION PS
SUNRISE VILLA PS
LATTE HEIGHTS SUBMARINE PS
BARRIGADA PS
MARBO CAVE
HARMON INDUSTRIAL PARK
M. RIVERA
SEA BREEZE
PEREZ PARK

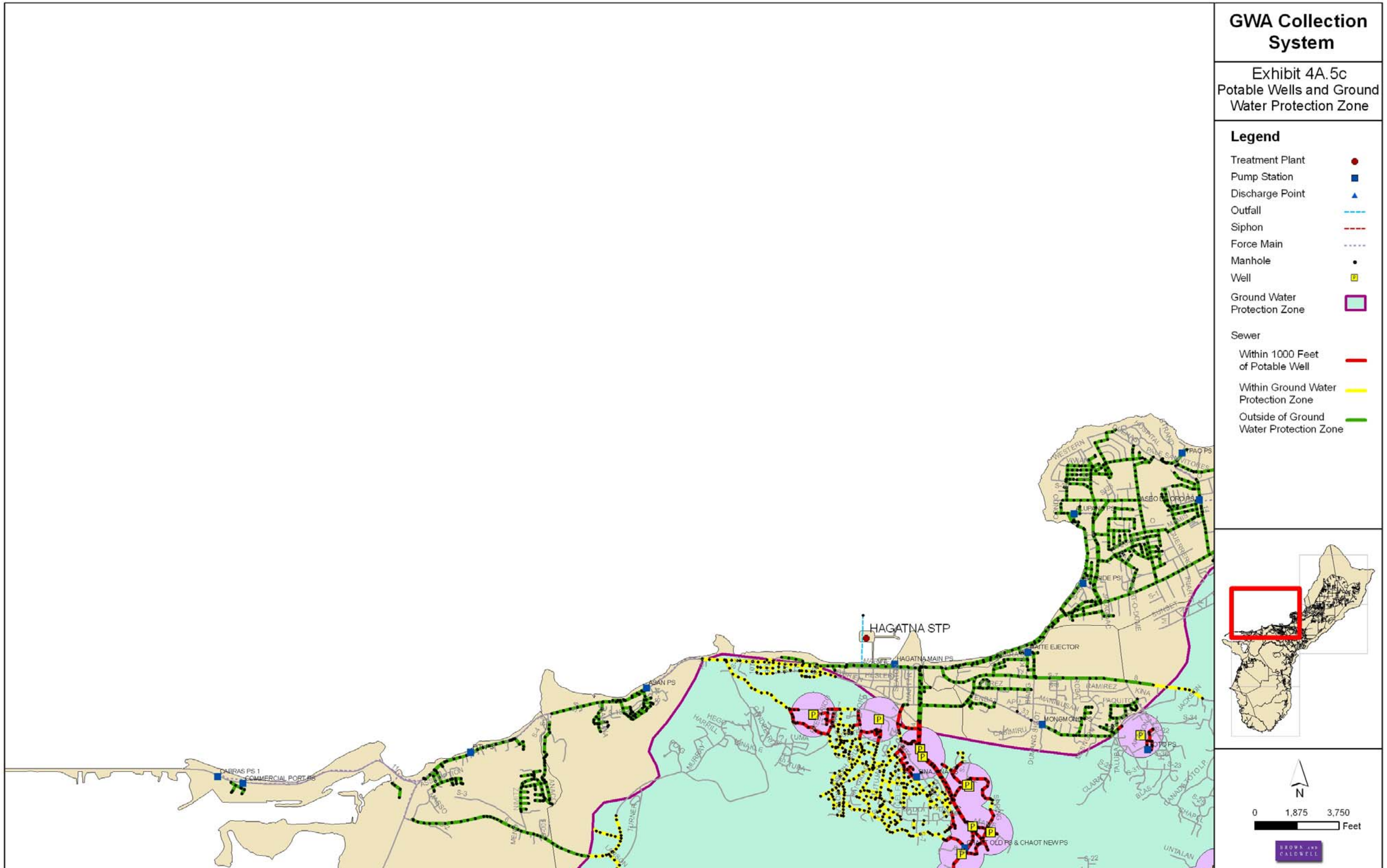

GWA Collection System
Exhibit 4A.4c
Pipe Invert Elevation
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Table
≤2.5 ft msl
>2.5 ft msl
Unknown
HAGATNA STP
HAGATNA MAIN PS
CABRAS PS 1
COMMERCIAL PORT PS
N
0
1,875
3,750
Feet

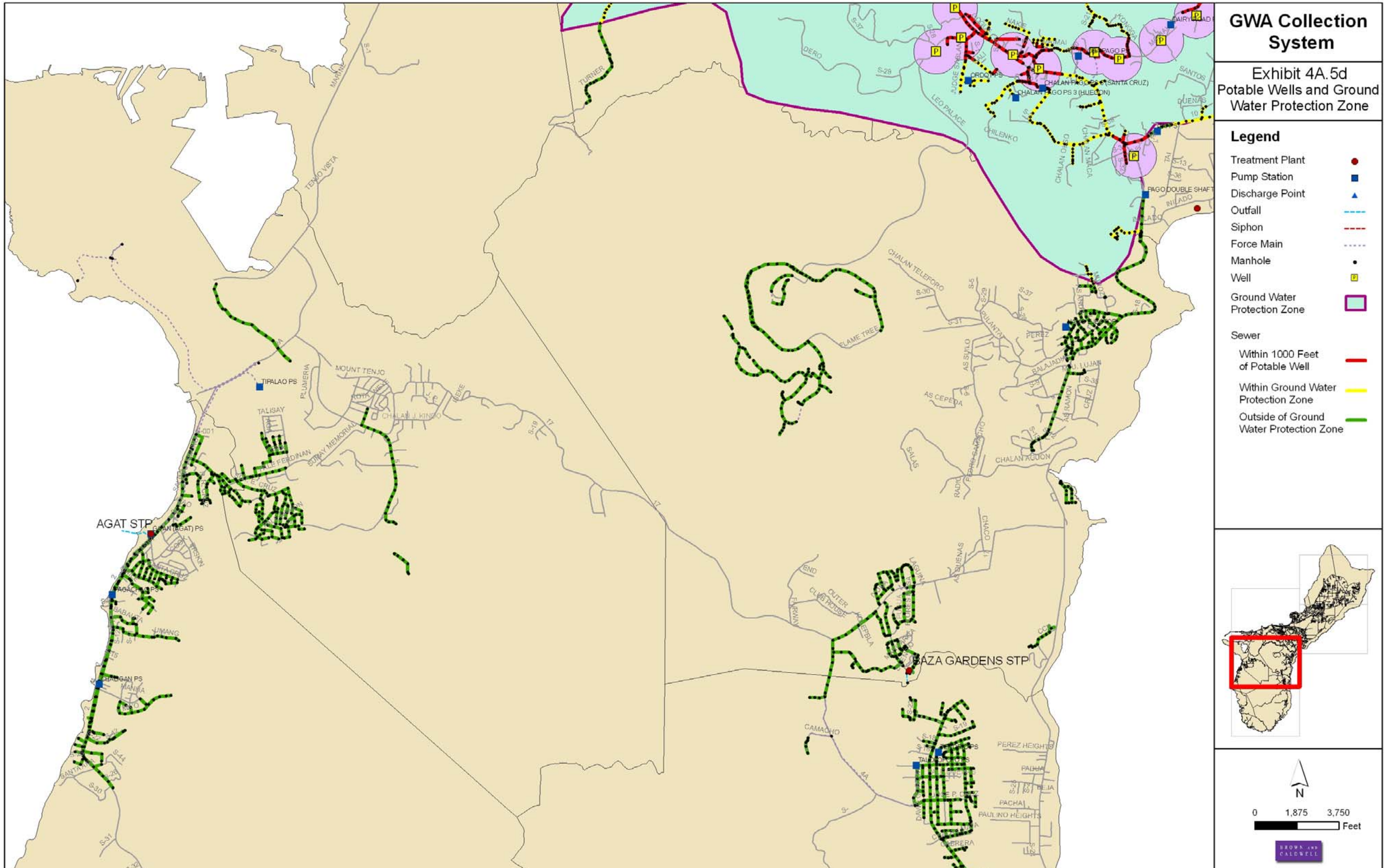

GWA Collection System
Exhibit 4A.4d
Pipe Invert Elevation
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Table
≤2.5 ft msl
>2.5 ft msl
Unknown
N
0 1,875 3,750
Feet
AGAT STP
BAZA GARDENS STP
TIPALAO PS
PAGO DOUBLE SHAFT
CHALAN PAGO PS 3 (HUEGON)

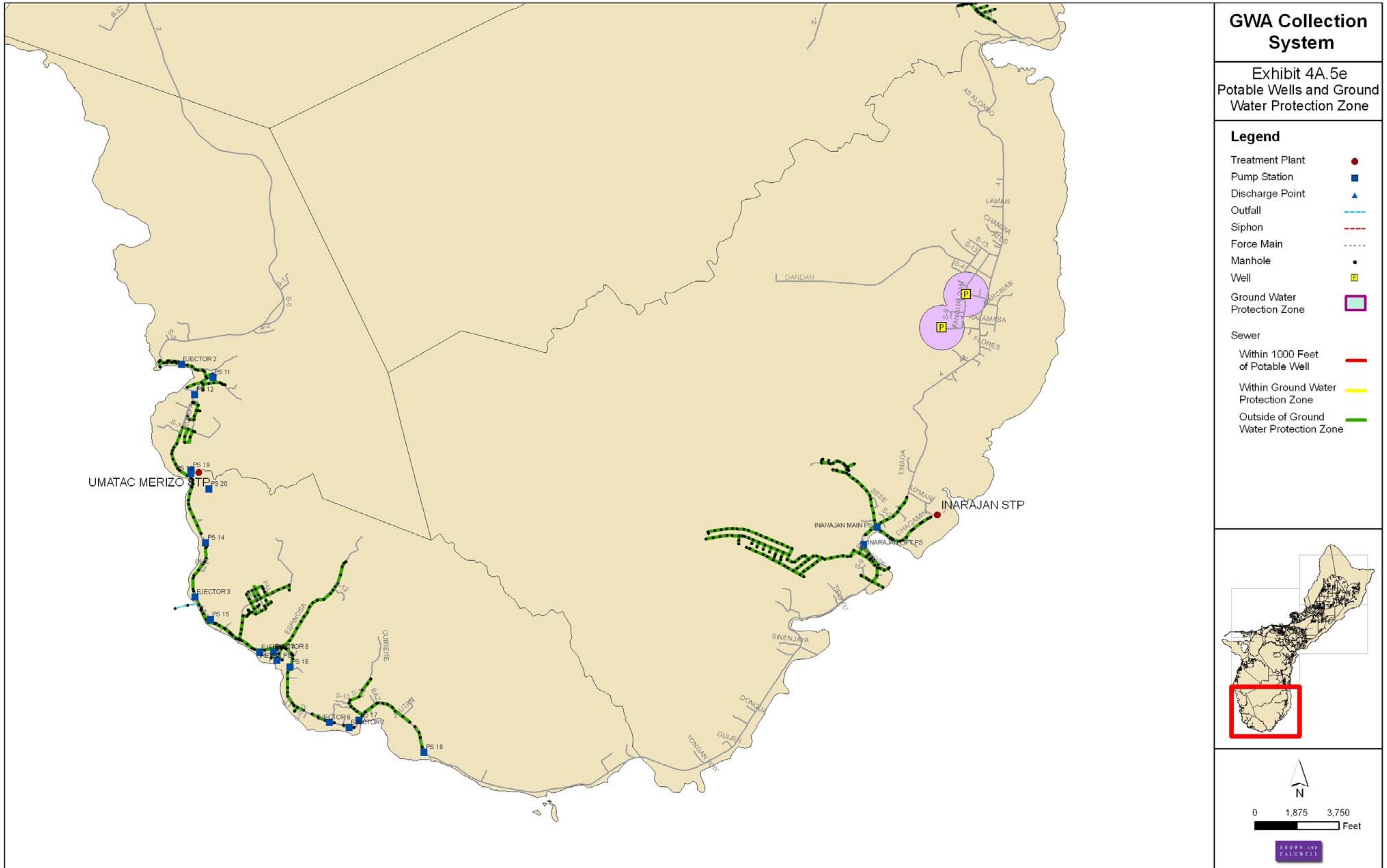

GWA Collection System
Exhibit 4A.4e
Pipe Invert Elevation
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Table
≤2.5 ft msl
>2.5 ft msl
Unknown
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
PS 11
PS 12
PS 19
PS 20
PS 14
EJECTOR 3
PS 15
PS 16
PS 17
PS 18
EJECTOR 6
DANDAN
N
0
1,875
3,750
Feet

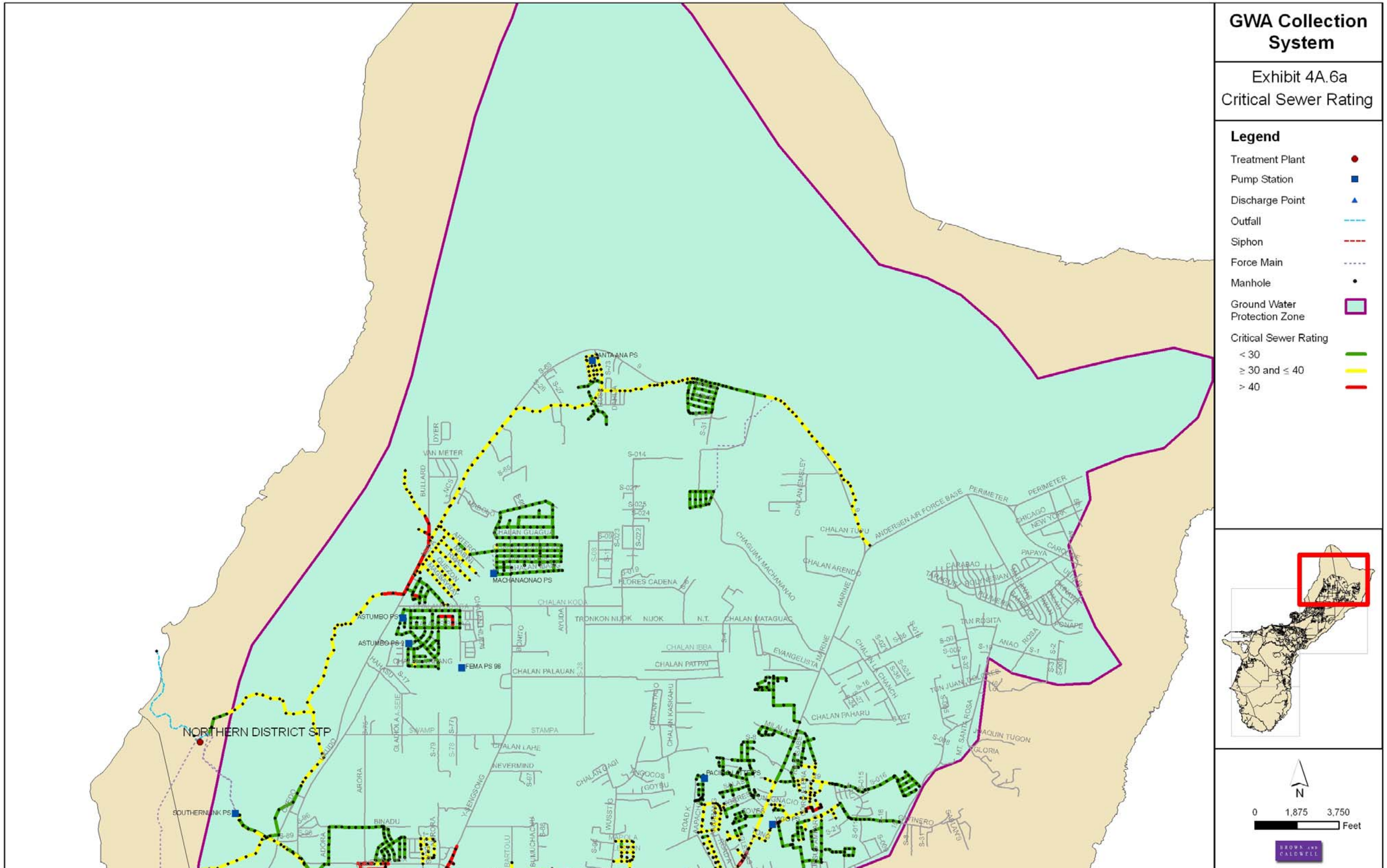

GWA Collection System
Exhibit 4A.5a
Potable Wells and Ground Water Protection Zone
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Well
Ground Water Protection Zone
Sewer
Within 1000 Feet of Potable Well
Within Ground Water Protection Zone
Outside of Ground Water Protection Zone
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
SOUTHERNLINK PS
MACHANAONAO PS
FEMA PS 98
ASTUMBO PS
CHALAN PALAUAN
CHALAN PATPAT
TRONKON NIJOK
NUOK
CHALAN MATAGUAC
FLORES CADENA
ANDERSEN AIR FORCE BASE
PERIMETER
CHALAN TUFU
CHALAN ARENDO
MARINE
JOAQUIN TUGON
MT. SANTA ROSA

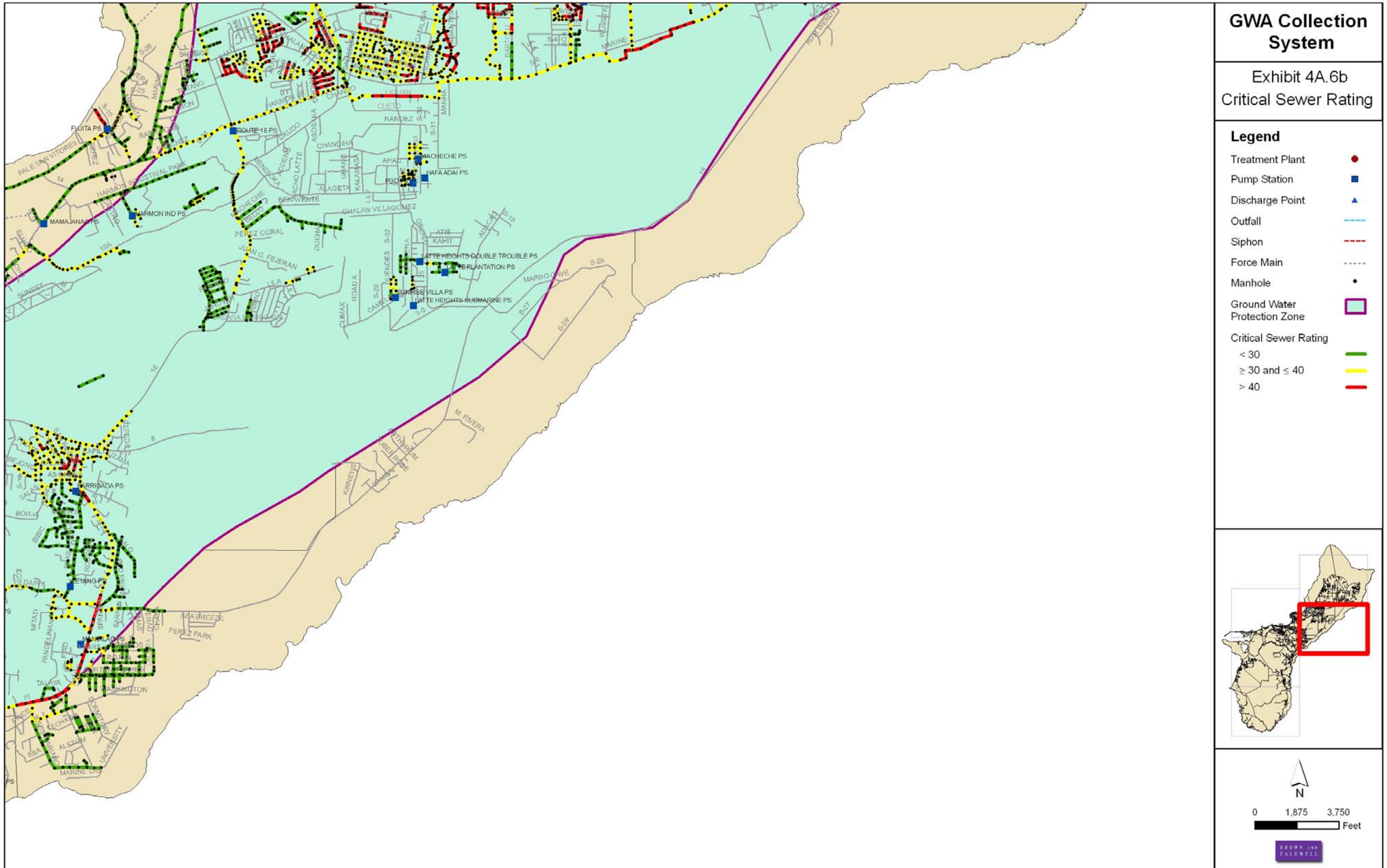

GWA Collection System
Exhibit 4A.5b
Potable Wells and Ground Water Protection Zone
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Well
Ground Water Protection Zone
Sewer
Within 1000 Feet of Potable Well
Within Ground Water Protection Zone
Outside of Ground Water Protection Zone
N
0
1,875
3,750
Feet

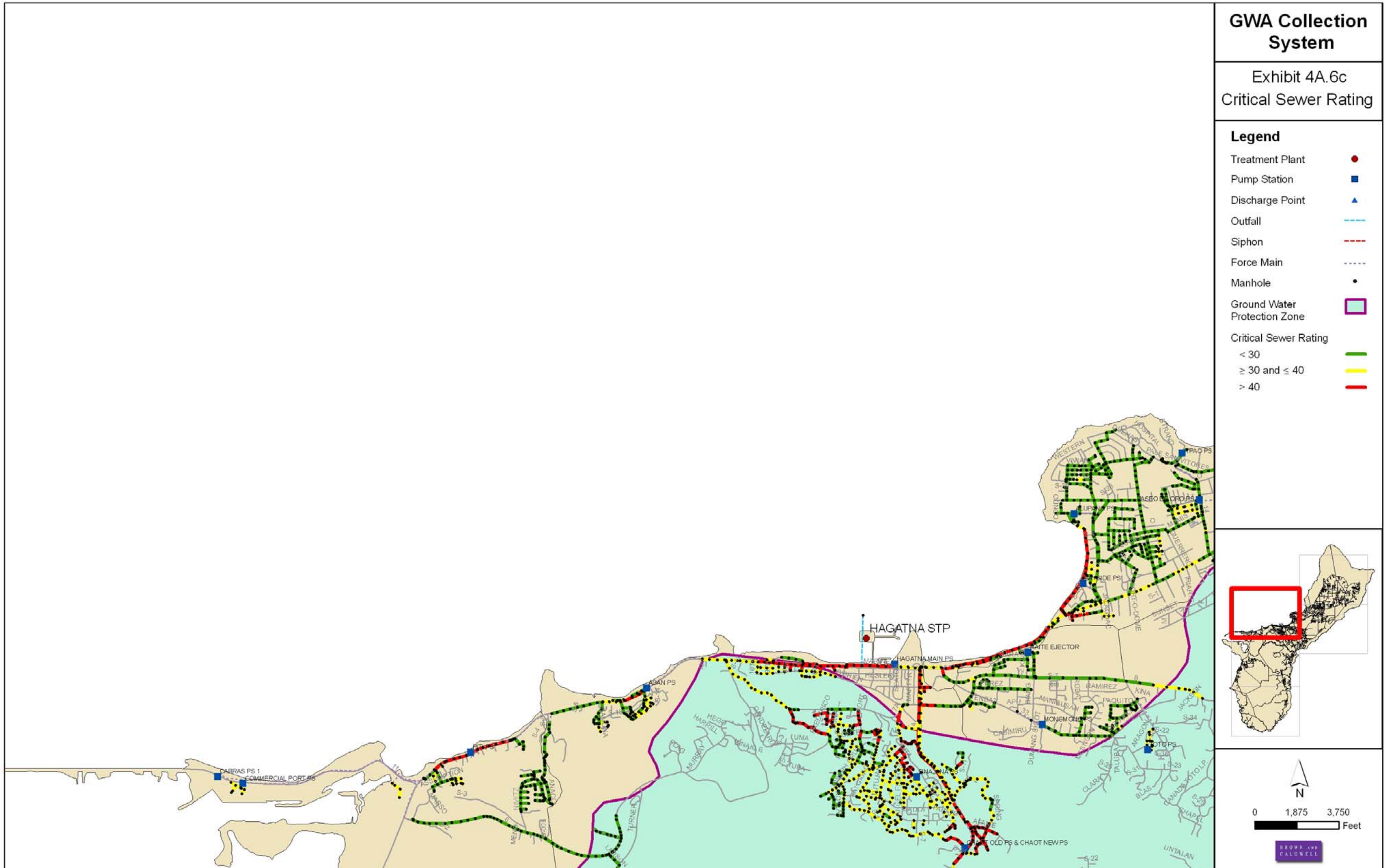

GWA Collection System
Exhibit 4A.5c
Potable Wells and Ground Water Protection Zone
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Well
Ground Water Protection Zone
Sewer
Within 1000 Feet of Potable Well
Within Ground Water Protection Zone
Outside of Ground Water Protection Zone
N
0 1,875 3,750
Feet
HAGATNA STP
HAGATNA MAIN PS
CABRAS PS 1
COMMERCIAL PORT PS
OLD PS & CHAOT NEW PS

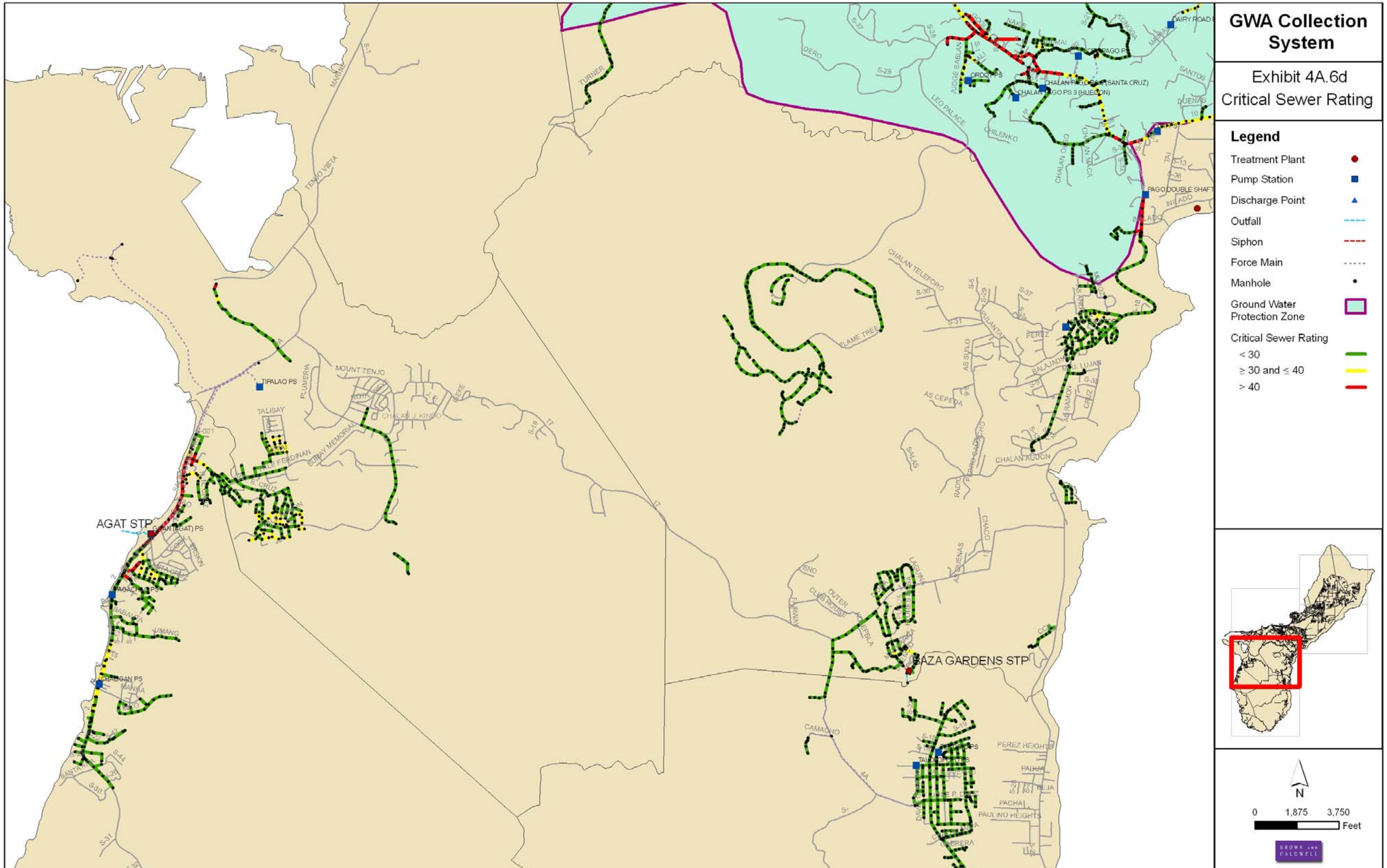

GWA Collection System
Exhibit 4A.5d
Potable Wells and Ground Water Protection Zone
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Well
Ground Water Protection Zone
Sewer
Within 1000 Feet of Potable Well
Within Ground Water Protection Zone
Outside of Ground Water Protection Zone
N
0
1,875
3,750
Feet
AGAT STP
BAZA GARDENS STP
TIPALAO PS
MOUNT TENJO
CHALAN TELEFORO
PAGO DOUBLE SHAFT
PEREZ HEIGHTS
PAULINO HEIGHTS

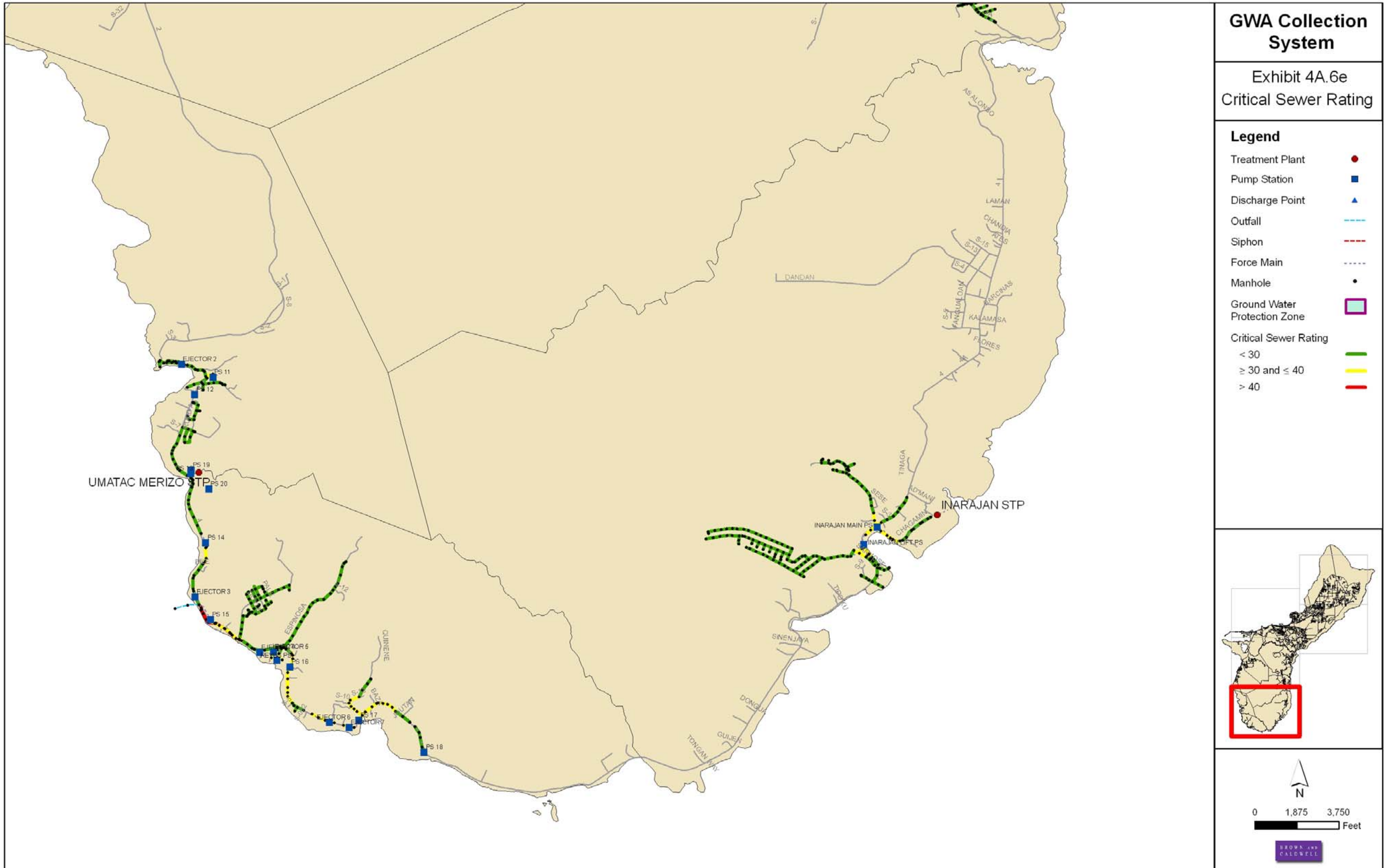

GWA Collection System
Exhibit 4A.5e
Potable Wells and Ground Water Protection Zone
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Well
Ground Water Protection Zone
Sewer
Within 1000 Feet of Potable Well
Within Ground Water Protection Zone
Outside of Ground Water Protection Zone
N
0
1,875
3,750
Feet
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
PS 11
PS 12
PS 19
PS 20
PS 14
EJECTOR 3
PS 15
PS 16
PS 18
DANDAN
SINENJAYA
ESPINOSA

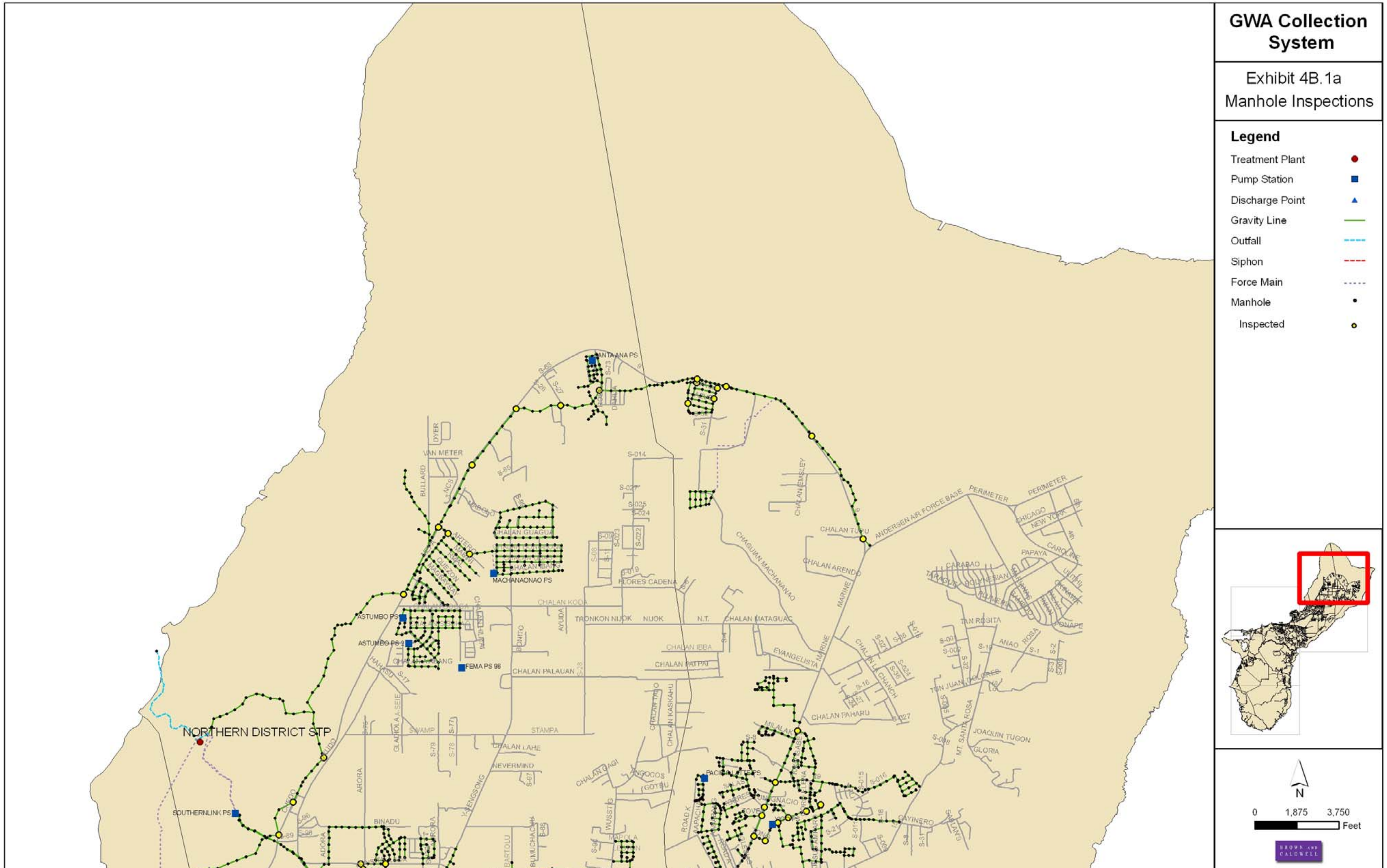

GWA Collection System
Exhibit 4A.6a
Critical Sewer Rating
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Protection Zone
Critical Sewer Rating
< 30
≥ 30 and ≤ 40
> 40
N
0
1,875
3,750
Feet
NORTHERN DISTRICT STP
MACHANAONAO PS
ASTUMBO PS
FEMA PS 98
ANDERSEN AIR FORCE BASE
PERIMETER
CHALAN PALAUAN
CHALAN PAHARU
CHALAN LAHE
STAMPA
NEVERMIND
BINADU
ARORA
VAN METER
TRONKON NIJOK
NIJOK
FLORES CADENA
CHALAN KODA
CHALAN TUTU
CHALAN ARENDO
CHALAN MATAGUAC
EVANGELISTA
CHALAN IBBA
CHALAN PAIPAI
JOAQUIN TUGON

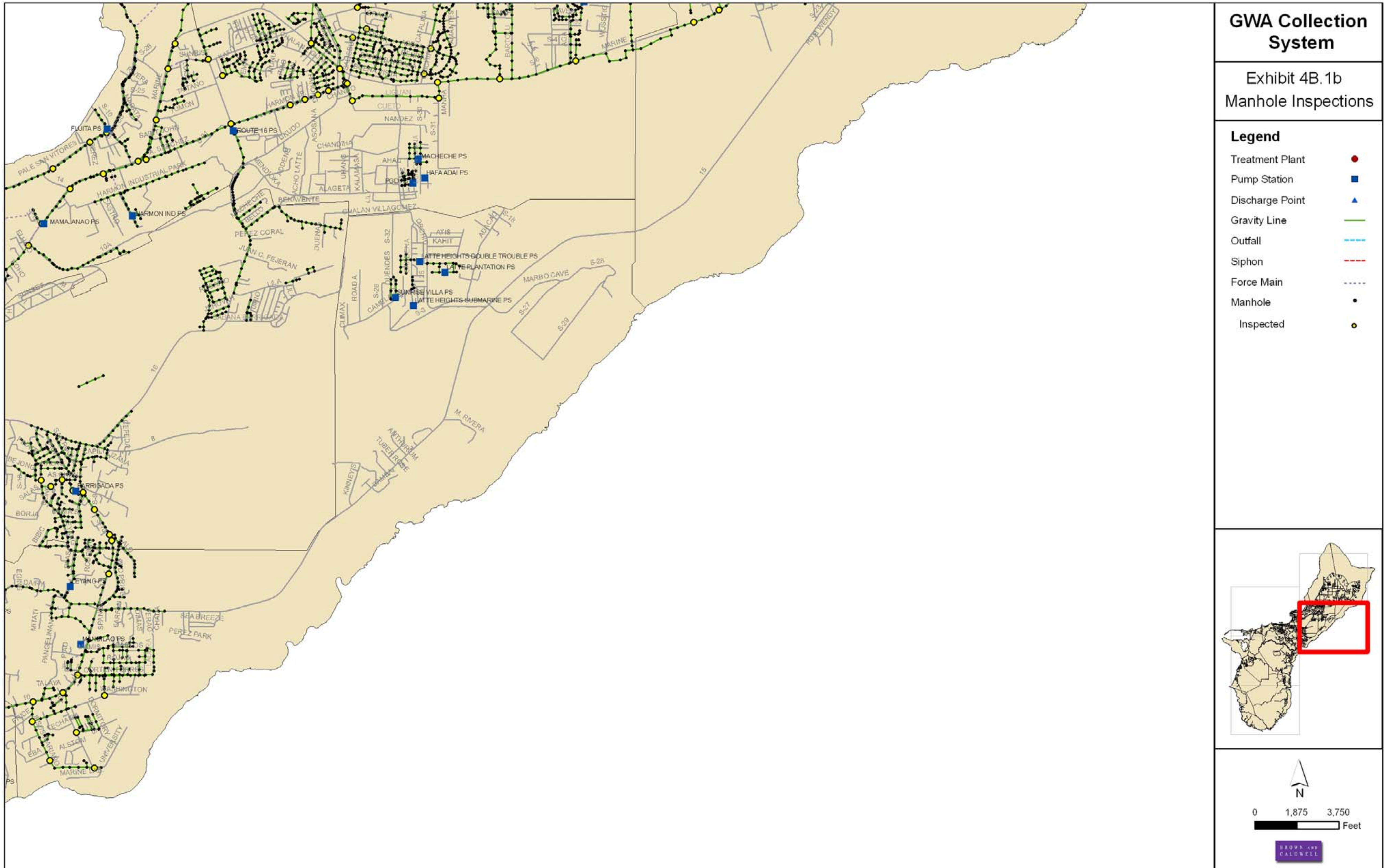

GWA Collection System
Exhibit 4A.6b
Critical Sewer Rating
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Protection Zone
Critical Sewer Rating
< 30
≥ 30 and ≤ 40
> 40
N
0
1,875
3,750
Feet
FUJITA PS
ROUTE 16 PS
MACHECHE PS
HAFA ADAI PS
HARMON IND PS
MAMAJANAO PS
LATTE HEIGHTS DOUBLE TROUBLE PS
LATTE PLANTATION PS
SUNRISE VILLA PS
LATTE HEIGHTS SUBMARINE PS
BARRIGADA PS
MARBO DRIVE
M. RIVERA
SEA BREEZE
PEREZ PARK

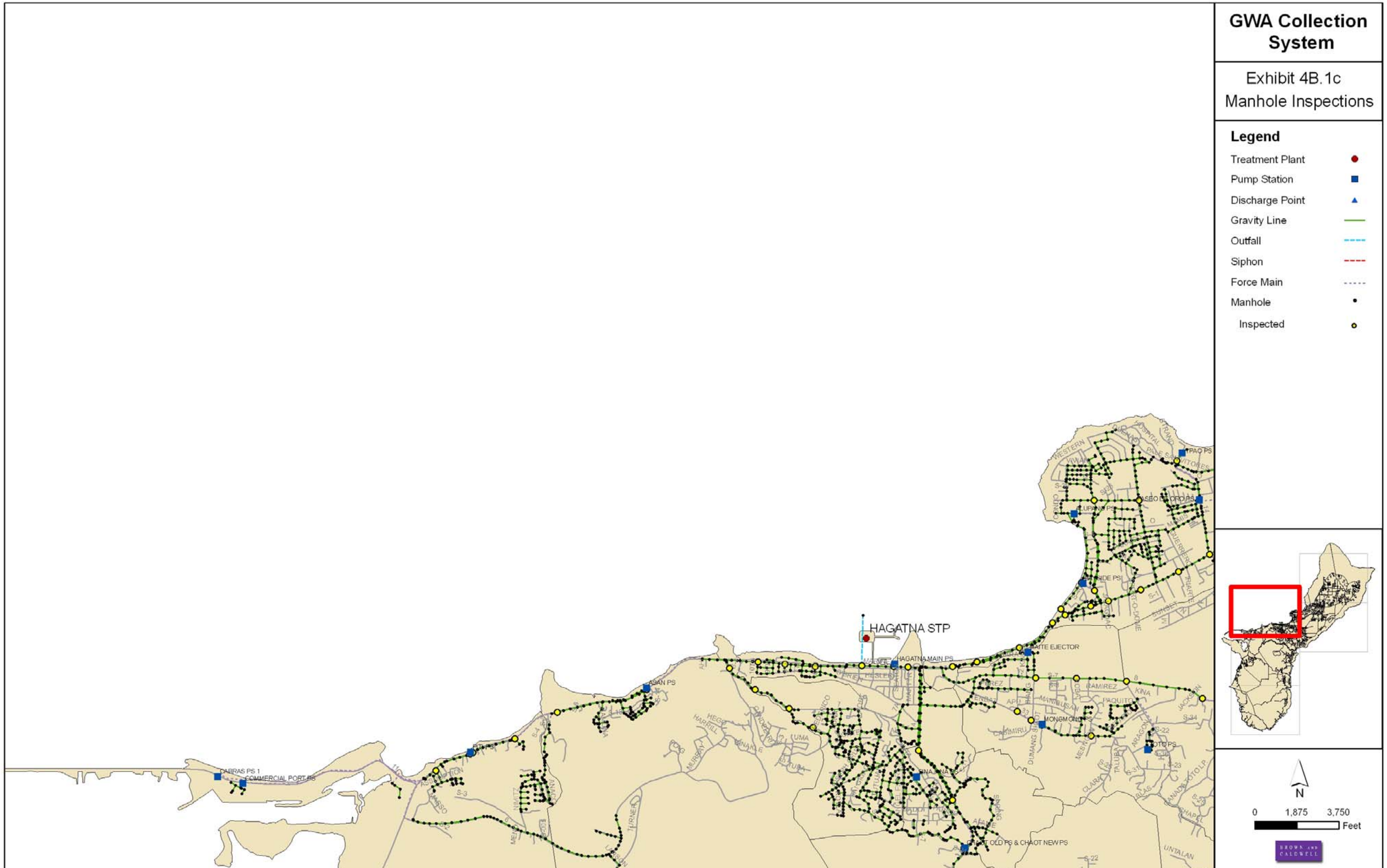

GWA Collection System
Exhibit 4A.6c
Critical Sewer Rating
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Protection Zone
Critical Sewer Rating
< 30
≥ 30 and ≤ 40
> 40
HAGATNA STP
HAGATNA MAIN PS
CABRAS PS 1
COMMERCIAL PORT PS
OLD PS & CHAOT NEW PS
N
0 1,875 3,750
Feet

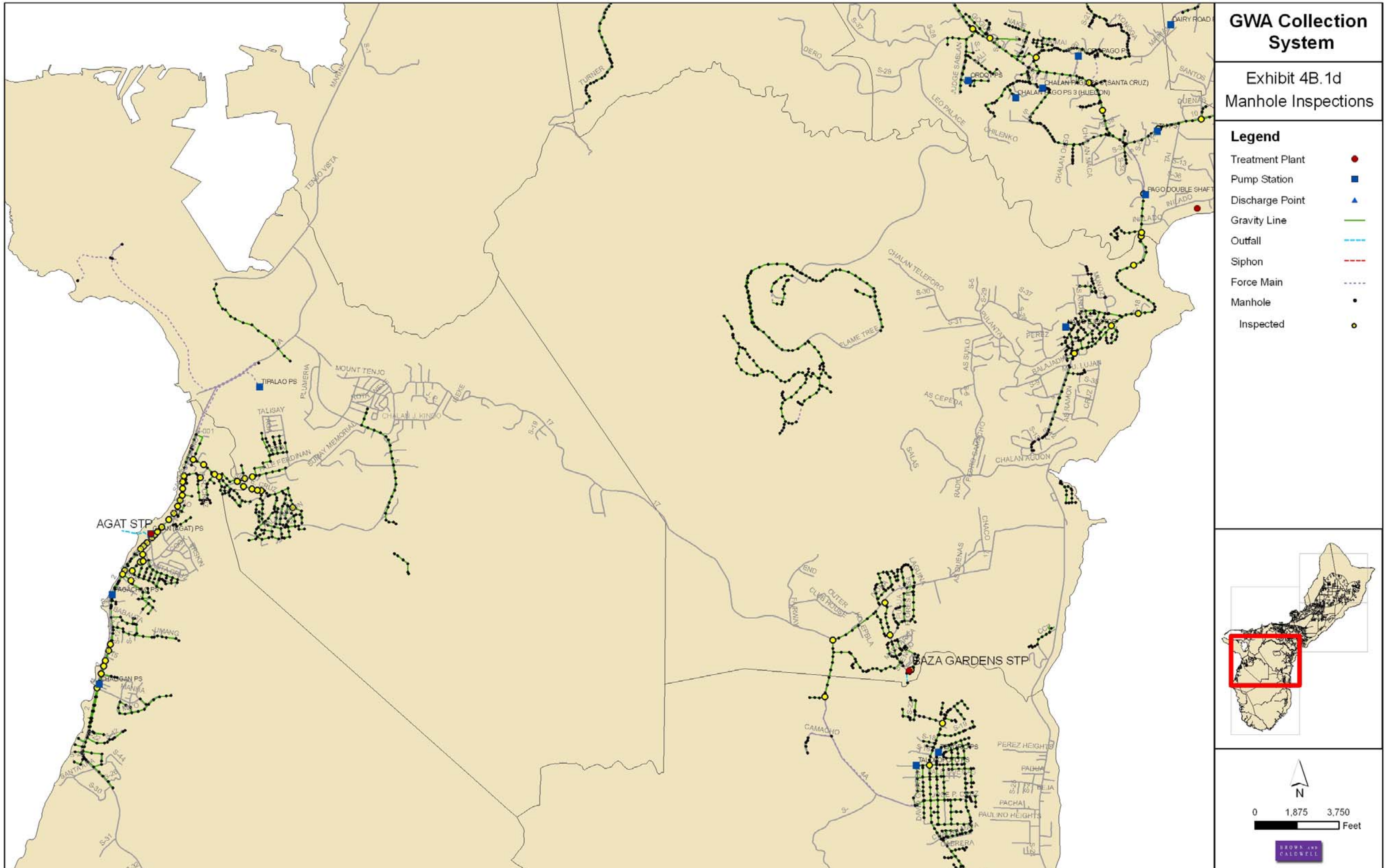

GWA Collection System
Exhibit 4A.6d
Critical Sewer Rating
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Protection Zone
Critical Sewer Rating
< 30
≥ 30 and ≤ 40
> 40
N
0
1,875
3,750
Feet
AGAT STP
BAZA GARDENS STP
TIPALAO PS
MOUNT TENJO
TENJO VISTA
CHALAN TELEFORO
FLAME TREE
AS CEPEDA
CHALAN AGOON
PEREZ HEIGHTS
PAULINO HEIGHTS
PAGO DOUBLE SHAFT
DAIRY ROAD
CAMACHO
SALAS
CHACO
PLUMERIA
TALISAY
TURNER


GWA Collection System
Exhibit 4A.6e
Critical Sewer Rating
Legend
Treatment Plant
Pump Station
Discharge Point
Outfall
Siphon
Force Main
Manhole
Ground Water Protection Zone
Critical Sewer Rating
< 30
≥ 30 and ≤ 40
> 40
N
0
1,875
3,750
Feet
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
PS 11
PS 12
PS 19
PS 20
PS 14
EJECTOR 3
PS 15
PS 16
EJECTOR 6
PS 17
PS 18
DANDAN
ESPINOSA
QUINENE
TINAGA
SINENJAYA
KALAMASA
FLORES
LAMAN


GWA Collection System
Exhibit 4B.1a
Manhole Inspections
Legend
Treatment Plant
Pump Station
Discharge Point
Gravity Line
Outfall
Siphon
Force Main
Manhole
Inspected
NORTHERN DISTRICT STP
SOUTHERNLINK PS
MACHANAONAO PS
ASTUMBO PS
FEMA PS 98
SANTA ANA PS
N
0 1,875 3,750
Feet


GWA Collection System
Exhibit 4B.1b
Manhole Inspections
Legend
Treatment Plant
Pump Station
Discharge Point
Gravity Line
Outfall
Siphon
Force Main
Manhole
Inspected
N
0
1,875
3,750
Feet


GWA Collection System
Exhibit 4B.1c
Manhole Inspections
Legend
Treatment Plant
Pump Station
Discharge Point
Gravity Line
Outfall
Siphon
Force Main
Manhole
Inspected
HAGATNA STP
HAGATNA MAIN PS
N
0
1,875
3,750
Feet


GWA Collection System
Exhibit 4B.1d
Manhole Inspections
Legend
Treatment Plant
Pump Station
Discharge Point
Gravity Line
Outfall
Siphon
Force Main
Manhole
Inspected
N
0
1,875
3,750
Feet
AGAT STP
BAZA GARDENS STP
TIPALAO PS
MOUNT TENJO
TALISAY
FERDINAN
PLUMERIA
CHALAN TELEFORO
CHALAN AGGON
PEREZ HEIGHTS
PAULINO HEIGHTS
CAMACHO
PAGO DOUBLE SHAFT
DAIRY ROAD
SANTOS


GWA Collection System
Exhibit 4B.1e
Manhole Inspections
Legend
Treatment Plant
Pump Station
Discharge Point
Gravity Line
Outfall
Siphon
Force Main
Manhole
Inspected
UMATAC MERIZO STP
INARAJAN STP
INARAJAN MAIN PS
EJECTOR 2
EJECTOR 3
PS 11
PS 14
PS 15
PS 16
PS 18
PS 19
PS 20
DANDAN
N
0
1,875
3,750
Feet

Exhibit 4C.1 – Example Field Inspection Report Form

#5 Per DO

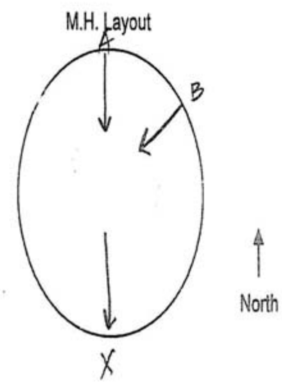
Manhole In[illegible]ection Report

Overview

Manhole Number:	30562	Weather:	Clear day
Location:	HARMON LOOP RD	Inspector Name:	Oliver – Vander
Map Number:		Date of Inspection:	WE-4-6-05
		Time of Inspection:	10:42 AM

Pictures

	Photo Number
General Area:	
Cover On:	
Cover Bottom:	
Down Manhole:	
Other:	



		Pipe Diameter	Pipe Material
Effluent:	X	18"	RCP
Influent 1:	A	18"	RCP
Influent 2:	B	18"	RCP
Influent 3:			
Influent 4:			
Other:			

GPS Coordinates: N Deg: 13° 30562
E Deg: 144° 49179

Site Information

Status:	☑ Located	☐ Not Located	☐ Could Not Open	☐ Not Accessible			
Surface Cover:	☑ Pavement	☐ Off Pavement	☐ Sidewalk	☐ Parking Lot	☐ Landscape	☐ Back Yard	☐ Open Field
Surface Condition:	☑ No Problem	☐ Cracked	☐ Pothole	☐ Raised	☐ Concrete Collar		
Traffic Setup:	☐ Roadway	☐ Off Roadway	☐ Intersection	☐ Sidewalk	☐ Driveway	☐ Private Property	☑ Highway
Traffic Volume:	☐ None	☐ Light	☑ Heavy				

Manhole Cover

Status when located:	☑ Normal	☐ Missing	☐ Cracked	☐ Rocking	☐ Seized	☐ Sealed	☐ Bolted	☐ Buried/Covered
Shape:	☑ Round	☐ Square	☐ Other					
Size:	☑ 24" Diameter	☐ 36" Diameter	☐ Other	Size: ______				
Material:	☑ Iron	☐ Plastic/Composite	☐ Other	Description: ______				
Corrosion:	☐ None	☐ Light	☐ Medium	☑ Heavy				

Grade Ring/Frame

Condition:	☑ Good	☐ Cracked	☐ Missing	
Corrosion:	☐ None	☑ Light	☐ Medium	☐ Heavy
Lid to Frame Seal:	☐ None	☑ Good	☐ Poor	
Frame to Ring Seal:	☐ None	☑ Good	☐ Poor	

General

Steps/Rungs:	☑ None	☐ Iron	☐ Plastic/Coated	☐ Other
Step Condition:	☑ Good	☐ Deteriorated	N/A	
Evidence of Surcharge:	☑ No	☐ Yes	Height ______	
Vandalism:	☑ No	☐ Yes	Description ______	

Exhibit 4C.1 – Example Field Inspection Report Form (continued)

Chimr : Cone					
Shape:	☒ Concentric	☐ Eccentric	☐ Other	Describe________	
Material:	☒ CIP Concrete	☐ PreCast Concrete	☐ Lined	☐ Brick	☐ Other
Condition – Visual:	☒ Good	☐ Fair	☐ Poor		
Scrape/Penetrate – Near Surface:	☒ Hard	☐ Soft	Inches______		
Scrape/Penetrate @ Cone:	☒ Hard	☐ Soft	Inches______		
Infiltration/Inflow:	☒ None	☐ Stains/Deposits	☐ Dripping	☐ Running	☐ Streaming

Barrel / Wall					
Material:	☒ CIP Concrete	☐ PreCast Concrete	☐ Lined	☐ Brick	☐ Other
Condition-Visual:	☒ Good	☐ Fair	☐ Poor		
Scrape/Penetrate invert +4ft:	☐ Hard	☐ Soft	Inches______		
Scrape/Penetrate @ Bench:	☐ Hard	☐ Soft	Inches______		
Infiltration/Inflow:	☒ None	☐ Stains/Deposit	☐ Dripping	☐ Running	☐ Streaming

Bench					
Material:	☒ CIP Concrete	☐ PreCast Concrete	☐ Lined	☐ Brick	☐ Other
Condition-Visual:	☒ Good	☐ Fair	☐ Poor		
Scrape/Penetrate near wall:	☐ Hard	☐ Soft	Inches______		
Scrape/Penetrate near channel:	☐ Hard	☐ Soft	Inches______		
Infiltration/Inflow:	☒ None	☐ Stains/Deposits	☐ Dripping	☐ Running	☐ Streaming

Channel					
Material:	☒ CIP Concrete	☐ PreCast Concrete	☐ Lined	☐ Brick	☐ Other
Condition-Visual:	☒ Good	☐ Fair	☐ Poor		
Scrape/Penetrate @ crown of pipe:	☐ Hard	☐ Soft	Inches______		
Scrape/Penetrate @ water line:	☐ Hard	☐ Soft	Inches______		
Infiltration/Inflow:	☒ None	☐ Stains/Deposits	☐ Dripping	☐ Running	☐ Streaming

Flow Velocity:	☐ Dry	☐ Stagnant	☒ Slow (0-1 fps)	☐ Normal (1-4 fps)	☐ Fast (>4 fps)	☐ Turbulent
Flow Depth:	☐ Dry	☐ 1/4 Pipe Dia.	☐ 1/2 Pipe Dia.	☐ 3/4 Pipe Dia.	☒ Full Pipe	☐ Surcharged
Grease:	☐ None	☒ Light	☐ Medium	☐ Heavy		
Pests/Insects:	☐ None	☒ Few	☐ Many	☐ Infested	Type CR	
Manhole Depth:	Inches 8'9"					
Silt:	☒ No	☐ Yes Inches______				
Debris:	☒ No	☐ Yes Description____________				
Unusual Odor:	☒ No	☐ Yes Description____________				

pH: 7.82 **Temperature:** 29.9 **Conductivity:** 1059