DRAFT

Development of Guam Northern Watershed Bacteria TMDLs

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1. Overview

Data collected through Guam's Recreational Beach Monitoring Program (RBMP) has served as the basis to place a number of locations on their §303(d) list. Guam's Integrated Report indicates that a priority action is to work towards developing TMDLs for impaired Tier 1 beaches. This TMDL report summarizes information for seventeen beaches located in the Northern Watershed and describes the approach used to develop TMDLs for these impaired waters. These seventeen beaches, identified in Table 1-1, are listed as impaired due to exceedances of Guam's Water Quality Standards for enterococci bacteria.

Table 1-1. Waterbodies covered under the Guam Northern Watershed Bacteria TMDLs.

Waterbody ID	Name	Impairment
GUN-01	Tanguisson Beach	*Enterococci*
GUN-24	Gun Beach	*Enterococci*
GUN-25	North San Vitores / Okura	*Enterococci*
GUN-02	San Vitores	*Enterococci*
GUN-23	Fujita	*Enterococci*
GUN-03	Matapang Beach Park	*Enterococci*
GUN-04	Guma Trankilidat	*Enterococci*
GUN-05	Ypao Beach	*Enterococci*
GUN-06	Sleepy Lagoon	*Enterococci*
GUN-07	Dungca's Beach	*Enterococci*
GUN-26	Alupang Towers Beach	*Enterococci*
GUN-08	Trinchera Beach	*Enterococci*
GUN-09	Padre Palomo Park	*Enterococci*
GUN-10	Hagåtña Channel	*Enterococci*
GUN-11	Paseo Outrigger Ramp	*Enterococci*
GUN-12	Hagåtña Boat Basin	*Enterococci*
GUN-13	Hagåtña Bayside Park	*Enterococci*

These TMDLs will address the enterococci impairments. The report begins with a short summary of the setting and general water quality concerns including applicable standards. An important part of TMDL development is to build on existing knowledge. This involves a review and analysis of data collected from project area beaches. Included are groupings for beach TMDLs based on location, physical characteristics, and potential sources. Potential sources that affect water quality at RBMP sites are summarized and TMDL allocations are provided.

These TMDLs use a hydrology-based framework, combining RBMP data with flow and precipitation information. This provides an expanded analysis of the monitoring data, which allows patterns to be examined, based on estimates of flows conditions (e.g., wet versus dry). Knowledge of conditions most likely to cause water quality problems supports a meaningful transition to implementation efforts.

2. Setting

Guam has a tropical oceanic climate with warm temperatures and high humidity. The subtropical weather allows for year-round recreation at all beaches. The majority of recreational activity occurs along stretches of sandy beaches or limestone plateaus easily accessible from the shore that are classified as "M-2 waters" or "Good" under Guam's Water Quality Standards.

Data has been provided from 17 RBMP stations for the purpose of developing bacteria TMDLs. These sites are situated along Guam's northwestern shoreline *(Figure 2-1)*. Basic station information is summarized in Table 2-1. With the exception of Tanguisson Beach (GUN-01), the stations are grouped by the major water where they are located (e.g., Tumon Bay, East Hagåtña Bay, West Hagåtña Bay).

Information from the Recreational Beach Monitoring Program has been the basis for issuing health advisories at project area beaches, as well as including these waters on Guam's §303(d) list. Potential causes include wastewater related sources (septic systems, sewer line breaks, sanitary sewer overflows, treatment plant discharges), storm water (surface runoff from developed land, roads, construction areas), and recreation related sources (marinas, boat discharges).

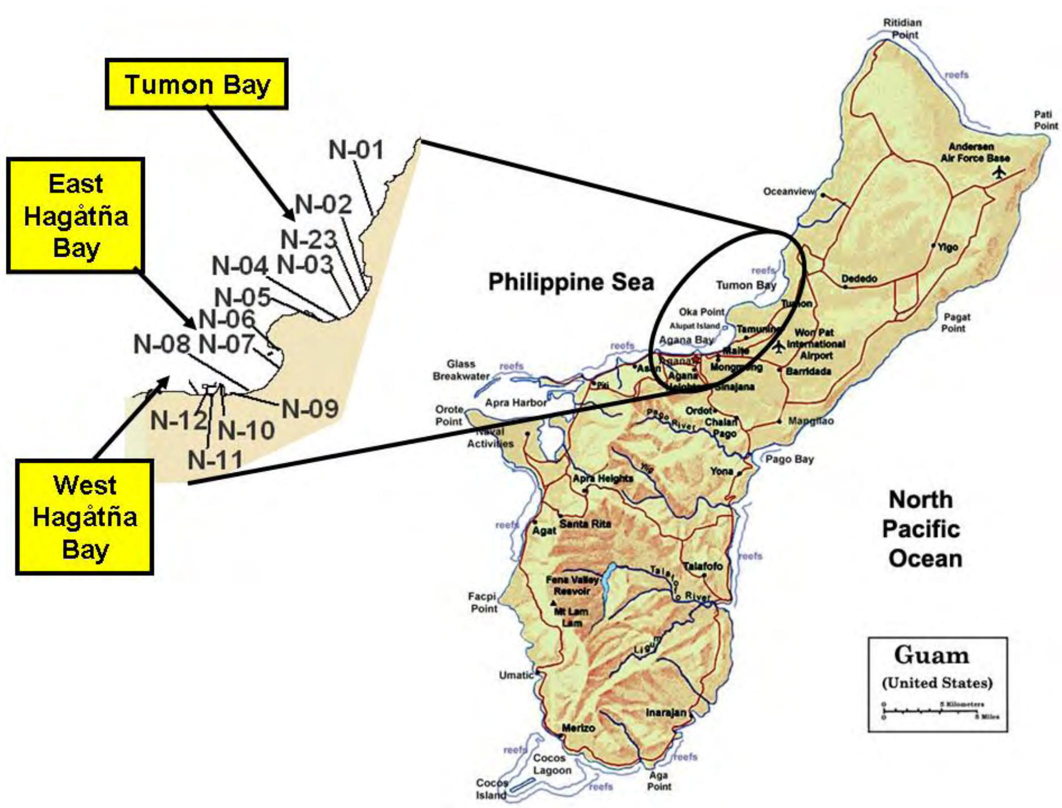

Figure 2-1. Location of Northern Guam TMDL project area beaches.

Table 2-1. Northern Guam TMDL project area beaches.

Village	Water	Beach	Site ID	Shore Access *(mi)*	Station Name	Features
Harmon	Northern	Tanguisson	GUN-01	0.25	Tanguisson Beach	Tanguisson Beach Park
Tamuning - Tumon	Tumon Bay	Gun	GUN-24	0.23	Gun Beach	
		Gognga	GUN-25	0.14	North San Vitores / Okura	
		Naton	GUN-02	0.39	San Vitores	Matapang Beach Park, Cushing Zoo
			GUN-23	0.29	Fujita	
			GUN-03	0.30	Matapang Beach Park	
			GUN-04	0.40	Guma Trankilidat	
		Ypao	GUN-05	0.46	Ypao Beach	Ypao Beach Park
Tamuning	East Hagåtña Bay	Dungca's	GUN-06	0.46	Sleepy Lagoon	
			GUN-07	0.46	Dungca's Beach	
		Alupang Towers	GUN-26	0.02	Alupang Towers Beach	
		Trinchera	GUN-08	0.46	Trinchera Beach	Padre Palomo Memorial Park
		Padre Palomo	GUN-09	0.46	Padre Palomo Park Beach	
Hagåtña	West Hagåtña Bay	Hagåtña Channel	GUN-10	0.15	Hagåtña Channel	Agana Marina
			GUN-11	0.15	Paseo Outrigger Ramp	
			GUN-12	0.12	Hagåtña Boat Basin	
		Bayside	GUN-13	0.31	Hagåtña Bayside Park	

3. Applicable Water Quality Standards

Criteria have been developed that form the basis of Guam's beach advisory program. These criteria are based on the applicable water quality standards. Guam's waterbodies are classified into categories based on designated uses. These categories for marine waters are M-1 / Excellent (whole body contact recreation), M-2 / Good (whole body contact recreation) and M-3 / Fair (limited body contact recreation). All beaches in the Northern Watershed TMDL project area are classified as M-2.

The applicable standards for whole body contact recreation and the rationale supporting the criteria are described in *"Recreational Beach Monitoring Plan: Guam Coastal Waters"* (Guam EPA, 2003). Guam uses the enterococci bacterial indicator to establish criteria that protect for contact recreational uses. For M-1 and M-2 waters, Guam's water quality standards state that:

> *"Concentrations of enterococci bacteria shall not exceed 35 enterococci/100 mL based upon the geometric mean of five (5) sequential samples taken over a period of thirty (30) days. No instantaneous reading shall exceed 104 enterococci/100 mL"*.

Recreational swimming and wading occurs year round on Guam's beaches. Guam EPA issues swimming advisories based upon either an instantaneous concentration of 104 MPN/100mL or a geometric mean concentration of 35 MPN/100mL, over a five week period. Advisory procedures are described in the RBMP Plan. Guam's *"2006 Integrated Report"* indicated that for calendar year 2004, 864 swimming advisories were issued, while in calendar year 2005, 535 swimming advisories were issued. (Guam EPA, 2006, Tables B7a-c and B8a-c, Appendix B).

4. Water Quality Data

An important step in the TMDL development process is the review of water quality conditions, particularly data and information used to list segments. Examination of water quality monitoring data is a key part of defining the problem that these TMDLs are intended to address. This section provides a brief review of available water quality information including a summary of the spatial distribution for the bacteria monitoring data. The discussion also considers seasonal patterns and trends in order to help identify potential analytical methods that can strengthen the TMDL development process for Guam's Northern Watershed beaches.

4.1 Available Information

The importance of Guam's beaches for water contact recreation has provided long standing support for the RBMP. Data has been collected by Guam EPA under this program for over 20 years. As a result of the Beach Act, an inventory of 113 beaches was conducted. Of these, 73 were prioritized into three tiers. Tier 1 includes beaches that are easily accessible, highly visited, characterized by a high number pollution sources, and require frequent monitoring.

Guam's Northern RBMP monitoring stations identified in Table 2-1 are all classified as Tier 1. Data collected weekly from these sites is used to make beach advisory decisions, as well as to assess status and trends. Table 4-1 provides an inventory that summarizes locations sampled each year since 1997.

Table 4-1. Inventory of Northern Watershed recreational beach TMDL project monitoring data.

Station ID	Station Name	Data Coverage										
		97	98	99	00	01	02	03	04	05	06	07
GUN-01	Tanguisson Beach	X	X	X	X	X	X	X	X	X	X	X
GUN-24	Gun Beach									X	X	X
GUN-25	North San Vitores / Okura									X	X	X
GUN-02	San Vitores	X	X	X	X	X	X	X	X	X	X	X
GUN-23	Fujita					X	X	X	X	X	X	X
GUN-03	Matapang Beach Park		X	X	X	X	X	X	X	X	X	X
GUN-04	Guma Trankilidat	X	X	X	X	X	X	X	X	X	X	X
GUN-05	Ypao Beach	X	X	X	X	X	X	X	X	X	X	X
GUN-06	Sleepy Lagoon	X	X	X	X	X	X	X	X	X	X	X
GUN-07	Dungca's Beach	X	X	X	X	X	X	X	X	X	X	X
GUN-26	Alupang Towers Beach									X	X	X
GUN-08	Trinchera Beach	X	X	X	X	X	X	X	X	X	X	X
GUN-09	Padre Palomo Park	X	X	X	X	X	X	X	X	X	X	X
GUN-10	Hagåtña Channel	X	X	X	X	X	X	X	X	X	X	X
GUN-11	Paseo Outrigger Ramp			X	X	X	X	X	X	X	X	X
GUN-12	Hagåtña Boat Basin	X	X	X	X	X	X	X	X	X	X	X
GUN-13	Hagåtña Bayside Park	X	X	X	X	X	X	X	X	X	X	X

4.2 Spatial Distribution

Sites included in the Northern Watershed TMDL project area represent an array of settings. Each has a unique set of features that includes effects from a range of different sources. A logical starting point for developing these beach TMDLs is to examine the spatial distribution of enterococcus concentrations using the RBMP information. Figure 4-1 shows the spatial distribution for sites (from north to south) grouped by major water. In particular, Figure 4-1 displays the frequency of advisories for each beach, based on monitoring data collected between 1997 and 2007. Figure 4-2 provides a summary of the data distribution for each beach over the same period using the *"box and whisker"* format.

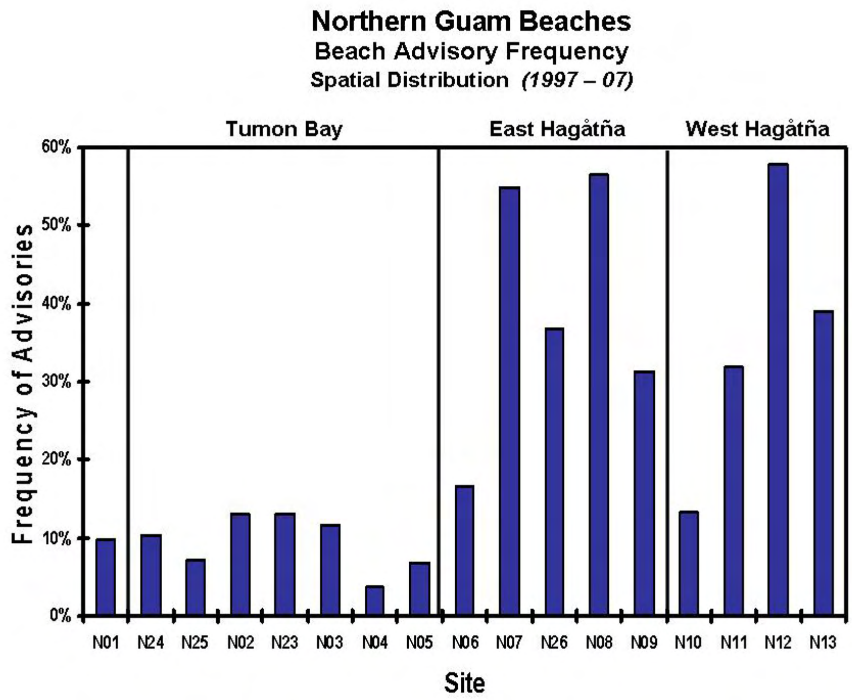

Figure 4-1. Spatial distribution of Northern Guam Watershed TMDL project area beach advisories.

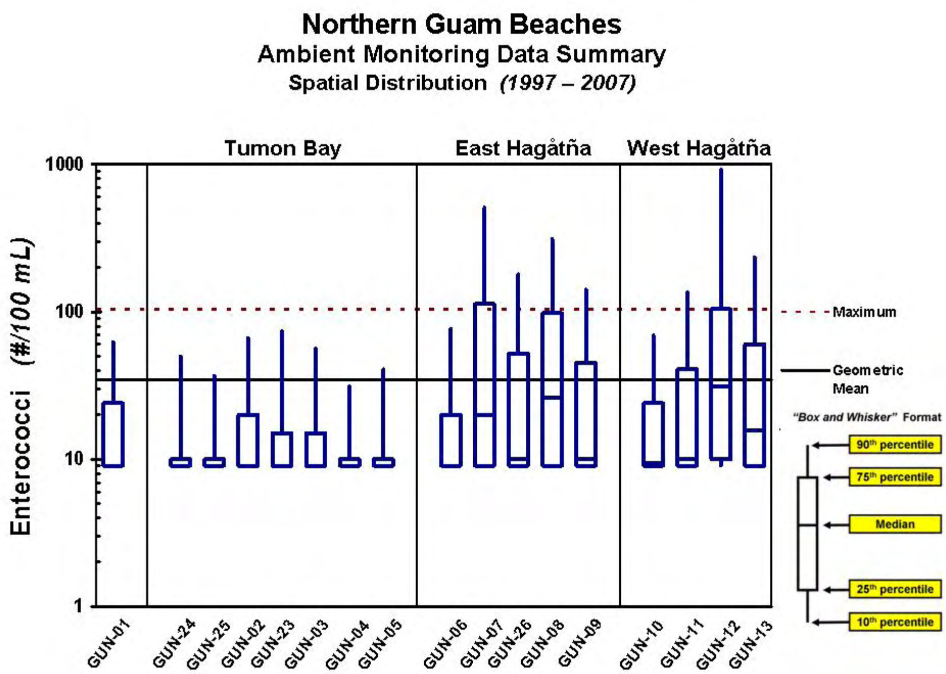

Figure 4-2. Spatial distribution of Northern Watershed TMDL project beach monitoring data.

The *"box and whisker"* format allows analysis of general patterns by displaying the data distribution. The top of the *"whisker"* is the 90^{th} percentile, i.e. ninety percent of all data are at or below that level. The *"box"* depicts the 75^{th} percentile (top) and the 25^{th} percentile (bottom). Half of all observed values fall within this range. The line through the *"box"* is the median (or 50^{th} percentile), while the bottom of the *"whisker"* represents the 10^{th} percentile.

Several patterns emerge from this visual display that warrant further analysis. For instance, Hagåtña Bay clearly has the highest concentrations. Tanguisson Beach, located at the northern end of the project area, also experiences elevated levels. Within Tumon Bay, three sites on Naton Beach (San Vitores, Fujita, and Matapang) deserve a closer look. In addition to potential sources, factors to be considered in a more detailed analysis include seasonal variation and trends.

4.3 Seasonal Variation

TMDL development must consider temporal (e.g., seasonal or inter-annual) variations in discharge rates, receiving water flows, and effects on designated uses. These considerations are particularly important because point and nonpoint sources can discharge at different rates during different time periods (see USEPA Pathogen Protocol for more detail).

Seasonal changes often relate to typical amounts of rainfall. In Guam, the wet season normally extends from July to November and dry season from January to May, with transitional periods between. Annual average rainfall varies from about 110 inches in the higher areas to about 80 inches along the shores.

4.3.1 Seasonal Patterns in Beach Monitoring Data

Figure 4-3 depicts an example display of seasonal patterns at one of the project area monitoring sites. While general patterns may be apparent, there is also a noticeable amount of variability. Some of this variability is likely attributed to different source areas that affect each site. In addition, samples taken during the dry season could coincide with rain events. This would result in measured bacteria concentrations that reflect wet-weather sources. Similarly, wet season samples could have been collected following a dry period.

Methods exist to improve the analysis of wet- versus dry-weather patterns. One option is to display concentration measurements against precipitation data. However, adjustments would need to be made to account for runoff processes and lag time. These adjustments can be made through use of a rainfall-runoff model. This approach allows screening tools to be utilized that enable a look at the role of hydrologic conditions. In particular, patterns in observed bacteria levels can be examined in terms of surface runoff or stream flow.

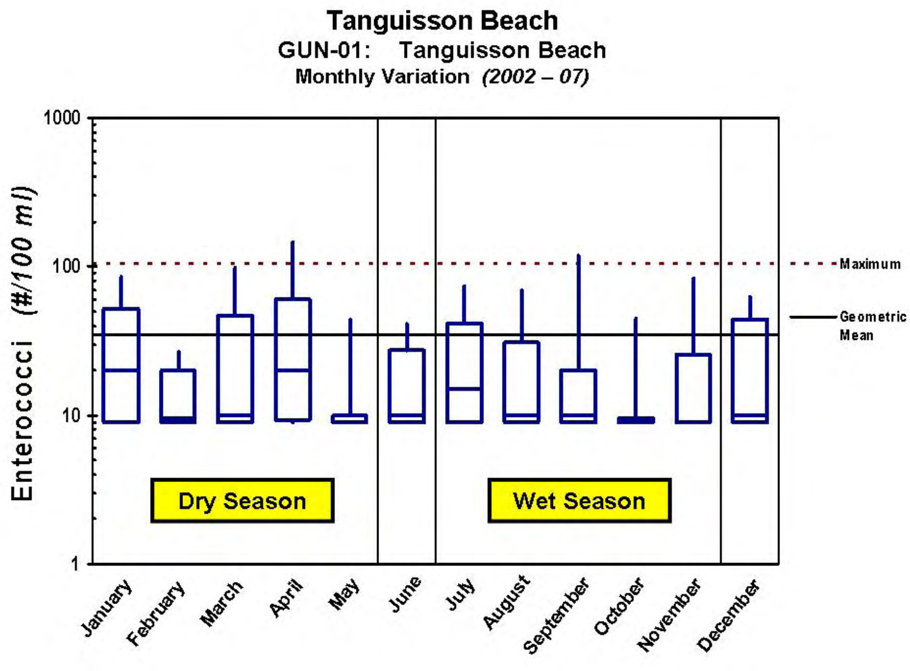

Figure 4-3. Seasonal variation at Tanguisson Beach.

4.3.2 Stream Flow and Seasonal Variation

Water quality at some beaches is severely influenced during heavy rainfall events either by excessive runoff from land or by storm drains. Guam EPA has identified beaches that receive additional monitoring after a rainfall event greater than two inches in a 24-hour period, including a number in the TMDL project area. In fact several beaches in the project area have signs posted advising the public of the risk associated with elevated bacteria levels associated with excessive rainfall and the proximity of storm drains at those sites.

Water quality parameters can often be related to stream flow rates, particularly for samples associated with storm events. The connection between beach advisories and rainfall is an example, where sites are affected by surface runoff or located near storm drains. Seasonal variation in flow can be a key part of TMDL development. Routine flow monitoring of storm runoff has not been conducted in the project area. This is largely due to the lack of perennial streams that discharge to Northern Watershed beaches.

The U.S. Geological Survey (USGS) operates a flow gage on the Pago River, which is located in the general proximity *(Figure 4-4)*. In some situations, flow information from nearby sites can be used as an indicator of general hydrologic conditions. Although the data is collected outside the immediate project area, the information may be of utility in examining water quality patterns in the Northern Watershed beaches.

Figure 4-5 illustrates the seasonal variation in flow for the Pago River. There is definitely a seasonal pattern that shows the difference between wet- and dry-seasons. Information from this gage could be used to explore potential relationships between observed bacteria levels and hydrologic conditions.

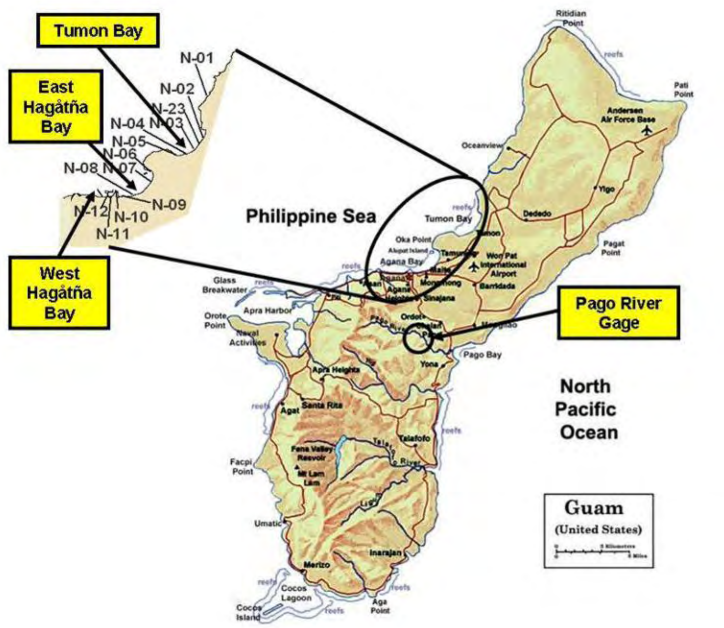

Figure 4-4. Location of Pago River stream gage.

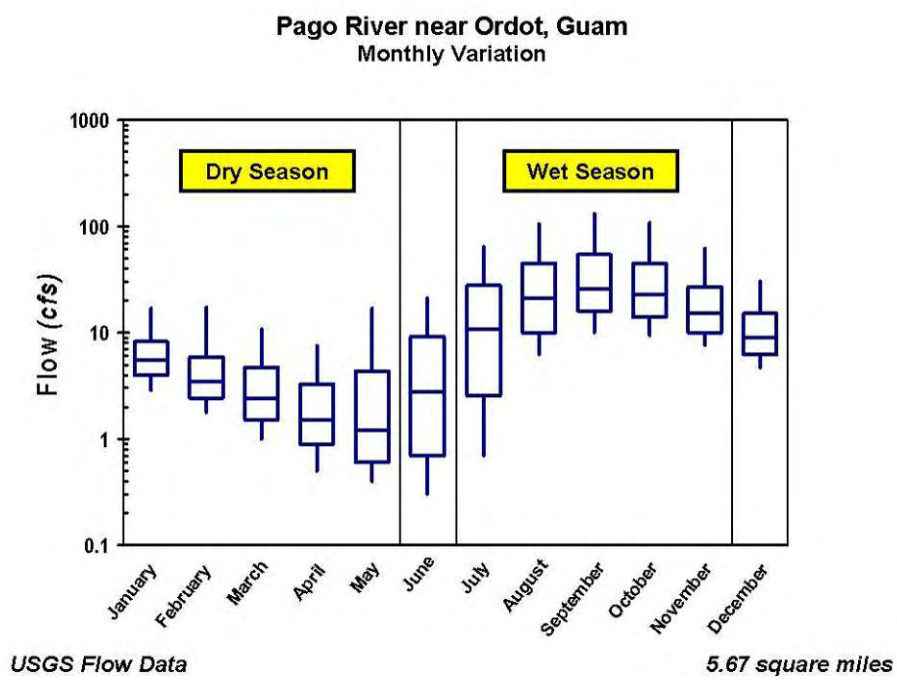

Figure 4-5. Seasonal variation of flows for the Pago River.

4.3.3 Flow Duration Curves

Flow duration curves provide a way to address the inherent variability associated with hydrologic information (e.g., seasonal variation, year-to-year variation). Duration curves describe the percentage of time during which specified flows are equaled or exceeded *(Leopold, 1994)*. Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period. Duration analysis results in a curve, which relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently.

Duration curves provide the benefit of considering the full range of flow conditions. Development of a flow duration curve is based on daily average stream discharge data. A typical curve runs from high flows to low flows along the x-axis, as illustrated in Figure 4-6 for the Pago River. Note the flow duration interval of sixty associated with a stream discharge of 5.6 cfs (i.e., sixty percent of all observed stream discharge values equal or exceed 5.6 cfs).

Flow duration curve intervals can be grouped into several broad categories or zones. These zones provide additional insight about conditions and patterns associated with the impairment. A common way to look at the duration curve is by dividing it into five zones, as illustrated in Figure 4-6: one representing *high flows (0-10%)*, another for *moist conditions (10-40%)*, one covering *mid-range flows (40-60%)*, another for *dry conditions (60-90%)*, and one representing *low flows (90-100%)*. This particular approach places the midpoints of the moist, mid-range, and dry zones at the 25th, 50th, and 75th percentiles respectively (i.e., the quartiles). The high zone is centered at the 5th percentile, while the low zone is centered at the 95th percentile.

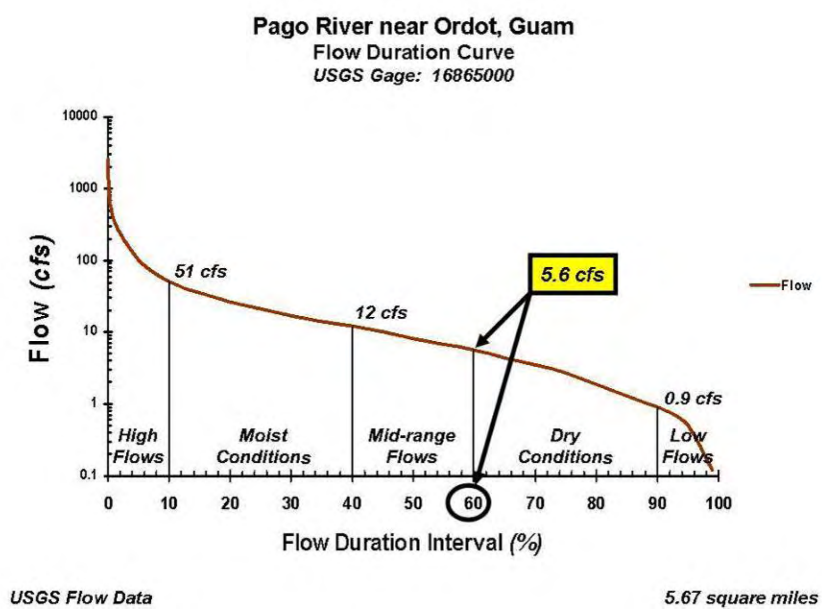

Figure 4-6. Flow duration curve for Pago River.

4.3.4 Water Quality Duration Curves

Ambient monitoring data, taken with some measure or estimate of flow at the time of sampling, can be used to develop water quality duration curves. Using the relative percent exceedance from the flow duration curve that corresponds to the stream discharge at the time the sample was taken, the water quality value can be plotted in a duration curve format.

By displaying ambient water quality data and the daily average flow on the date of the sample (expressed as a flow duration curve interval), a pattern develops. This pattern describes the characteristics of the water quality impairment. Values that plot above the criterion or numeric target indicate an exceedance of the water quality criterion, while those below the load duration curve show compliance.

The pattern of impairment can be examined to see if it occurs across all flow conditions, corresponds strictly to high flow events, or conversely, only to low flows. Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left generally reflect potential nonpoint source contributions. This concept is illustrated in Figure 4-7. Data may also be separated by season (e.g., wet versus dry). For example, Figure 4-7 uses a "+" to identify those samples collected during the wet season (July – November).

The utility of duration curve zones for pattern analysis can be further enhanced to characterize wet-weather concerns. Some measure or estimate of flow is available to develop the duration curves. As a result, stream discharge measurements on days preceding collection of the ambient water quality sample may also be examined.

Rapid increases in the daily average flow can serve as an indicator of storm events. This concept is illustrated in Figure 4-7 by comparing the flow on the day the sample was collected with the flow on the preceding day. Any one-day increase in flow is assumed to be the result of surface runoff due to a storm event. In Figure 4-7, these samples are identified with a shaded diamond.

Figure 4-7 illustrates the utility of water quality duration curves in assessing Guam's Recreational Beach Monitoring Program data. A definite pattern exists between enterococci measurements at this site and flow conditions associated with the Pago River gage. For example, the highest bacteria levels are generally associated with storm events (indicated by the shaded diamonds) and high flow conditions. Several of the high flow exceedances did occur during the dry season.

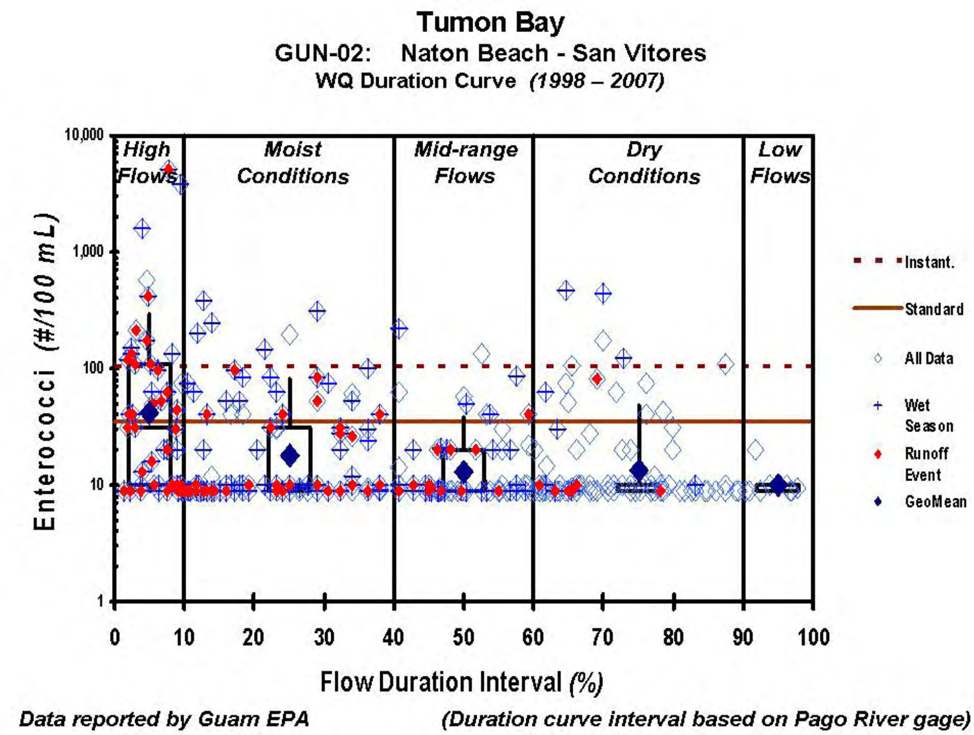

Figure 4-7. Water quality duration curve for San Vitores Beach site.

The duration curve framework provides a way to address variability issues described earlier relative to dry- versus wet season type analysis. Another observation is the high levels in the dry condition and low flow zones. These are likely associated with dry weather source areas and delivery mechanisms, which warrant further investigation.

4.3.5 Trends

The 2006 Integrated Report describes actions that have been taken to improve water quality at several sites. Figure 4-8 presents a year-by-year summary of the RBMP data for one site. This provides a useful way to examine trends at each site relative to both central tendency and annual variation. One important factor to consider in looking at the graph is that a change in analytical methods occurred starting with samples collected in September 2000. Data notes indicate that after September 2000, the IDEXX test was used to determine enterococcus concentrations.

This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness.

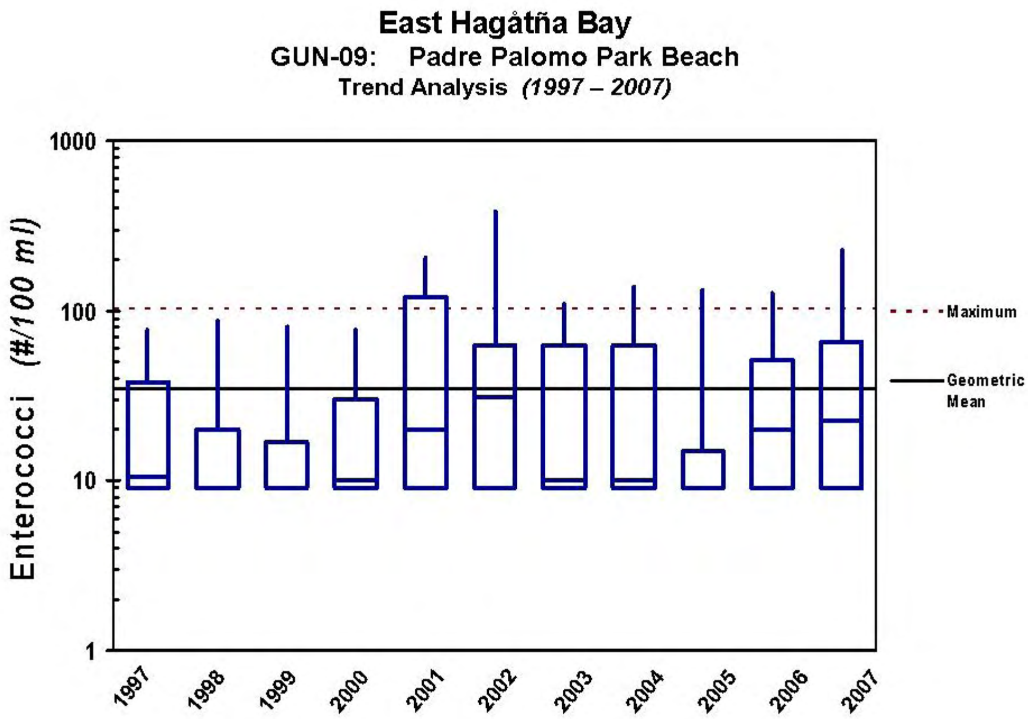

Figure 4-8. Trend analysis for Padre Palomo Beach site.

5. Source Assessment

Source assessments are an important component of water quality management plan and TMDL development. These analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody (USEPA, 1999). Source assessment methods vary widely with respect to their applicability, the ease of use, and acceptability. This document contains a detailed discussion of potential bacteria sources to Northern Guam Beaches.

Assessment reports prepared by Guam EPA have identified a number of pollution threats to these beaches. Included are concerns such as storm water runoff, sewer line blockages and breaks, point source effluents, sanitary system overflows, septic systems, marina and recreational boating, debris and bottom deposits, and seeps connected to storm water ponding basins. For purposes of this assessment, potential sources have been grouped into three general categories that include:

- Waste Water
- Storm Water
- Recreation and Other

The intent of these groupings is two-fold. The first is to examine potential source area and delivery mechanisms. This supports informed decisions regarding the most appropriate technical approach for connecting water quality data to TMDL targets. For example, storm water sources are driven by rainfall and the resultant runoff. Elevated bacteria levels under high flow conditions reflect this pattern where storm water is a significant source.

The second reason for grouping categories is to align sources in a way that looks ahead to those water quality management programs and implementation efforts best suited to address the problems.

5.1 Waste Water Sources

This group includes those sources associated with the generation, conveyance, treatment, and discharge of domestic and industrial waste water. Potential threats identified in Guam EPA assessments are:

- Septic systems
- Sewer line blockages and / or breaks
- Sanitary system overflows (SSOs)
- Publicly owned treatment works (POTWs)
- Industrial point sources (e.g., GPA effluent)

Domestic waste water associated with population increase is the largest potential source of pollution to all waters of Guam (GEPA, 2006). There are a number of potential opportunities for waste water sources to contribute bacteria to Northern Guam recreational beach waters. Transport and delivery mechanisms include:

- Groundwater transport of leachate from failed septic systems either directly or indirectly to coastal waters
- Leaking from blockage or breakage of sewerage mains that result in either direct or indirect discharge to coastal waters
- Inadequate treatment or lack of disinfection from POTWs

These processes tend to be more common in areas with higher population densities, such as residential or commercial zones. Due to economic difficulties, development in many areas has occurred without adequate sewage infrastructure. As a result, a number of residential and commercial buildings depend on septic tanks and leaching field systems for waste disposal. Guam EPA has identified buildings in the TMDL project area that are not sewered through Geographic Information System (GIS) data layers *(Figure 5-1)*.

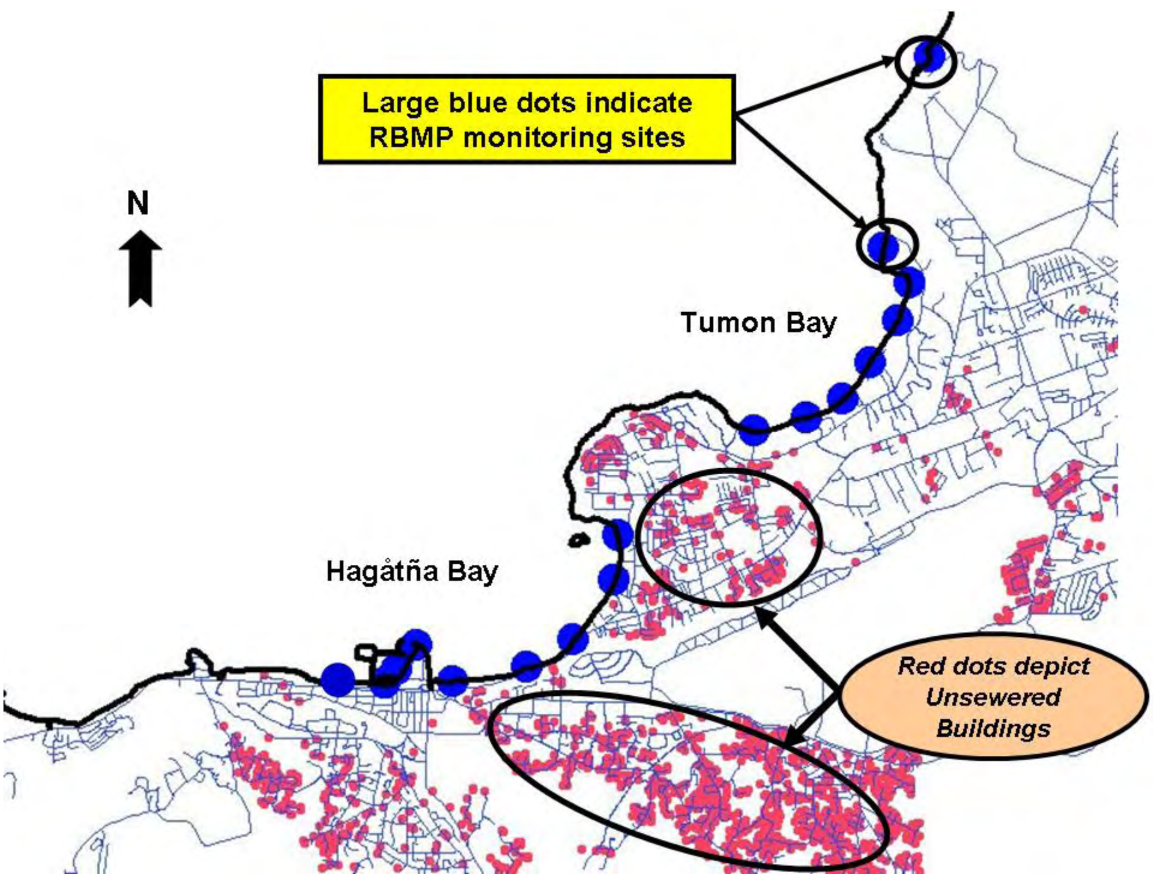

Figure 5-1. Location of unsewered buildings in Northern Guam Beach TMDL project area.

Residential septic systems treat human wastes using a collection system that discharges liquid wastes into the soil through a series of distribution lines that comprise the drain field. Bacteria naturally die-off as the effluent percolates through the soil to groundwater. Septic systems are designed to effectively remove bacteria when properly installed and maintained.

A septic system failure occurs when there is a discharge of waste to the soil surface where it becomes available for washoff into surface waters (both directly or indirectly through the network of storm drains and ditches). Failing septic systems can deliver high bacteria loads to surface waters, depending on the proximity of the discharge to drainage systems and the timing of opportunities for pollutant delivery (e.g., rainfall events). Septic system failures typically occur in older systems that are not adequately maintained with periodic pump outs.

In more densely populated areas, residential and commercial buildings have been connected to wastewater collection systems. Efforts to phase out septic systems has resulted in reduced bacteria loads from these sources. However, portions of the collection system suffer from sewer line blockages or breaks. This results in sanitary system overflows (SSOs) or direct discharge to coastal waters. SSOs and sewer line breaks can also result in indirect discharge to coastal waters by conveyance through the storm drainage or ditch network.

Several point sources with NPDES permits discharge in areas that may affect water quality at Northern Guam recreational beaches *(Table 5-1)*. The Guam Waterworks Authority (GWA) owns and operates two wastewater treatment facilities that affect these TMDL waters, shown in Figure 5-2. GWA is currently under a Stipulated Order to address several problems that contribute to beach advisories. Included in the Order are renovations and upgrades to the WWTPs, as well as actions to correct problems associated with portions of the conveyance system. Permitted facilities identified in Table 5-1 will receive waste load allocations (WLAs). The Government of Guam will receive load allocations (LAs) to address nonpoint sources.

Table 5-1. Point sources with NPDES permits that may affect Northern Guam Beaches.

NPDES ID	Facility Name	Receiving Water
GU0020087	Agana WWTP	Philippine Sea
GU0020141	Northern District WWTP	Philippine Sea
GU0000027	GPA Tanguisson Power Plant	Philippine Sea
GU0020281	Continental Micronesia	Harmon Sink
GU0020290	Guam Airport Authority	Harmon Sink

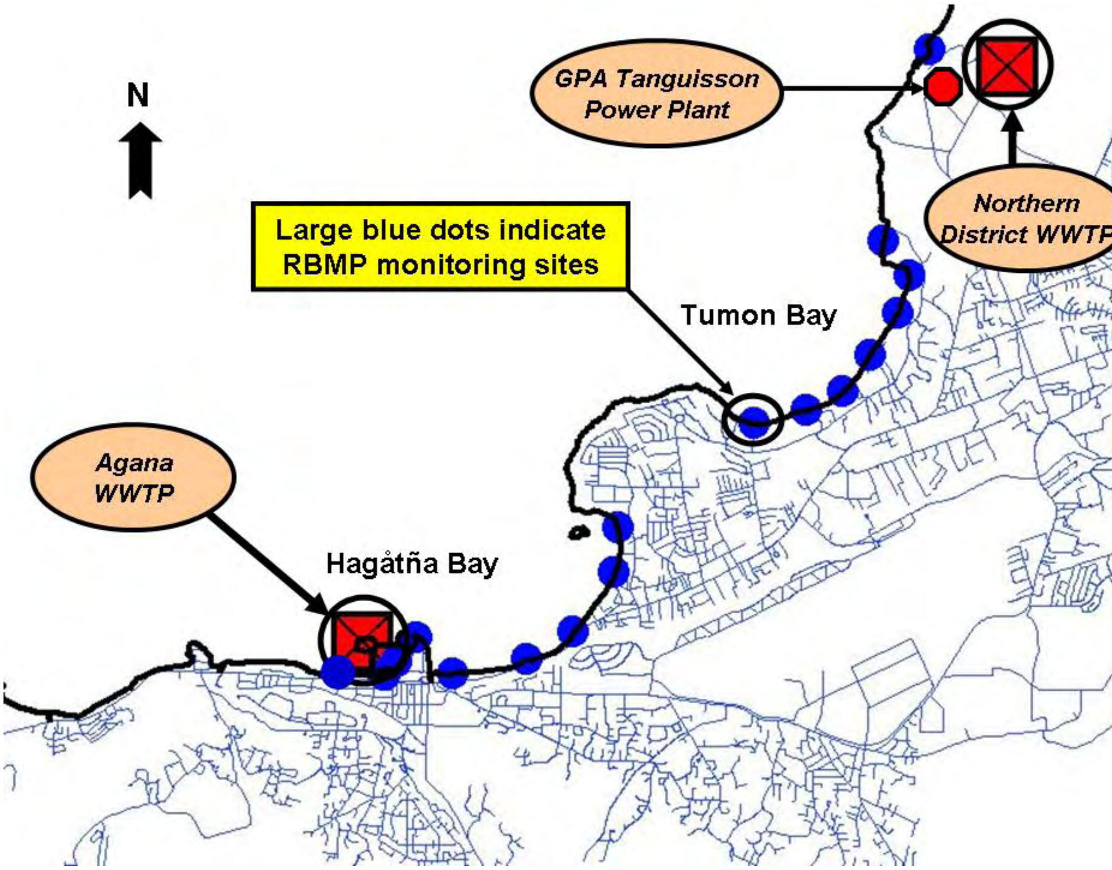

Figure 5-2. Location of WWTPs in Northern Guam Beach TMDL project area.

5.2 Storm Water Sources

This group includes those sources associated with bacteria delivered to Northern Guam Recreational Beach waters as a result of storm water runoff. Potential threats identified in Guam EPA assessments are:

- Storm water runoff (nonpoint source)
- Storm water runoff (associated with permitted areas)
- Highway / road / bridge runoff
- Highway maintenance and runoff
- Construction

Urban areas are generally characterized by higher percentages of impervious land due to conversion of natural surfaces to pavement, concrete, and buildings. Higher percentages of impervious area, if not properly managed, result in greater surface runoff due to the reduced ability of water to infiltrate into the ground during rain events.

As water flows across the land and paved surfaces, debris and pollutants such as bacteria are entrained. Bacteria subsequently flow with the water into storm drains and ditches that lead to local coastal waters. Harmful bacteria and viruses carried by runoff from developed land to local waters can threaten human health and contribute to recreational beach closures. Studies have shown that bacteria levels are typically high in urban runoff (USEPA, 2001). Bacteria delivered to coastal waters from developed land may be a significant source of pollution to Northern Guam's Recreational Beaches.

5.3 Recreation and Other Sources

This group includes sources related to recreational activities and other concerns that could deliver bacteria to Guam's Northern recreational beaches. Potential threats identified in Guam EPA assessments are:

- Marina and recreational boating
- Boat discharges
- Recreation and tourism activities
- Debris and bottom deposits
- Contaminated sediments
- Spills
- Seepage from storm water ponding basins and infiltration chambers

Unsolicited discharge of untreated wastewater to coastal beaches can occur from recreational sources, notably boats and marinas. Moored boats may be transient and may not pose a constant threat to water quality. Frequency of use in the area and number of boats that may discharge their holding tanks directly to coastal waters are major factors that affect the pollution threat from these sources.

Bacteria discharges from boats in marinas may have a more significant effect on coastal waters based on their sheltered locations and reduced freshwater and tidal inflows. Figure 5-3 shows the location of a major marina identified in Guam EPA GIS data files.

Another concern is seepage from storm water ponding basins and infiltration chambers *(Figure 5-4)*. The largest and most studied is the Harmon Sink. The Sink, located 1 to 3 km south of Tumon Bay and 2 to 4 km east of Agana Bay, is surrounded by Guam's densest industrial and urban areas. The Harmon Sink collects storm water from a surrounding industrial park and the adjacent airport. In recent years, the Sink has also received large discharges of sewage from failing lift stations. There has been concern that contaminants entering the Sink may be carried to recreational beaches by groundwater discharging in the coastal zone.

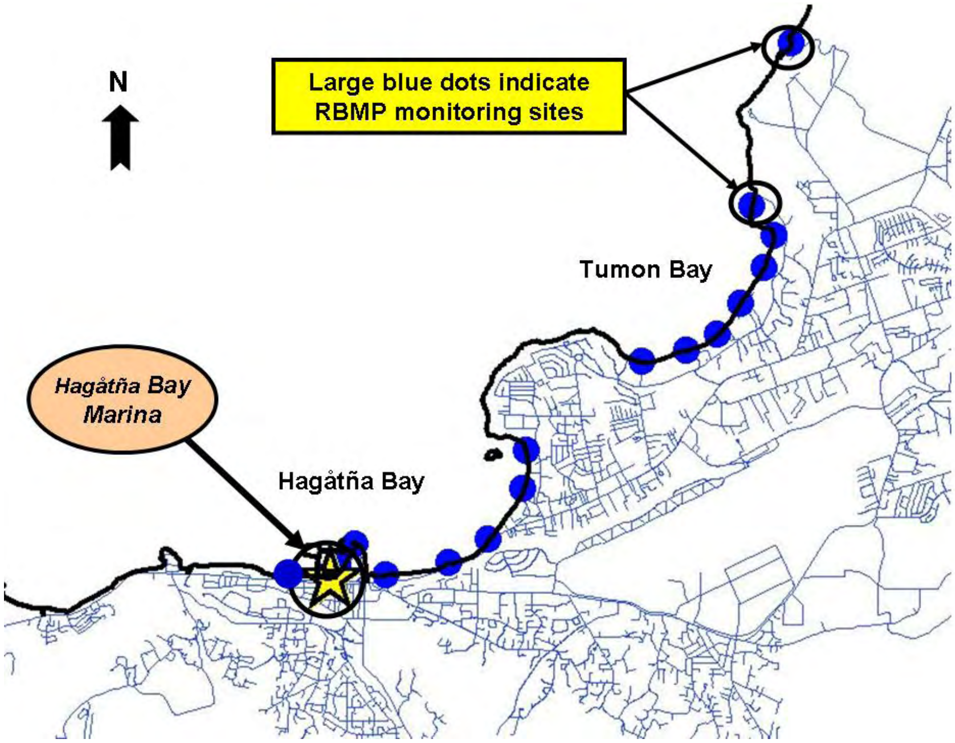

Figure 5-3. Location of marinas in Northern Guam Beach TMDL project area.

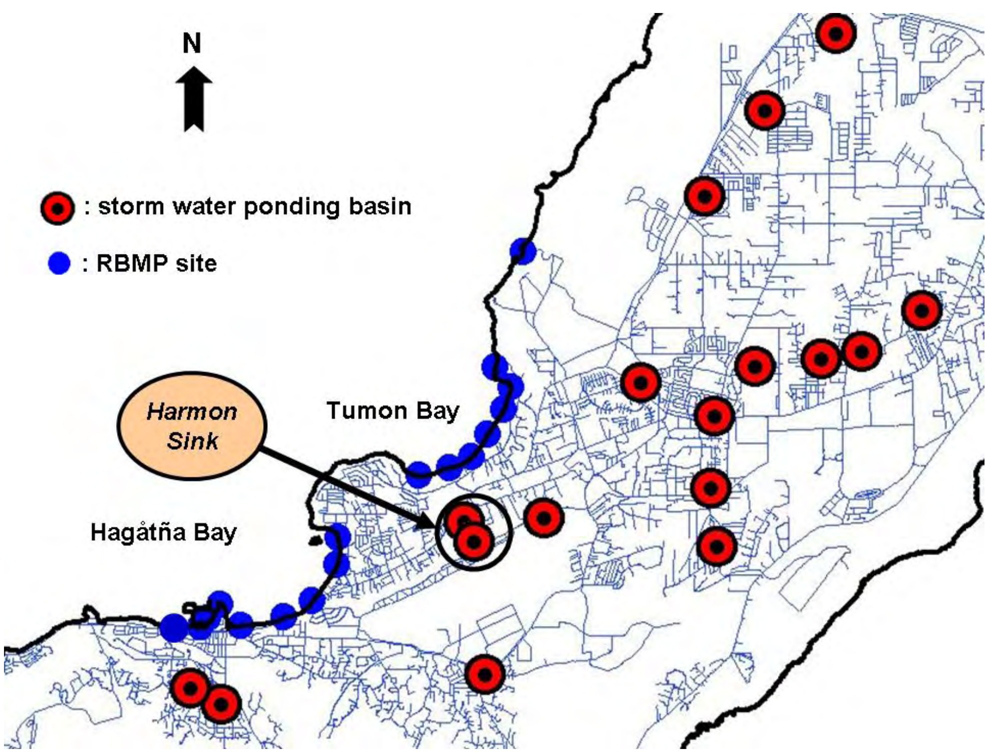

Figure 5-4. Location of storm water ponding basins in Northern Guam Beach TMDL project area.

The University of Guam Water and Environmental Research Institute (WERI) conducted a dye trace study to help characterize groundwater transport from the Sink to the adjacent coastal zone (Moran and Jenson, 2004). Dye receptors were placed at seeps and springs in both East Hagåtña and Tumon Bays.

Dye from the Harmon Sink surface injection was detected earliest at two locations on East Hagåtña Bay (within 4 to 6 days). The study hypothesized that the relatively fast transport to East Hagåtña Bay is controlled by relatively open, regional-scale fracture pathways. Dye was detected much later (day 17) and at much lower levels at the Tumon Bay site (Ypao Beach). The approximate flow path from the Harmon Sink to each site is shown in Figure 5-5. The wider arrow from the Harmon Sink illustrates the direction that the faster transport seemed to occur, based on reported study results.

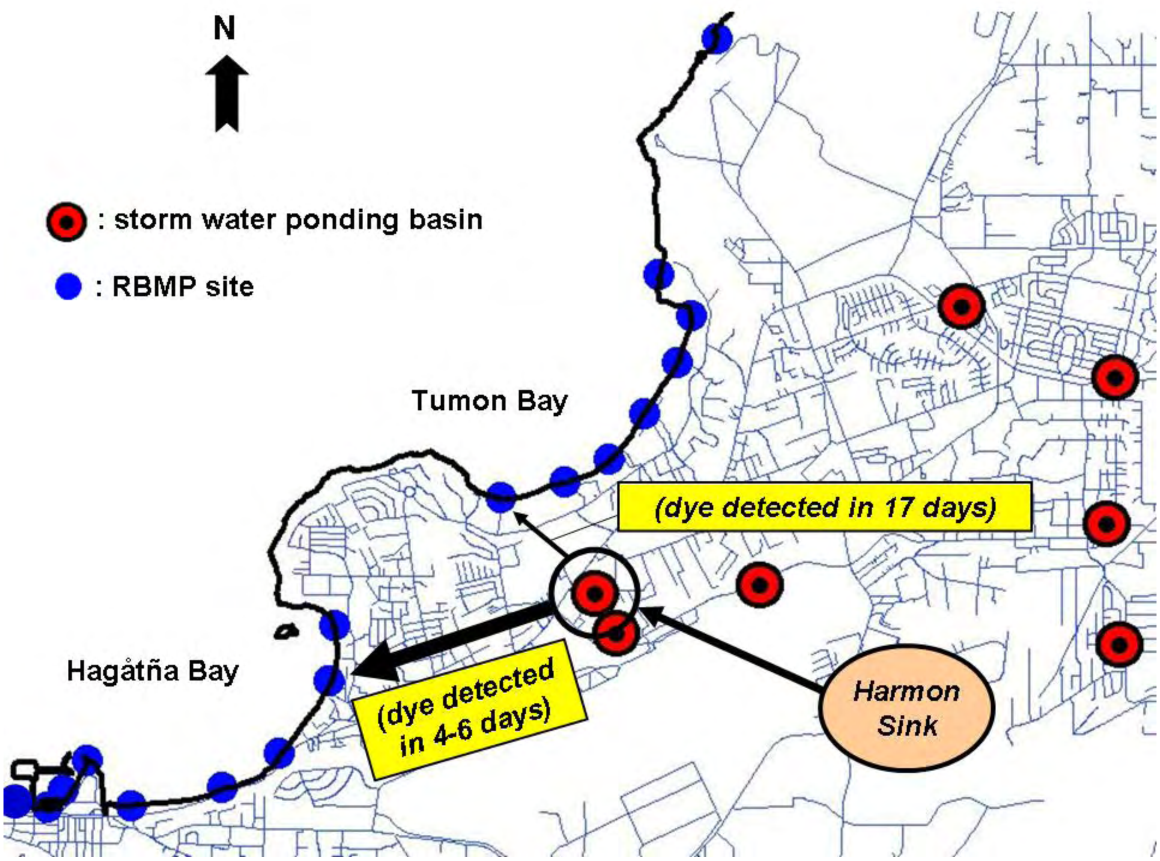

Figure 5-5. Harmon Sink dye study flow paths.

5.4 Summary

In addition to describing pollution threats, reports prepared by Guam EPA provide an indication of those beaches that may be affected by various source categories. Table 5-2 summarizes pollution threats identified in the §305(b) report for the TMDL project area beaches. Table 5-2 provides a transition into the linkage analysis, where the water quality data is evaluated in a way that considers potential sources.

Table 5-2. Pollution threats for northern Guam TMDL project area beaches.

<table>
<tr><th rowspan="2">Water</th><th rowspan="2">Beach</th><th rowspan="2">Site</th><th rowspan="2">Name</th><th colspan="3">Pollution Threats</th></tr>
<tr><th>Wastewater</th><th>Storm Water</th><th>Recreation & Other</th></tr>
<tr><td>Northern</td><td>Tanguisson</td><td>N-01</td><td>Tanguisson Beach</td><td>W1, W3, W4, W5</td><td>S1</td><td>O2, O3, O4, O5, O6</td></tr>
<tr><td rowspan="7">Tumon Bay</td><td>Gun</td><td>N-24</td><td>Gun Beach</td><td>W1</td><td>S1, S5</td><td>R3</td></tr>
<tr><td>Gognga</td><td>N-25</td><td>San Vitores / Okura</td><td>W1, W2</td><td>S1, S5</td><td>R3</td></tr>
<tr><td rowspan="4">Naton</td><td>N-02</td><td>San Vitores Beach</td><td rowspan="4">W1, W2, W3</td><td rowspan="4">S1, S4, S5</td><td rowspan="4">R3</td></tr>
<tr><td>N-23</td><td>Fujita</td></tr>
<tr><td>N-03</td><td>Matapang Beach Park</td></tr>
<tr><td>N-04</td><td>Guma Trankilidat Beach</td></tr>
<tr><td>Ypao</td><td>N-05</td><td>Ypao Beach</td><td>W1, W2, W3</td><td>S1, S4, S5</td><td>R3</td></tr>
<tr><td rowspan="5">East Hagåtña Bay</td><td rowspan="2">Dungca's</td><td>N-06</td><td>Sleepy Lagoon</td><td rowspan="2">W1, W2, W3</td><td rowspan="2">S1, S2</td><td rowspan="2">R4, O1</td></tr>
<tr><td>N-07</td><td>Dungca's Beach</td></tr>
<tr><td>Alupang</td><td>N-26</td><td>Alupang Towers Beach</td><td>W1, W2, W3</td><td>S1, S2, S3</td><td>R4</td></tr>
<tr><td>Trinchera</td><td>N-08</td><td>Trinchera Beach</td><td rowspan="2">W1, W2, W3</td><td rowspan="2">S1, S2, S3</td><td rowspan="2">R4, O1</td></tr>
<tr><td>Palomo</td><td>N-09</td><td>Padre Palomo Park</td></tr>
<tr><td rowspan="4">West Hagåtña Bay</td><td rowspan="3">Hagåtña Channel</td><td>N-10</td><td>Hagåtña Channel</td><td rowspan="4">W1, W2, W3, W4</td><td rowspan="4">S1, S2</td><td rowspan="4">R1, R2</td></tr>
<tr><td>N-11</td><td>Paseo Outrigger Ramp</td></tr>
<tr><td>N-12</td><td>Hagåtña Boat Basin</td></tr>
<tr><td>Bayside</td><td>N-13</td><td>Hagåtña Bayside Park</td></tr>
<tr><td colspan="2" rowspan="21">Pollution Threat Codes</td><td colspan="2" rowspan="5">Wastewater</td><td>W1</td><td colspan="2">Septic Systems</td></tr>
<tr><td>W2</td><td colspan="2">Sewer line Blockage / Break</td></tr>
<tr><td>W3</td><td colspan="2">SSO</td></tr>
<tr><td>W4</td><td colspan="2">POTW</td></tr>
<tr><td>W5</td><td colspan="2">Industrial point source (GPA effluent)</td></tr>
<tr><td colspan="2" rowspan="5">Storm Water</td><td>S1</td><td colspan="2">Storm Water Runoff</td></tr>
<tr><td>S2</td><td colspan="2">Storm Water Runoff (permitted)</td></tr>
<tr><td>S3</td><td colspan="2">Highway / Road / Bridge Runoff</td></tr>
<tr><td>S4</td><td colspan="2">Highway Maintenance and Runoff</td></tr>
<tr><td>S5</td><td colspan="2">Construction</td></tr>
<tr><td colspan="2" rowspan="10">Recreation & Other</td><td>R1</td><td colspan="2">Marina and Recreational Boating</td></tr>
<tr><td>R2</td><td colspan="2">Boat Discharge</td></tr>
<tr><td>R3</td><td colspan="2">Recreational & Tourism Activities</td></tr>
<tr><td>R4</td><td colspan="2">Recreational & Tourism Activities (RUMP)</td></tr>
<tr><td>O1</td><td colspan="2">Debris & Bottom Deposits</td></tr>
<tr><td>O2</td><td colspan="2">Contaminated Sediments</td></tr>
<tr><td>O3</td><td colspan="2">Spill (Oil Underground)</td></tr>
<tr><td>O4</td><td colspan="2">Atmospheric Deposition</td></tr>
<tr><td>O5</td><td colspan="2">Squatters</td></tr>
<tr><td>O6</td><td colspan="2">Wildlife</td></tr>
</table>

6. Technical Approach and Linkage Analysis

Developing TMDLs requires a combination of technical analysis, practical understanding of important watershed processes, and interpretation of watershed loadings and receiving water responses to those loadings. In identifying the technical approach for development of the bacteria TMDLs for Guam's Northern Beaches, the following core set of principles was identified and applied:

- ***The TMDLs must be based on scientific analysis and reasonable and acceptable assumptions.*** All major assumptions have been made based on available data and in consultation with appropriate agency staff.

- ***The TMDLs must use the best available data.*** All available data in the watershed were reviewed and were used in the analysis where possible or appropriate.

- ***Methods should be clear and as simple as possible to facilitate explanation to stakeholders.*** All methods and major assumptions used in the analysis are described. The TMDL document has been presented in a format accessible by a wide range of audiences, including the public and interested stakeholders.

An essential component of TMDL development is establishing a relationship between numeric indicators intended to measure attainment of beneficial uses and source loads. The linkage analysis examines connections between water quality targets, available data, and potential sources.

6.1 Pattern Analysis

The seventeen beaches that are the focus of this TMDL report represent an array of situations, as evidenced by information presented in the data summary and source assessment. One way to capitalize on the wealth of ambient beach monitoring information is to examine patterns associated with potential source area and delivery mechanisms. The duration curve method provides one option for building a framework that supports pattern analysis.

For instance, use of the Pago River gage to identify duration curve intervals demonstrated the connection between high flow conditions following storm events and elevated bacteria levels at beach monitoring sites. Although duration curve intervals based on flow conditions highlight advantages of the method, data gaps at the Pago River gage prevent full use of the RBMP monitoring information. One way to address this issue is to utilize precipitation data to determine duration curve intervals.

A simple rainfall – runoff model, such as the P8 – Urban Catchment Model (P8-UCM), can be combined with northern Guam precipitation data to develop duration curve interval estimates. This approach accounts for the lag between the onset of a storm event and actual delivery to beach waters from potential source areas, as opposed to simply using rainfall data alone.

Figure 6-1 displays data from a site presented earlier *(Figure 4-7)*. Duration curve intervals are based on estimates using P8-UCM and precipitation information rather than flow data from the Pago River gage. In this case, the patterns are very similar to the previous example *(Figure 4-7)* as indicated by the *"box and whisker"* plot in each duration curve zone. However, the use of P8-UCM supports a more robust analysis of the monitoring information by including data for samples taken when Pago River flows were not measured.

In this situation, the largest geometric means occur under high flow conditions. The same pattern exists for the upper range of the *"box and whisker"* plot (e.g., the 90th percentile). In considering the potential threats identified for this site *(*Table 5-2*)*, the most likely dominant source under high flow conditions is storm water runoff. Thus, targets identified in the TMDL for this site should support a focus on source control efforts to address bacteria delivered to recreational beach waters that result from storm water runoff.

The duration curve framework provides the opportunity to connect water quality data with TMDLs and subsequent implementation efforts. In order to take advantage of this approach, all duration curves used for the Northern Guam Beach TMDLs were created using the P8-UCM model.

6.1.1 Spatial Patterns

The geometric mean and 90th percentile are used to compare patterns between the different flow zones, as demonstrated by Figure 6-1. These values enable a comparison of patterns between each of the beach monitoring sites. In addition to being a criteria value for enterococci in Guam's water quality standards, the geometric mean provides a measure of central tendency; an important factor to guide long-term program implementation efforts. The 90th percentile, on the other hand, complements the geometric mean by providing a measure that reflects recurring shorter-term problems (e.g. sewer line breaks or spills).

Using these measures, the next step in the linkage analysis is to examine patterns at all 17 TMDL beach sites. Table 6-1 summarizes the geometric means associated with each duration curve zone for the RBMP monitoring sites in the project area. Table 6-2 provides a summary of the 90th percentiles for the same sites. This information was developed using all data regardless of season. Similar to the situation observed in Figure 6-1, the greatest values for each site occur under high flow conditions.

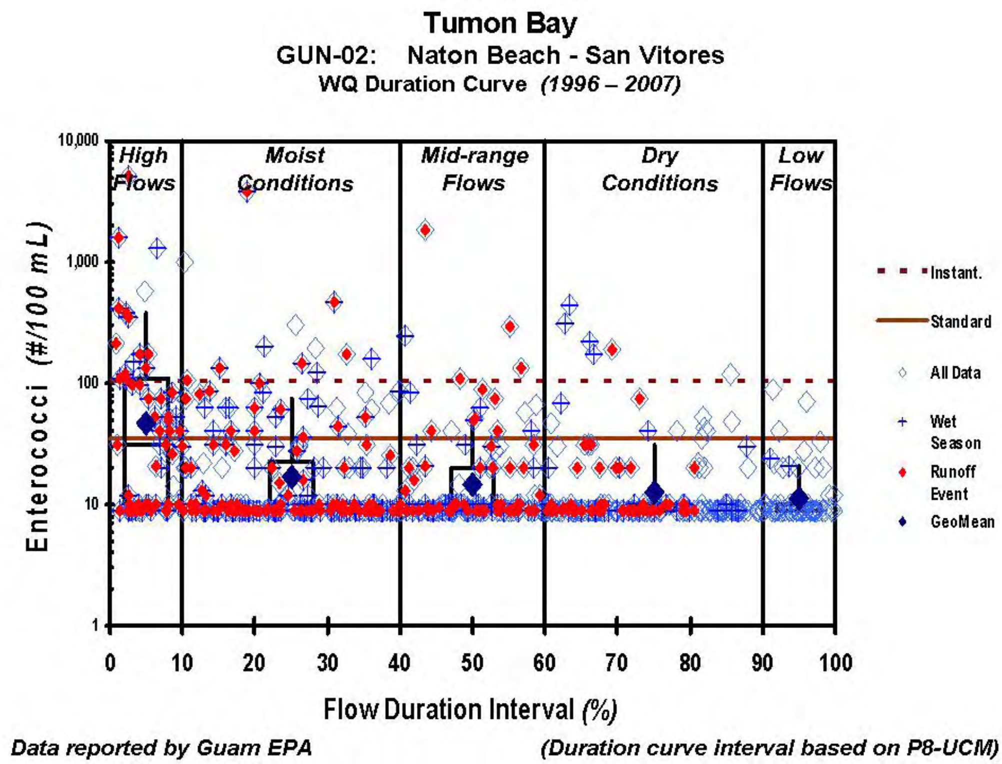

Figure 6-1. Water quality duration curve for San Vitores Beach site.

Table 6-1 enables a comparison of patterns between duration curve zones by site. It also highlights sites and duration curve zones that exceed Guam's geometric mean criteria (those cells are shaded). Similarly, Table 6-2 highlights sites and duration curve zones where the 90th percentile exceeds Guam's instantaneous maximum criteria.

Examining the geometric mean on a year round basis, for example, the majority of the exceedances occur in Hagåtña Bay during high flow conditions. This analysis identifies the area and conditions where bacteria sources have the most long-term, chronic effect. Efforts to achieve Northern Guam Beach TMDL targets based on the geometric mean should focus on storm water discharges to Hagåtña Bay.

In addition, the data indicates that storm water sources are also a concern in Tumon Bay. For instance, the geometric mean at Naton Beach (site GUN-02) under high flow conditions exceeds the 35 #/100 mL criteria. The Naton Beach concern becomes more evident when comparing the 90th percentile values against the instantaneous criteria *(*Table 6-2*)*.

Table 6-1. Northern Guam TMDL beach data summary *(Geometric Mean – year round)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	32	13	15	17	17
Tumon Bay	Gun	GUN-24	18	17	13	11	10
	Gognga	GUN-25	23	13	12	13	11
	Naton	GUN-02	46	17	15	13	11
		GUN-23	27	14	15	13	14
		GUN-03	27	15	15	12	12
		GUN-04	17	12	13	12	12
	Ypao	GUN-05	19	13	14	12	12
East Hagåtña Bay	Dungca's	GUN-06	57	17	15	14	13
		GUN-07	226	44	31	25	27
	Alupang Towers	GUN-26	129	28	21	24	12
	Trinchera	GUN-08	107	34	40	32	27
	Padre Palomo	GUN-09	102	28	21	16	14
West Hagåtña Bay	Hagåtña Channel	GUN-10	50	16	15	14	13
		GUN-11	96	23	19	22	18
		GUN-12	223	74	37	31	20
	Bayside Park	GUN-13	126	35	22	21	15

Note: Shaded cells indicate those zones where the geometric mean criterion was exceeded. This is indicative of potential long term, chronic problems under those conditions.

Table 6-2. Northern Guam TMDL beach data summary *(90th percentile – year round)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	133	31	51	64	69
Tumon Bay	Gun	GUN-24	86	79	50	10	10
	Gognga	GUN-25	91	37	20	31	19
	Naton	GUN-02	386	74	49	31	21
		GUN-23	212	56	74	47	21
		GUN-03	190	78	38	20	25
		GUN-04	52	30	30	24	20
	Ypao	GUN-05	109	38	41	24	31
East Hagåtña Bay	Dungca's	GUN-06	635	63	62	52	39
		GUN-07	4,611	522	352	205	205
	Alupang Towers	GUN-26	7,717	196	158	141	20
	Trinchera	GUN-08	933	249	325	299	154
	Padre Palomo	GUN-09	717	130	84	84	58
West Hagåtña Bay	Hagåtña Channel	GUN-10	560	69	73	48	40
		GUN-11	2,268	129	83	96	74
		GUN-12	1,802	1,687	370	171	87
	Bayside Park	GUN-13	1,681	266	84	150	46

Note: Shaded cells indicate those zones where the 90th percentile exceeded the instantaneous maximum criterion. This is indicative of recurring short term problems under those conditions.

6.1.2 Seasonal Patterns

Developing duration curve intervals based on P8-UCM also enables a closer look at factors, such as seasonality. This provides the opportunity to examine patterns that may be associated with other potential bacteria sources. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. Similar to the analysis of spatial patterns, the geometric mean and 90th percentile serve as the primary measures for examining seasonality. This is illustrated in Figure 6-2.

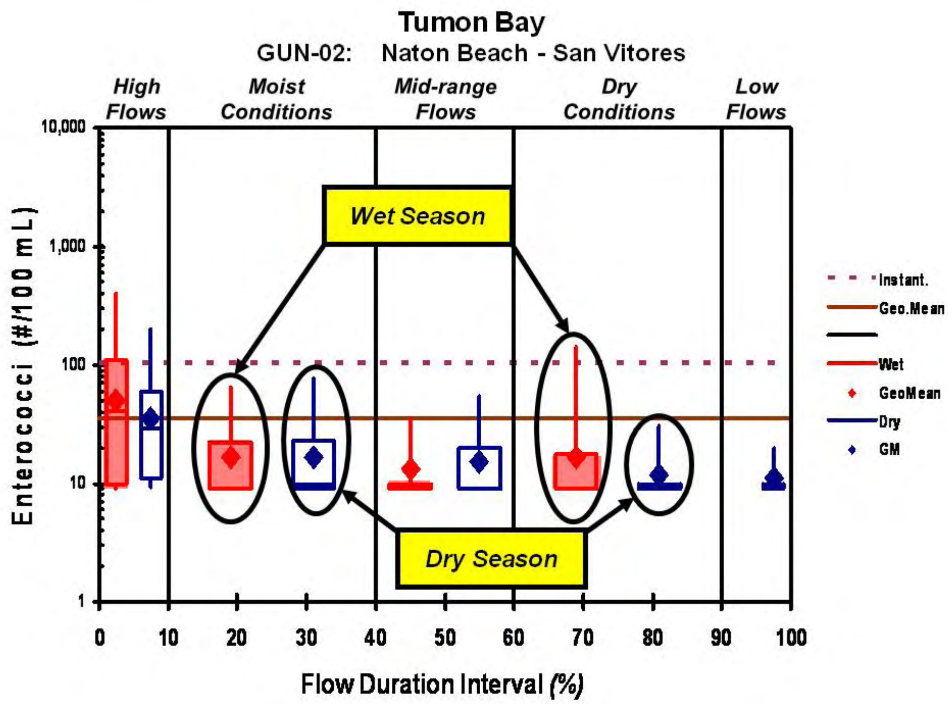

Figure 6-2. Wet versus dry season comparison for Naton Beach – San Vitores site.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. However, the wet season patterns under dry conditions indicate a concern relative to achieving the 90th percentile. Bacteria delivered under dry conditions are not typically associated with surface runoff from storm events. However, this could be the result of seepage from storm water ponds described in the source assessment.

The following tables summarize seasonality information for all RBMP sites.

Table 6-3. Northern Guam TMDL beach data summary *(Geometric Mean – dry season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	**45**	14	15	17	16
Tumon Bay	Gun	GUN-24		16	11	10	10
	Gognga	GUN-25		11	11	12	11
	Naton	GUN-02	**36**	17	15	12	11
		GUN-23	23	15	13	12	14
		GUN-03	21	18	15	12	12
		GUN-04	15	13	13	11	12
	Ypao	GUN-05	28	13	15	11	12
East Hagåtña Bay	Dungca's	GUN-06	**63**	18	16	13	13
		GUN-07	**348**	**44**	32	25	25
	Alupang Towers	GUN-26		27	21	22	12
	Trinchera	GUN-08	**141**	**42**	**41**	33	27
	Padre Palomo	GUN-09	**48**	24	19	14	13
West Hagåtña Bay	Hagåtña Channel	GUN-10	34	15	14	14	13
		GUN-11	**92**	19	19	21	17
		GUN-12	**268**	**72**	33	30	19
	Bayside Park	GUN-13	**191**	**37**	23	21	15

Note: Shaded cells indicate those zones where the geometric mean criterion was exceeded. This is indicative of potential long term, chronic problems under those conditions.

Table 6-4. Northern Guam TMDL beach data summary *(Geometric Mean – wet season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	28	13	15	15	
Tumon Bay	Gun	GUN-24	19	18	17	18	
	Gognga	GUN-25	24	15	14	25	
	Naton	GUN-02	**50**	17	13	16	
		GUN-23	29	14	18	21	
		GUN-03	29	14	15	15	
		GUN-04	18	12	13	16	
	Ypao	GUN-05	17	13	13	21	
East Hagåtña Bay	Dungca's	GUN-06	**55**	16	13	17	
		GUN-07	**198**	**44**	30	24	
	Alupang Towers	GUN-26	**96**	28	21	35	
	Trinchera	GUN-08	**99**	30	**37**	31	
	Padre Palomo	GUN-09	**129**	30	26	22	
West Hagåtña Bay	Hagåtña Channel	GUN-10	**56**	16	16	16	
		GUN-11	**98**	25	19	29	
		GUN-12	**210**	**76**	**44**	33	
	Bayside Park	GUN-13	**110**	34	20	20	

Note: Shaded cells indicate those zones where the geometric mean criterion was exceeded. This is indicative of potential long term, chronic problems under those conditions.

Table 6-5. Northern Guam TMDL beach data summary *(90th percentile – dry season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	205	37	48	64	68
Tumon Bay	Gun	GUN-24		19	19	10	10
	Gognga	GUN-25		19	10	26	19
	Naton	GUN-02	201	76	55	31	20
		GUN-23	227	59	33	20	21
		GUN-03	138	96	34	20	22
		GUN-04	29	33	31	20	20
	Ypao	GUN-05	511	41	54	20	31
East Hagåtña Bay	Dungca's	GUN-06	2,025	84	79	30	40
		GUN-07	5,676	354	313	164	182
	Alupang Towers	GUN-26		400	158	135	20
	Trinchera	GUN-08	985	264	334	325	157
	Padre Palomo	GUN-09	332	121	62	50	37
West Hagåtña Bay	Hagåtña Channel	GUN-10	199	48	40	32	37
		GUN-11	626	94	75	84	59
		GUN-12	1,490	1,447	368	178	71
	Bayside Park	GUN-13	1,613	243	85	145	48

Note: Shaded cells indicate those zones where the 90th percentile exceeded the instantaneous maximum criterion. This is indicative of recurring short term problems under those conditions.

Table 6-6. Northern Guam TMDL beach data summary *(90th percentile – wet season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	122	31	55	51	
Tumon Bay	Gun	GUN-24	88	86	118	91	
	Gognga	GUN-25	92	76	28	430	
	Naton	GUN-02	400	65	35	141	
		GUN-23	161	41	103	277	
		GUN-03	202	41	51	78	
		GUN-04	52	27	30	97	
	Ypao	GUN-05	72	31	35	175	
East Hagåtña Bay	Dungca's	GUN-06	543	55	37	115	
		GUN-07	1,487	576	353	212	
	Alupang Towers	GUN-26	4,896	135	132	218	
	Trinchera	GUN-08	879	235	273	159	
	Padre Palomo	GUN-09	1,273	133	130	195	
West Hagåtña Bay	Hagåtña Channel	GUN-10	717	99	77	93	
		GUN-11	2,325	158	83	187	
		GUN-12	3,582	1,695	361	145	
	Bayside Park	GUN-13	1,621	267	58	204	

Note: Shaded cells indicate those zones where the 90th percentile exceeded the instantaneous maximum criterion. This is indicative of recurring short term problems under those conditions.

6.2 Relationship to Other Indicators

Guam EPA's beach monitoring data can be combined with field observations of wind, tide, and water clarity conditions to examine patterns by duration curve zones. As part of the RBMP, Guam EPA staff noted field observations for several indicators that can be incorporated into the data analysis. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems. The intent is to make the greatest use of the ambient monitoring data in a way that can help identify potential solutions to beach closures.

Figure 6-3 provides a spatial summary of the presence or absence of turbidity information reported by Guam EPA staff. This shows the percent of time at a given location where turbidity was present at the time the bacteria sample was collected. As can be seen, there are certain areas where turbidity seemed more prevalent (e.g., N01: Tanguisson Beach, N02: San Vitores Beach, N12: Hagåtña Boat Basin)

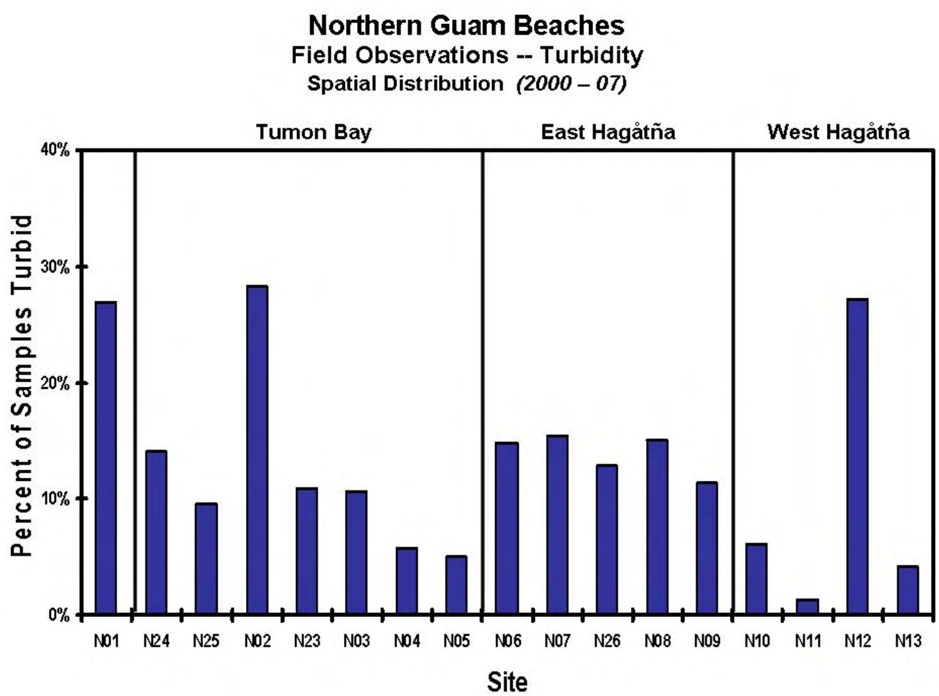

Figure 6-3. Spatial analysis of turbidity field observations during bacteria sampling events.

As an example, Figure 6-4 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. However, the effect of bacteria associated with resuspension of bottom sediments should also be considered as a possible source when wind and wave action could affect beach water quality. This potential effect could be examined by evaluating bacteria levels at other sites during similar conditions.

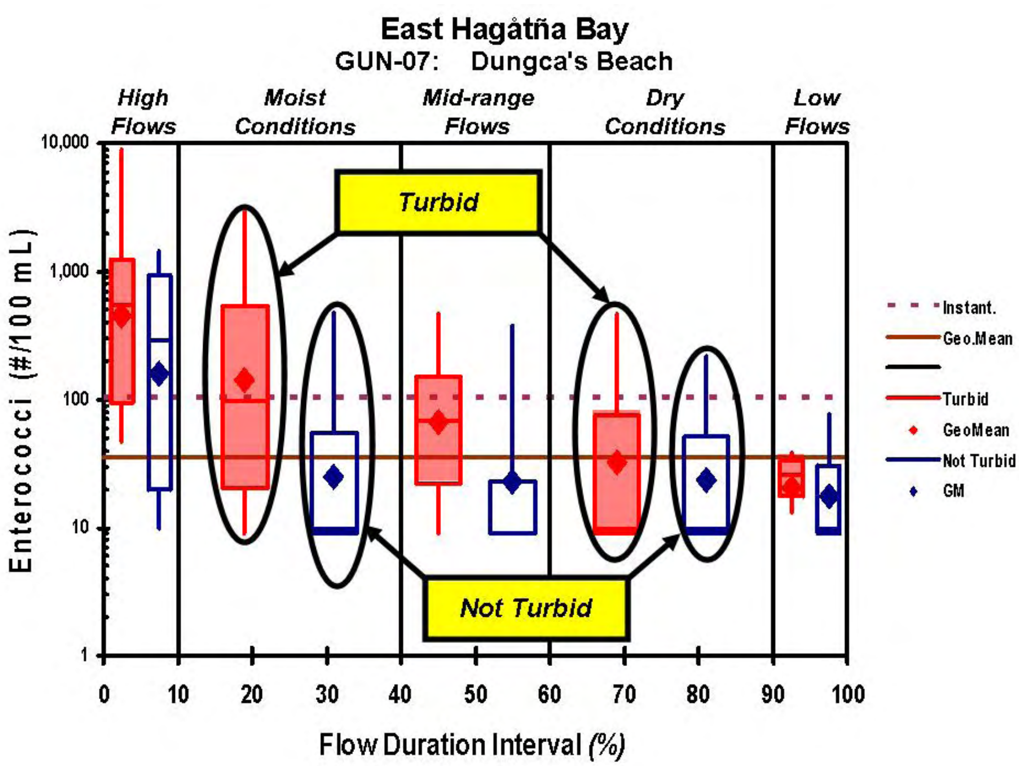

Figure 6-4. Turbid versus non-turbid sample comparison for Dungca’s Beach site.

7. TMDL Development

These TMDLs are designed to address bacteria impairments on seventeen water quality-limited segments located in the Guam's Northern Watershed. Section 303(d)(1)(C) of the Federal Clean Water Act requires that TMDLs must be *"… established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality"*.

Federal regulations provide further definition regarding the structure and content of Total Maximum Daily Loads. TMDLs are defined as the sum of the individual waste load allocations (WLAs), load allocations (LAs), and the margin of safety. TMDLs can be expressed in terms of *"… mass per time, toxicity, or other appropriate measure"* [40 CFR §130.2(i)]. WLAs are the portion of the receiving water's loading capacity allocated to existing or future point sources [40 CFR §130.2(h)]. LAs are the portion of the receiving water's loading capacity allocated to existing or future nonpoint sources or to natural background sources [40 CFR §130.2(g)]. Conceptually, this definition is denoted by the equation

$$\text{TMDL} = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + \text{MOS}$$

Under the current regulatory framework for development of TMDLs, calculation of the loading capacity for impaired segments identified on the §303(d) list is an important step. EPA's regulation defines loading capacity as *"the greatest amount of loading that a water can receive without violating water quality standards"*. The loading capacity provides a reference, which helps guide pollutant reduction efforts needed to bring a water into compliance with standards.

7.1 Options Considered

The loading capacity of the Northern Guam Beaches for enterococcus is the amount that can be assimilated in the listed segments without exceeding the water quality criteria. Based on USEPA protocols for TMDL development, as well as bacteria TMDLs established in other states and territories, several options were identified. These include:

- ✓ Load-based approach (mass per unit time)
- ✓ Concentration-based method
- ✓ Reference method with exceedance day frequencies
- ✓ Tidal prism method
- ✓ Concentration-based duration curve approach

The following factors were considered in reviewing each option and selecting a method for determining the loading capacity and allocation method:

- ✓ Ability of the method to adequately assess the loading capacity
- ✓ Availability of adequate data to apply to the method
- ✓ Ability of the method to account for seasonal variation
- ✓ Degree of uncertainty associated with the method
- ✓ Ease of determining compliance
- ✓ Equity of the methodology

7.1.1 Load-Based Approach (mass per unit time)

A load-based approach is defined in terms of a mass per unit time. For bacteria TMDLs, the most common expression of loading capacity using this approach is counts per day. Determination of a load-based approach requires an estimate of the volume of water or the amount of flow available to assimilate the pollutant load. For a pollutant in a typical river or stream, where flow is only in one direction, the loading capacity, or allowable loading over a given time interval, is determined by calculating the product of flow rate, the water quality criterion concentration (e.g. 35 counts per 100 mL), and a unit conversion factor.

For hydrologically complex waters, such as coastal beaches, several challenges exist relative to the load-based approach. First, there is a high degree of uncertainty in estimating loads associated with determining the appropriate receiving water volumes at each beach location. In addition, flow is in more than one direction due to effects of tides, which also adds to the uncertainty in identifying a loading capacity for each listed segment. Finally, determining compliance with these TMDLs would not be a simple task because of the amount of information needed to determine loads associated with each sample event.

7.1.2 Concentration-Based Method

Another common approach used for development of bacteria TMDLs is the concentration-based method. Basically, the loading capacity is defined in terms of maximum allowable concentrations. For the Northern Beaches, TMDLs using this method would be based on simply attaining the enterococcus concentrations defined in Guam's water quality standards. In other words, enterococcus concentrations must not exceed Guam's water quality criteria in order to meet the TMDLs.

This approach addresses most of the factors being considered. Because the loading capacity is equivalent to the numeric criteria, evaluating compliance with the TMDLs is straightforward. There is also adequate data to apply the method. The only uncertainties are those associated with the monitoring program itself.

Although seasonal variation is accounted for implicitly, a concentration-based approach adds only limited value to relating TMDL targets to those conditions of greatest concern (e.g., wet-weather versus dry-weather). For this reason, it is often difficult to connect concentration-based TMDLs with implementation programs needed to solve water quality problems.

7.1.3 Reference Method with Exceedance Day Frequencies

The State of California has utilized an *"exceedance day frequency"* to identify loading capacity targets for several beach TMDLs. The focus of this approach recognizes that under certain conditions, natural background loads exert a major effect on water quality criteria violations. Numeric targets are expressed as allowable exceedance days of the single sample criteria. Allowable exceedance days are based on an analysis of conditions at a reference site.

Advantages of the method include ease of determining compliance. The approach used in California also accounts for seasonal variation by identifying different summer and winter targets. The approach basically allows for exceptions under which the single sample criteria may be exceeded. Data from reference beaches are needed that describe situations where natural conditions are the only sources. In the case of the Northern Guam Beaches, each site included in these TMDLs is affected by some potential anthropogenic source. Furthermore, the method does not account for the 30-day geometric mean component of the water quality standards. A separate analysis is needed to demonstrate that the geometric mean criteria will also be achieved using and *"exceedance day frequency"* approach.

7.1.4 Tidal Prism Method

The tidal prism approach used to develop TMDLs for recreational beaches in the U.S. Virgin Islands. This concept behind the tidal prism method centers on that amount of water moved in and out of an impaired segment between ebb and flood tides. This provides an estimate of volume per unit time, which enables a loading calculation. The method then uses load estimates from land-based sources to develop components of the TMDLs (e.g., loading capacities and allocations). In short, the tidal prism method estimates the volume of the segment, and then adjusts for tidal flushing, freshwater inflow, and bacteria loads to the waterbody.

The major advantage of this method is that targets are expressed as loads; consistent with the strict statutory definition of a TMDL. However, disadvantages are quite similar to those associated with a load-based approach. Most notably, the need for additional data, uncertainties associated with developing load estimates, and difficulties related to determining compliance.

7.1.5 Concentration-Based Duration Curve Method

This approach is a variation of the concentration-based method. Again, the loading capacity is defined in terms of attaining the maximum allowable enterococcus concentrations simply defined in Guam's water quality standards. In addition, TMDL targets are expressed in terms of flow conditions using either stream gage data or model estimates (as described earlier in the data analysis section). These flow estimates can be used to identify whether elevated bacteria levels occur during rainfall events (and are likely watershed-driven) or during dry conditions.

The advantage of this approach is that both seasonal and flow variations are explicitly considered. This addresses one of the disadvantages of the plain concentration-based approach (i.e., conditions of concern are explicitly identified). There is no uncertainty in the calculation of loading capacities (again, simply the water quality criteria concentrations).

7.1.6 Selected Approach

The approach used to develop these Northern Guam Beaches bacteria TMDLs is the concentration-based duration curve method. The framework provides a way to assess the loading capacity because it is derived directly from Guam's water quality criteria. In addition, the method takes full advantage of Guam's RBMP information, using the data to examine patterns associated with flow conditions. The approach also accounts for seasonal variation and determining compliance with the TMDLs is relatively straightforward. There is equity in the method in that all sources are expected to meet the concentration-based targets.

Finally, the concentration-based duration curve method supports a meaningful transition into implementation programs. Because water quality data is used to examine flow-related patterns, monitoring information can be used to determine source areas and delivery mechanisms associated with these different conditions. This, in turn, can be used to identify those actions most likely needed to address water quality problems.

7.2 TMDL Components

Table 7-1 presents an example TMDL for one of the beach locations, identifying the loading capacity and allocations. These concentration-based values apply across all flow zones.

Table 7-1. Northern Guam Watershed TMDL summary *(Site GUN-01: Tanguisson Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

7.3 Margin of Safety

The Clean Water Act requires that each TMDL be established with a margin of safety. The statutory requirement that TMDLs incorporate a margin of safety is intended to account for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS also accounts for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality.

A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDLs (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions). The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, WLAs, and LAs. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. The MOS may also be a combination of both.

These TMDLs use an implicit MOS, through inclusion of two conservative assumptions. First, the TMDLs do not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur. In addition, the concentration criteria accounts for seasonal variations and critical conditions.

8. Individual Beach Assessments and TMDLs

An important part of the transition from TMDL targets to program implementation is information derived from site-specific analyses. In particular, an in-depth evaluation of monitoring data relative to potential sources that may affect water quality at each station adds value to the overall process. Individual beach assessments can be used to guide development of strategies that address documented problems.

The purpose of this section is to present a beach-by-beach analysis and the TMDL for each location. Connections between observed water quality patterns, factors that affect each site, and potential solutions are highlighted. Figure 8-1 displays the Northern Guam Beach TMDL project area. Each of the seventeen monitoring sites is identified in relation to key bays, notably Tumon and Hagåtña.

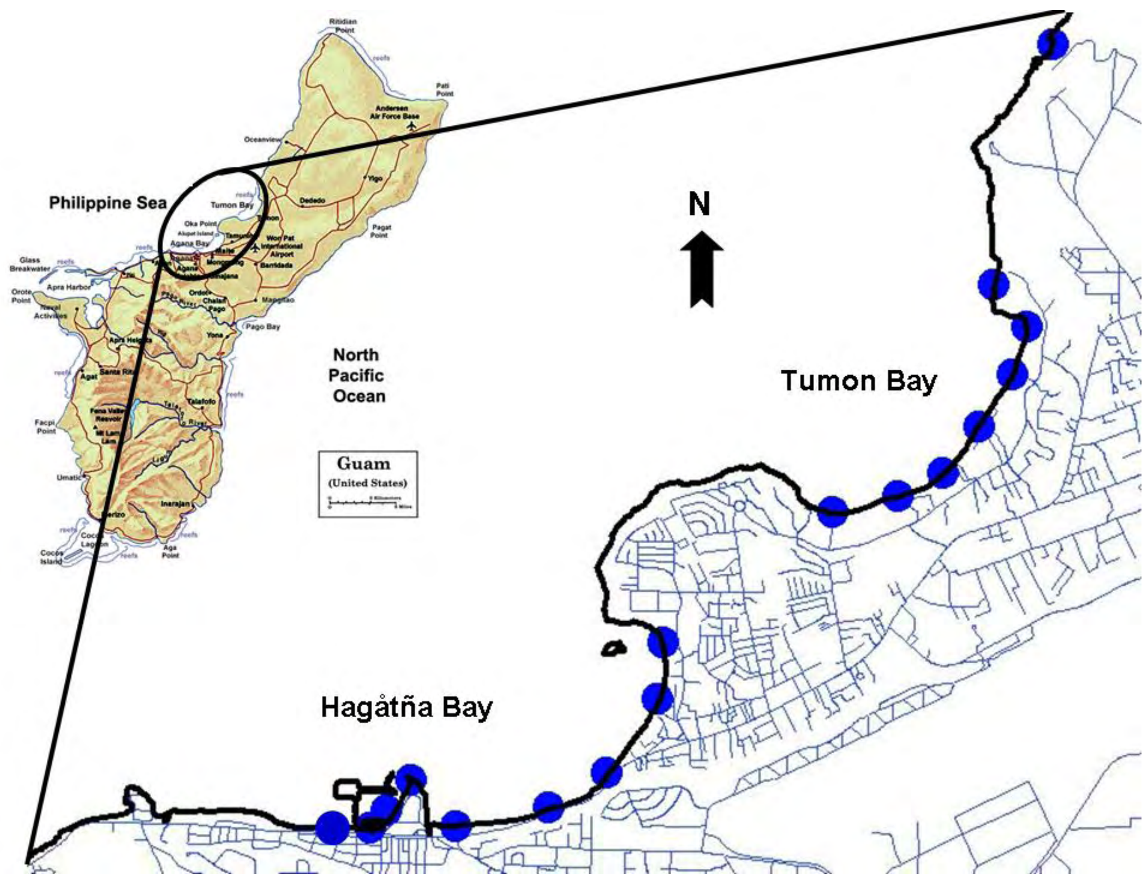

Figure 8-1. Location of monitoring sites in the Northern Guam Beach TMDL project area.

Individual assessments provides brief background material on each beach including a longitudinal graph, which highlights bacteria levels at that site compared to other project area monitoring stations. Summary graphs are presented using monitoring data to examine patterns. Information is related to potential sources through the use of additional maps. Table 8-1 summarizes the list of GIS coverages provided by Guam EPA that were considered in developing individual beach assessments.

Table 8-1. Geographic Information System data layers considered in individual beach assessments.

Data Category	Description
Coast	*Guam coast line*
Contours	*Elevation contours (10 meter intervals) used to characterize topography*
Beach TMDL Sites	*Location of Recreational Beach Monitoring Program stations*
WWTP	*GWA Waste Water Treatment Plant locations*
Marinas	*Location of Guam marinas under jurisdiction of Port Authority of Guam*
Streets	*Streets mapped in GEPA data base as of October 2008*
Buildings	*Buildings identified in GEPA data base as of June 2006*
Sewered Buildings	*Buildings in data base identified as connected to sewer*
Non-sewered Buildings	*Buildings in data base identified as not connected to sewer*
Main Sewer	*Main sewer lines under jurisdiction of Guam Waterworks Authority (GWA)*
Lateral Sewer	*Lateral sewer lines identified by GWA*
Pump Station	*Location of GWA sewer pump / lift stations*
Fittings	*Loaction of GWA sewer fittings*
Manhole	*Sewer manholes*
SIA Ponding Basins	*Surface Impoundment Areas identified by Guam Dept. of Public Works*

8.1 Tanguisson Beach (GUN-01)

Tanguisson Beach is the northernmost beach in the TMDL project area *(Figure 8-2)*. Relative to the other sites, it is fairly isolated. Access is through Tanguisson Park, and the beach itself is situated behind the Tanguisson Power Plant. Although less frequently visited by bathers compared to the other beaches, the location is used for fishing.

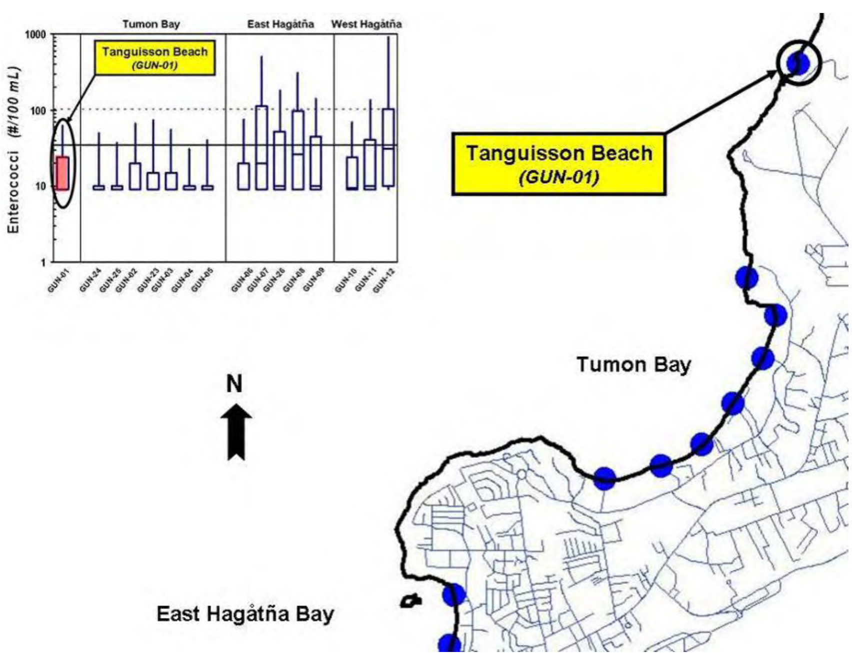

Figure 8-2. Location of Tanguisson Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Tanguisson Beach between 1997 and 2007 was low (10%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Tanguisson Beach were basically in the same range as other project area monitoring stations *(Figure 4-2 and Figure 8-2)*. The geometric mean of all individual samples was 16 counts /100mL, while the 75th and 90th percentiles were 24 and 63 counts /100 mL respectively. Although bacteria concentrations are lower than other RBMP sites, this beach is still impaired. Water quality improvements are clearly needed, though they will not be as significant as those required at other project area locations.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-3 shows the seasonal variability of bacteria concentrations at Tanguisson Beach. The highest concentrations were observed between January and April, indicating the importance of dry season sources at Tanguisson Beach.

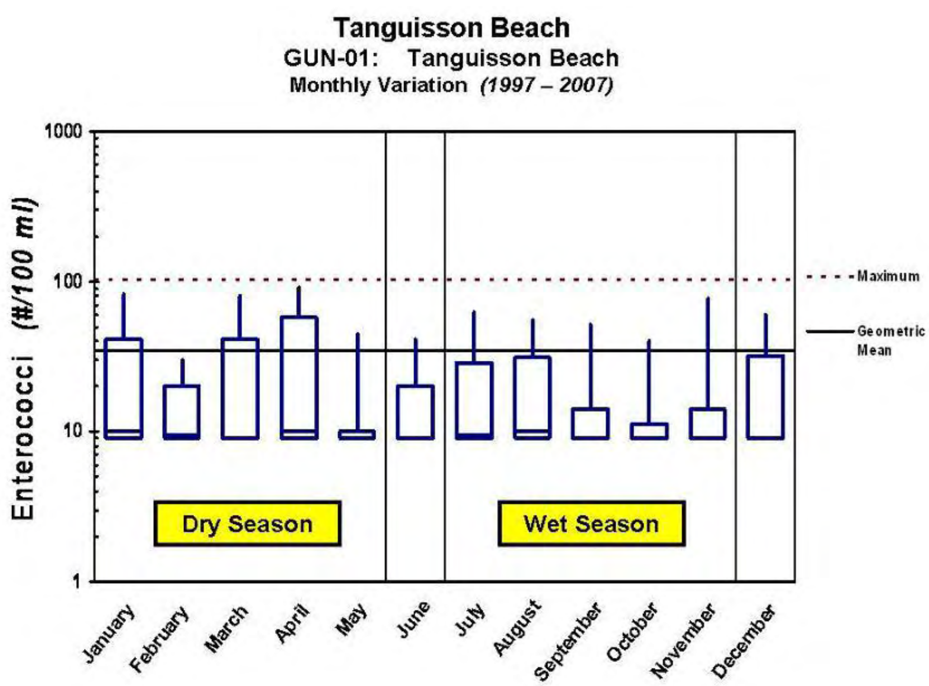

Figure 8-3. Seasonal variation at Tanguisson Beach.

<u>Effect of Flow Conditions</u>. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-4 shows enterococci monitoring data collected at Tanguisson Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-4, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is slightly higher than that observed at other Northern Guam RBMP sites. However, the 90th percentile exceeds the instantaneous maximum criterion in the high flow zone. This indicates that sources associated with periodic short term problems (e.g., sewer overflows during heavy rains) may be a concern under these conditions.

One interesting observation at Tanguisson Beach is the increase in bacteria concentrations moving across from the moist condition zone to the low flow zone. This pattern is often indicative of the influence of point source loads. This is again consistent with seasonal patterns noted earlier relative to the potential effect of the Northern District WWTP at Tanguisson Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-5.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. One interesting observation is the higher bacteria concentrations during the dry season across the moist, mid-range, and dry zones. As mentioned above, this is likely due to the effect of the Northern District WWTP which would tend to be more pronounced when wet weather sources are less of a concern.

<u>Relationship to Other Indicators</u>. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

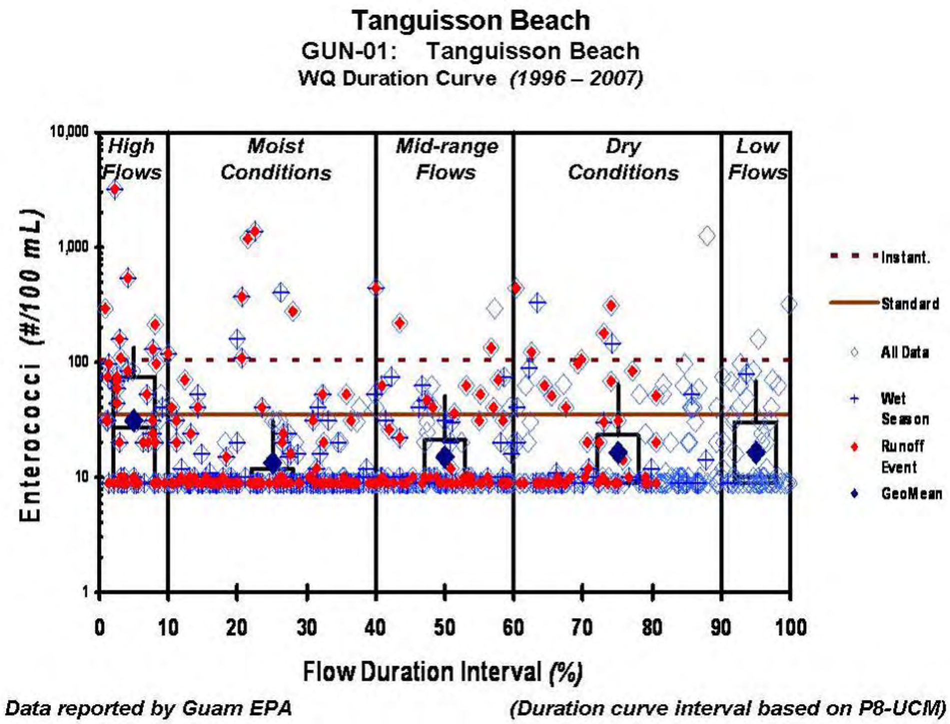

Figure 8-4. Water quality duration curve for Tanguisson Beach site.

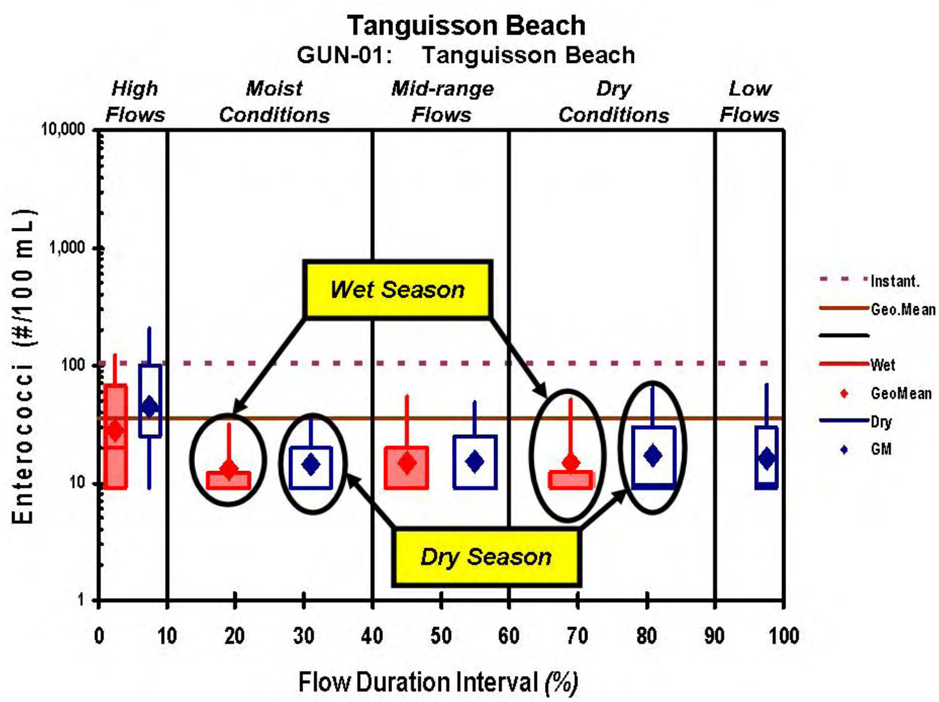

Figure 8-5. Wet versus dry season comparison for Tanguisson Beach.

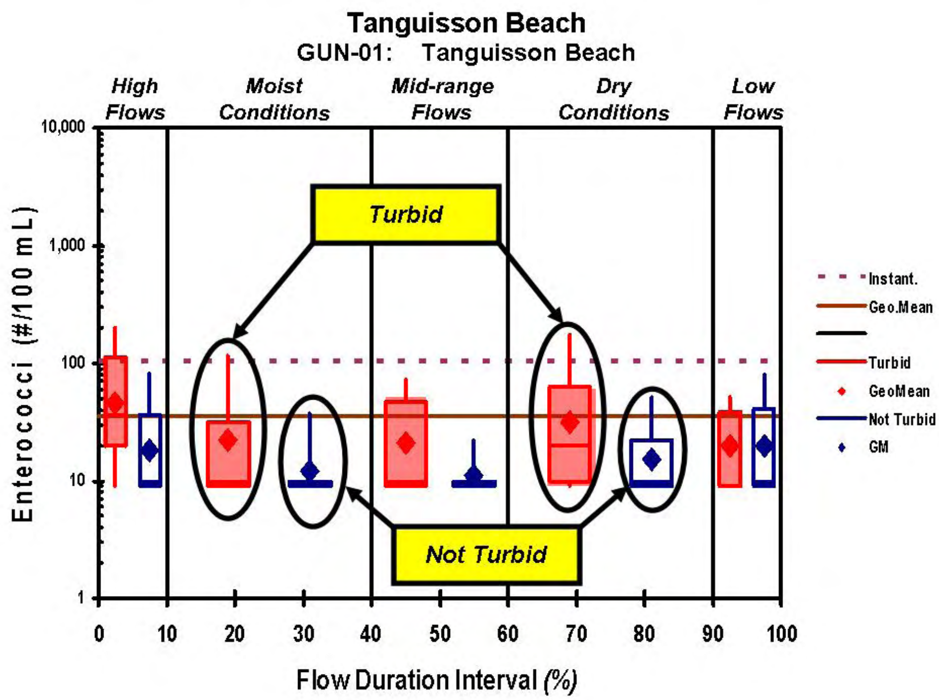

Figure 8-6. Turbid versus non-turbid sample comparison for Tanguisson Beach site.

Figure 8-6 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

<u>Potential Sources</u>. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Tanguisson Beach. Included are wastewater sources (septic systems, SSO, WWTP, GPA Power Plant), storm water runoff, and other sources (squatters, wildlife, debris and bottom deposits, atmospheric deposition). In addition, GEPA staff identified specific potential sources that could affect water quality at Tanguisson Beach *(Table 8-2)*.

Figure 8-7 provides a closer look at the Tanguisson Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. For example, roads can provide a general indication of the urban drainage network and accompanying storm drains.

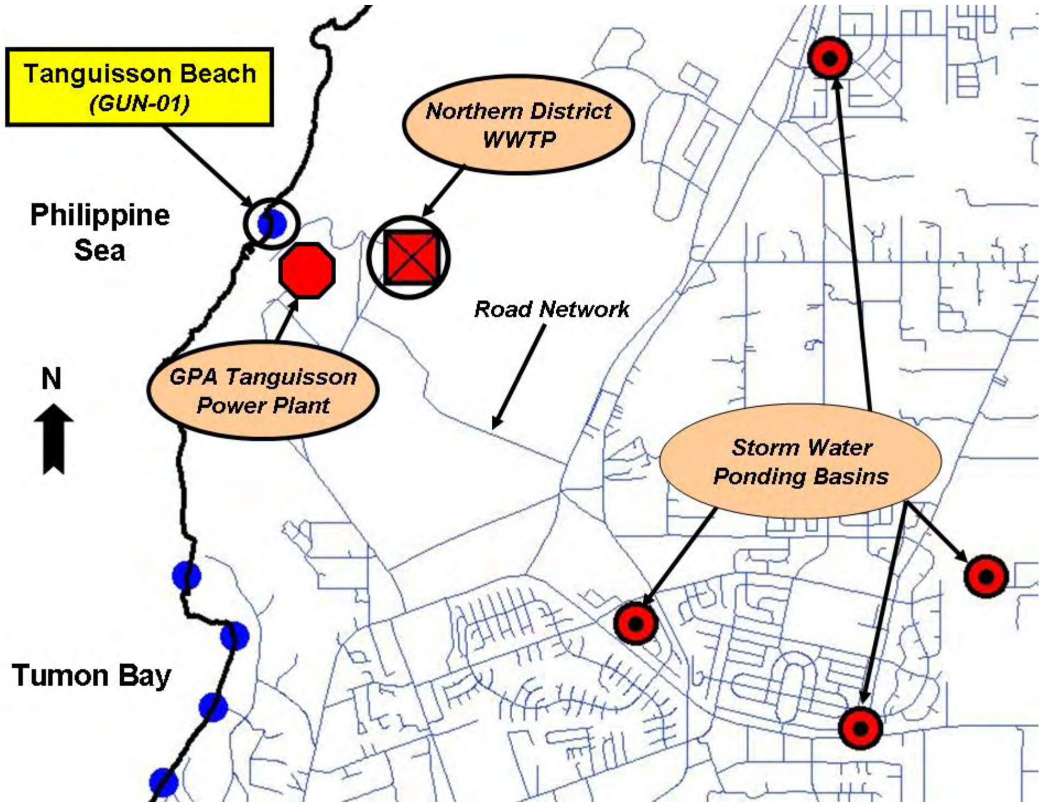

Figure 8-7. Location of Tanguisson Beach relative to potential source areas.

Table 8-2. Beach specific potential source summary *(Site GUN-01: Tanguisson Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-01	Wastewater	GWA Northern District WWTP Sewage outfall
		GWA Northern District (new) WWTP outfall
	Cooling water	GPA Tanguisson outfall
	Squatters	Squatters

Figure 8-8 shows unsewered buildings in the upland area adjacent to Tanguisson Beach. Sewer line blockages and breaks, as well as SSOs, could also contribute to elevated bacteria levels. Figure 8-8 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-9 shows an air photo of the area adjacent to Tanguisson Beach. This provides a different perspective, which highlights the remoteness of Tanguisson Beach in comparison to other project area monitoring locations.

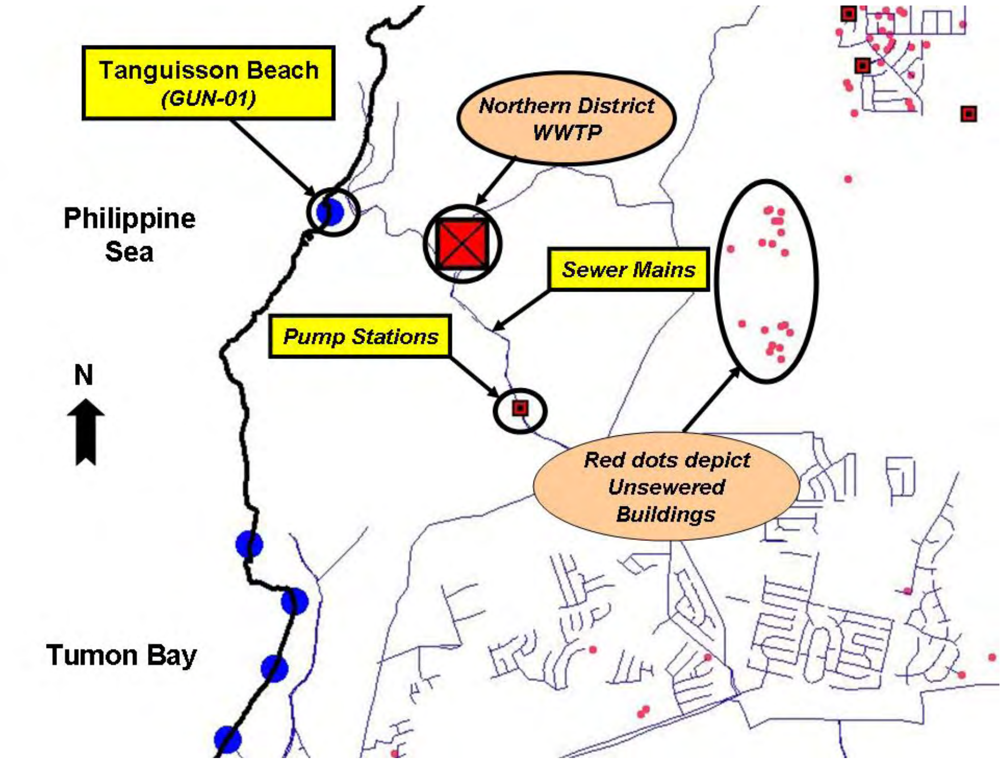

Figure 8-8. Location of Tanguisson Beach relative to potential unsewered buildings.

Figure 8-9. Air photo of Tanguisson Beach vicinity.

This beach is at a relatively remote location, is situated within a park, and has a low population density. For this reason, the influence of storm water runoff and septic tanks is not expected to be as dominant as at other sites. The major source of concern at Tanguisson Beach is the Northern District WWTP. This point source would tend to exert a greater influence during the dry season, consistent with the observations noted on Figure 8-4 and Figure 8-5.

Trends. Figure 8-10 presents a year-by-year summary of the enterococcus data for the Tanguisson Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

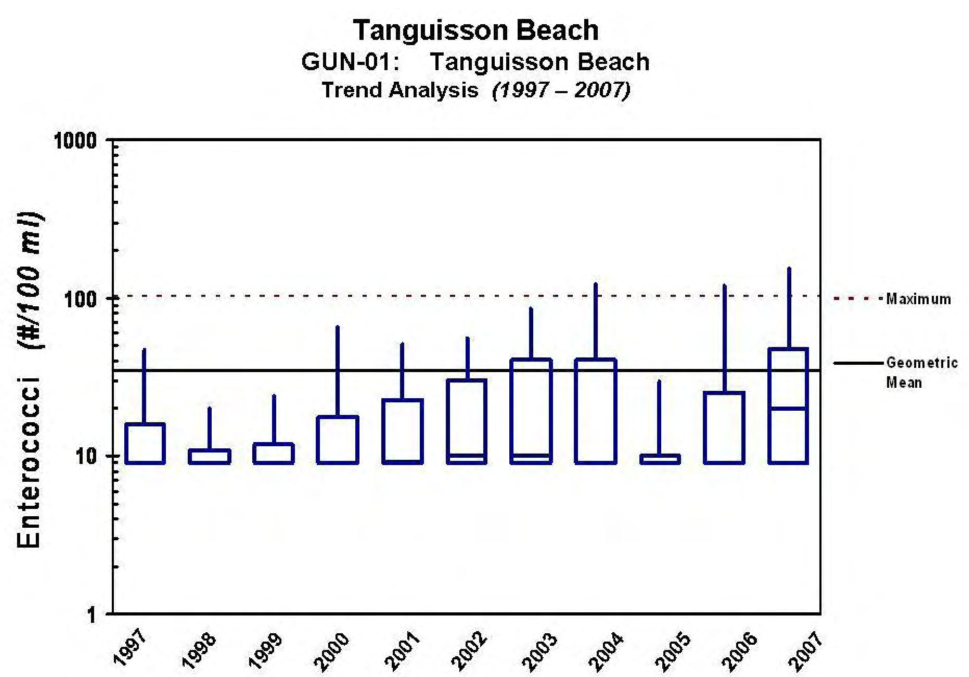

Figure 8-10. Trend analysis for Tanguisson Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Tanguisson Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between January and April, indicating the importance of dry season sources at Tanguisson Beach. This is consistent with the presence of point source loads identified at this location.

The connection between storm water sources and exceedances of numeric targets is also confirmed by examining the effect of flow conditions. At Tanguisson Beach, the highest bacteria concentrations occur under high flows. In short, the technical analyses presented in this assessment of Tanguisson Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-3 presents the TMDL for Tanguisson Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-3. Northern Guam Watershed TMDL summary *(Site GUN-01: Tanguisson Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-4 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-4. Needed reductions to meet TMDL targets *(Site GUN-01: Tanguisson Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	22%	---	---	---	---
Based on instantaneous maximum	49%	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	15%	---	---	---	---

8.2 Gun Beach (GUN-24)

Gun Beach is located on the northern most point of Tumon Bay past the last hotel *(Figure 8-11)*. Relative to the other sites on Tumon Bay, it is fairly isolated being located at the end of the road. It is named for the anti-aircraft gun found next to the cliff wall at the northern end of the beach. Relative to most other beaches in the project area, Gun Beach is fairly secluded.

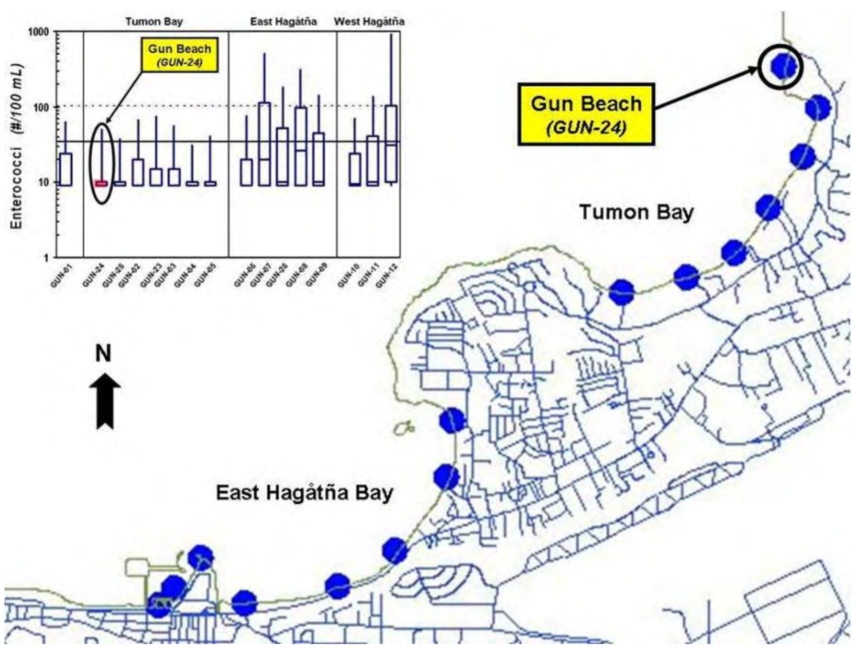

Figure 8-11. Location of Gun Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Gun Beach between 2005 and 2007 was low (10%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Gun Beach were among the lowest of all project area monitoring stations *(Figure 4-2 and Figure 8-11)*. The geometric mean of all individual samples was 13 counts /100mL, while the 75th and 90th percentiles were 10 and 50 counts /100 mL respectively. Although bacteria concentrations are lower than other RBMP sites, this beach is still impaired. Water quality improvements are clearly needed, though they will not be as significant as those required at other project area locations.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-12 shows the seasonal variability of bacteria concentrations at Gun Beach. The highest concentrations were observed between July and October, indicating the importance of wet season sources at Gun Beach.

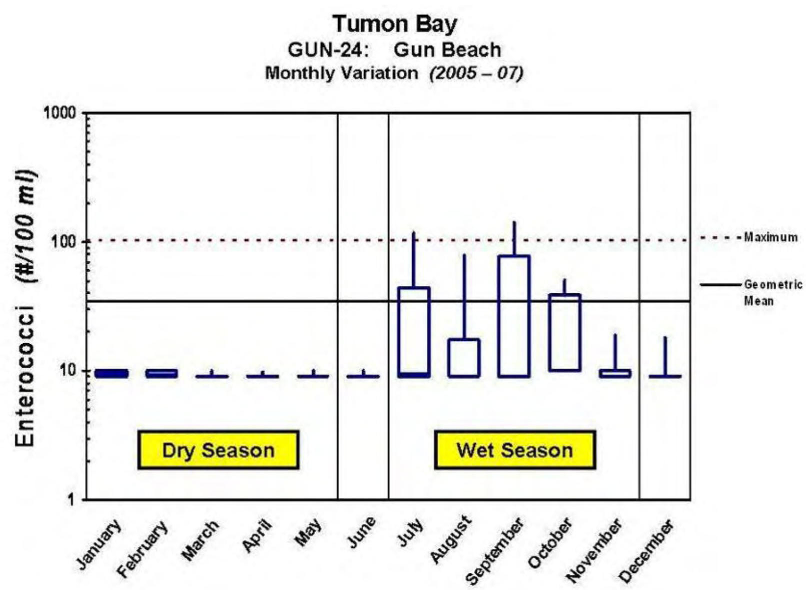

Figure 8-12. Seasonal variation at Gun Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-13 shows enterococci monitoring data collected at Gun Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-13, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during

heavy rainfall events. The magnitude of the increase appears to be lower than that observed at other Northern Guam RBMP sites.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-14.

As noted earlier *(Figure 8-3)*, dry season bacteria concentrations observed at Gun Beach are extremely low. This pattern is consistent across all flow zones. However, Figure 8-14 shows that during the wet season, measured values are at comparable levels in the high, moist, mid-range, and dry zones. This seems to indicate that seeps connected to storm water sources may be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

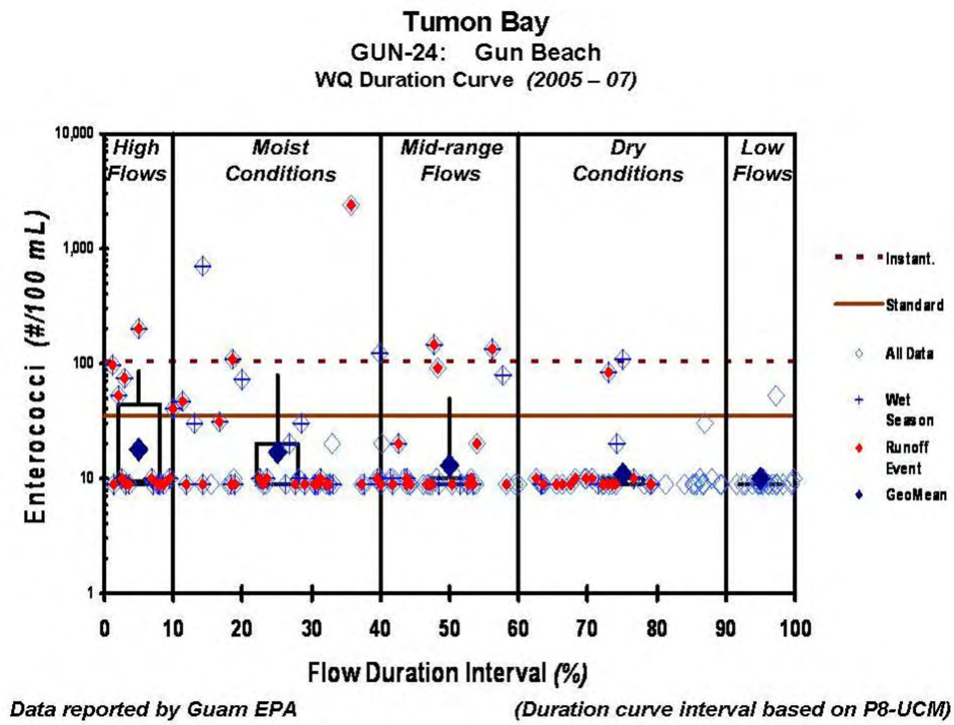

Figure 8-13. Water quality duration curve for Gun Beach site.

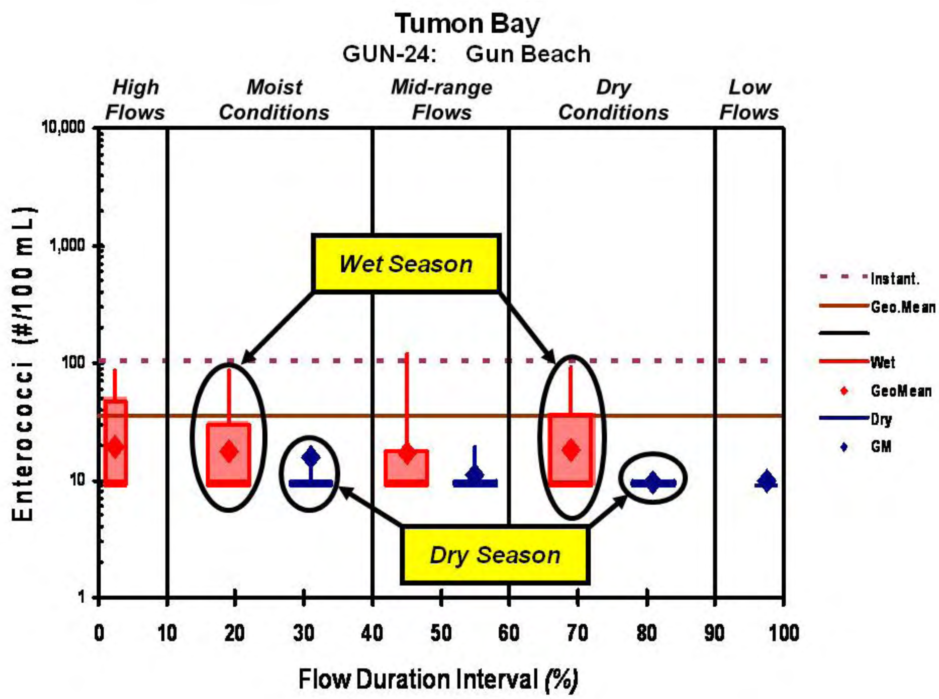

Figure 8-14. Wet versus dry season comparison for Gun Beach.

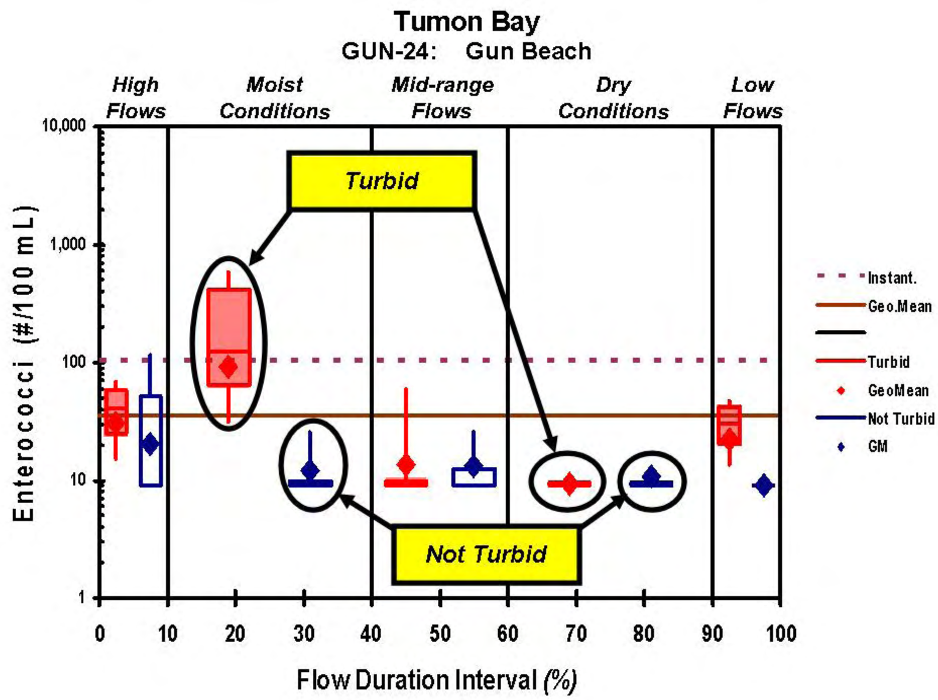

Figure 8-15. Turbid versus non-turbid sample comparison for Gun Beach site.

Figure 8-15 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high and moist conditions likely reflect the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Gun Beach. Included are wastewater sources (septic systems), storm water (overland runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Gun Beach *(Table 8-5)*.

Figure 8-16 provides a closer look at the Gun Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-16 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-16 also identifies major storm water ponding basins, including the Harmon Sink.

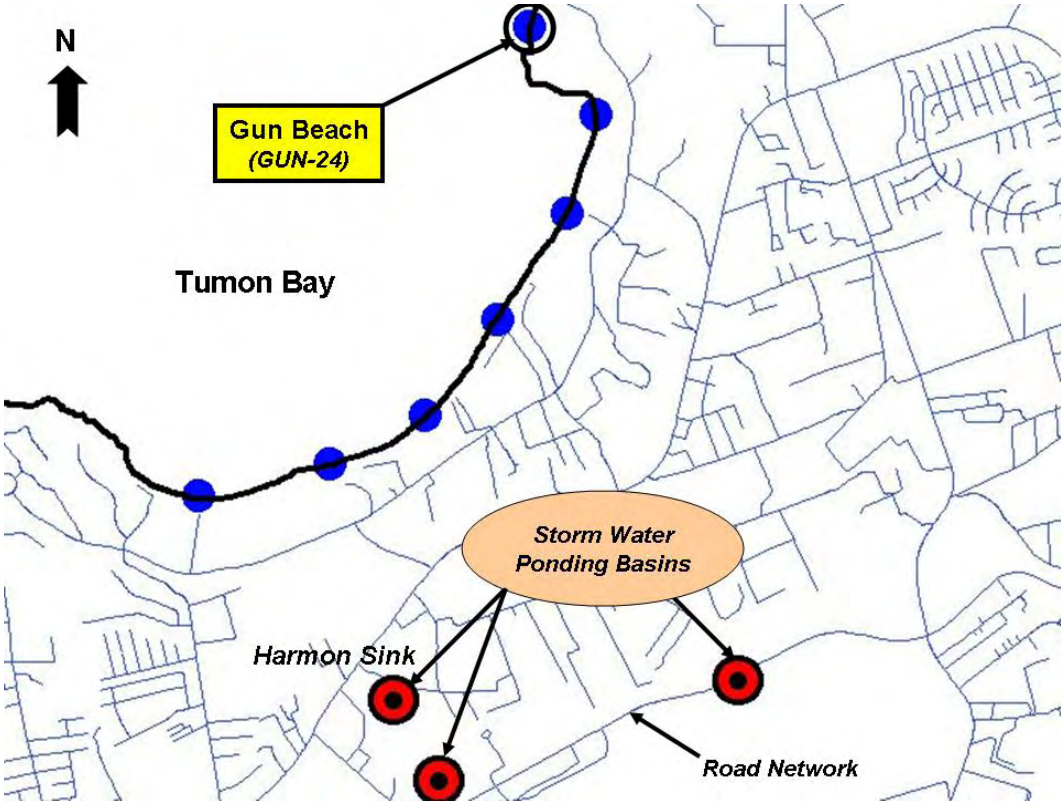

Figure 8-16. Location of Gun Beach relative to potential source areas.

Table 8-5. Beach specific potential source summary *(Site GUN-24: Gun Beach)*.

Site ID	Type	Source Name ***(notes)***
GUN-24	Storm drain runoff	Ponding Basin (possibly natural) *Low depression in natural topology results in runoff ponding area.*
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Sewage overflow	Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Gun Beach. This information is shown in Figure 8-17. Sewer line blockages and breaks, as well as SSOs, could also contribute to elevated bacteria levels. Figure 8-17 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

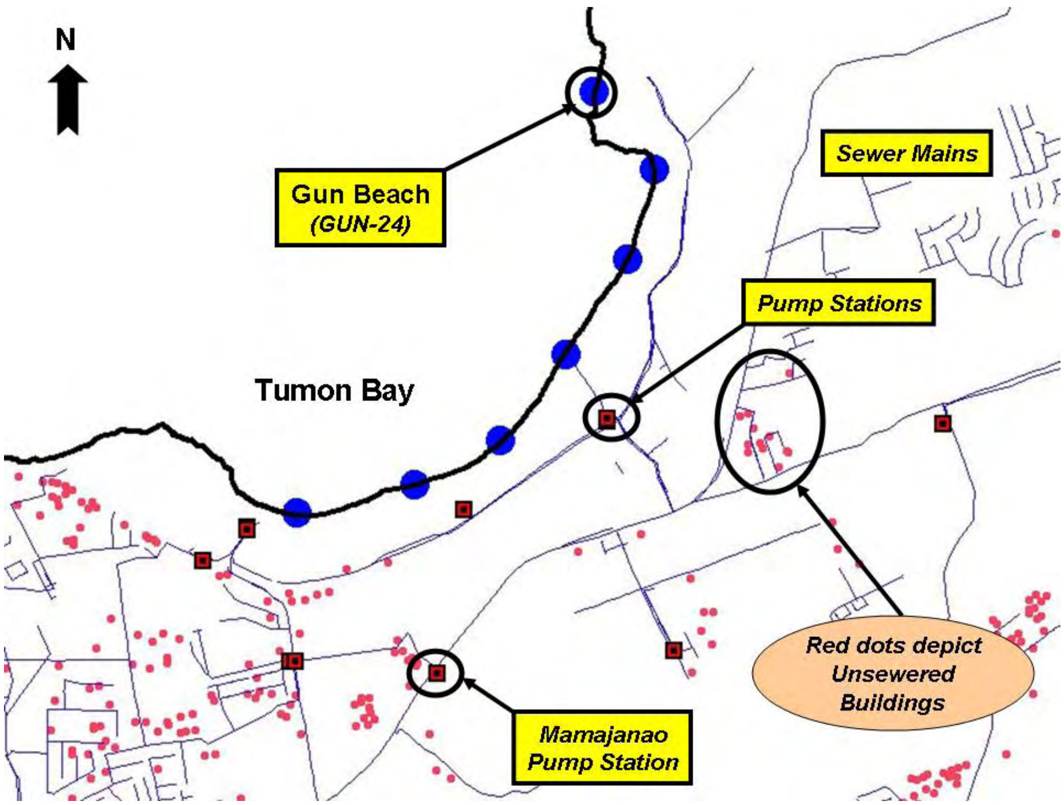

Figure 8-17. Location of Gun Beach relative to potential unsewered buildings.

Figure 8-18 shows an air photo of the area adjacent to Gun Beach. This provides a different perspective, which highlights the secluded nature of Gun Beach in comparison to other project area monitoring locations.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Gun Beach. Specifically, there is a low depression in natural topology in the immediate vicinity. This feature could result in a runoff ponding area that may collect storm drain runoff.

Figure 8-18. Air photo of Gun Beach vicinity.

Trends. Figure 8-19 presents a year-by-year summary of the enterococcus data for the Gun Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Gun Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and October, indicating the importance of wet season sources at Gun Beach. This is consistent with the presence of potential storm water sources identified at this location.

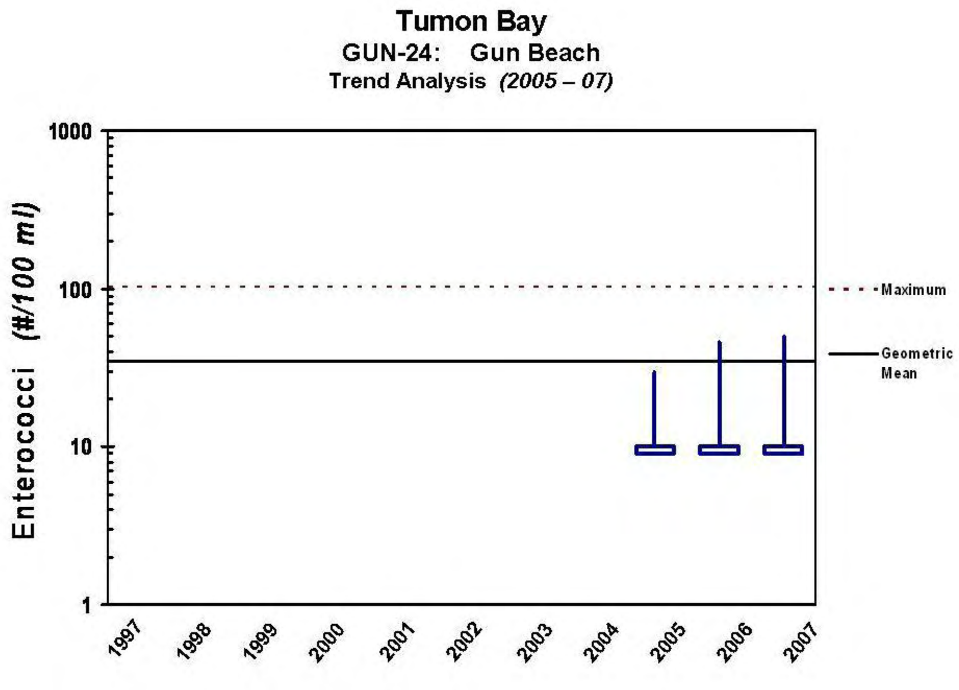

Figure 8-19. Trend analysis for Gun Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Gun Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Gun Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-6 presents the TMDL for Gun Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-6. Northern Guam Watershed TMDL summary *(Site GUN-24: Gun Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-7 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-7. Needed reductions to meet TMDL targets *(Site GUN-24: Gun Beach)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	---	12%	---	---

8.3 North San Vitores / Okura Beach (GUN-25)

North San Vitores / Okura Beach (also known as Gognga Beach) is one of several beaches located on Tumon Bay *(Figure 8-20)*. It is situated at the northern end of the bay, adjacent to the Aurora Resort. All of Tumon Bay is protected by a natural reef that stretches out about one mile from the beach shore. This portion of the project area is highly used for swimming, wind-surfing, snorkeling, kayaking and other popular water activities.

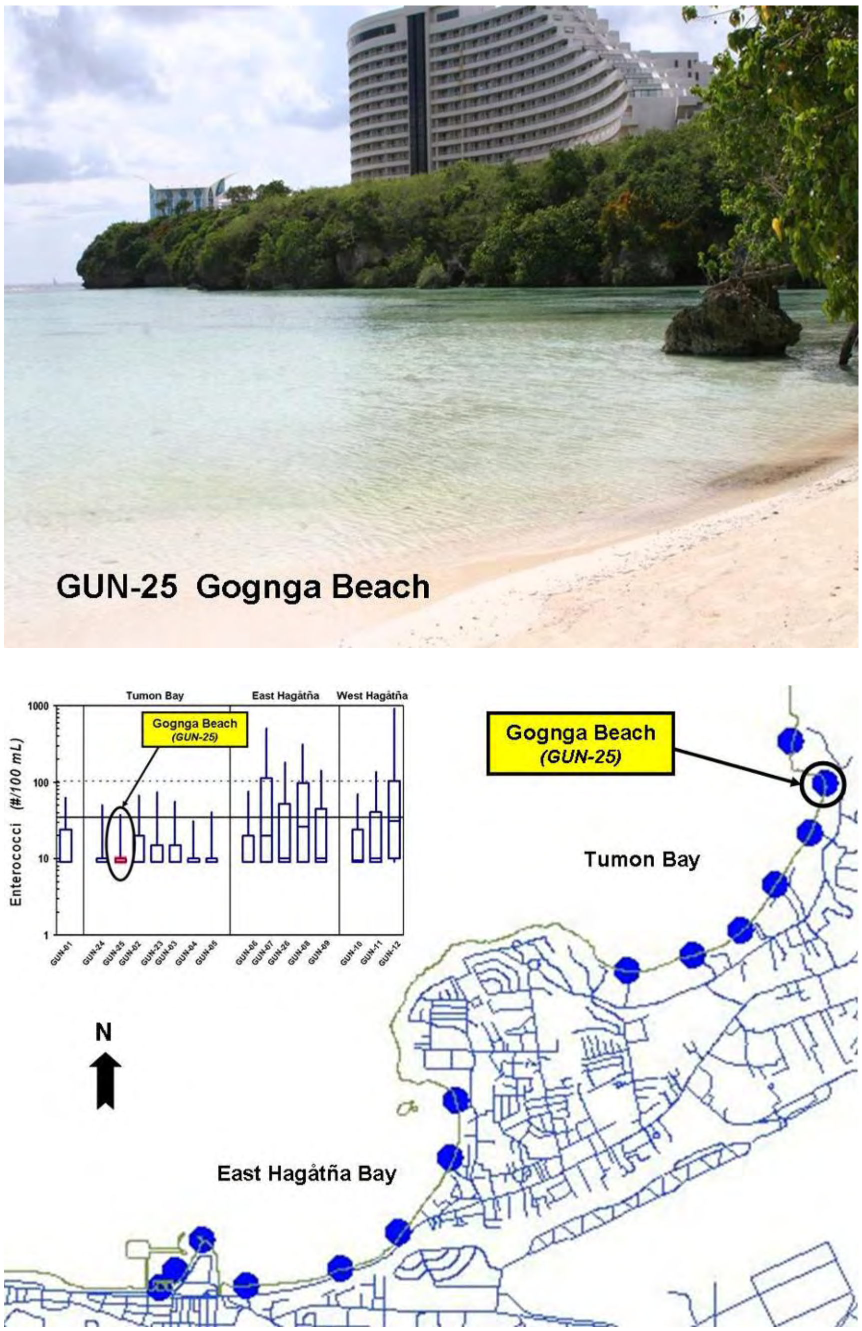

Figure 8-20. Location of North San Vitores / Okura Beach relative to other Northern Guam sites.

The frequency of beach advisories at North San Vitores / Okura Beach between 2005 and 2007 was low (7%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at North San Vitores / Okura Beach were among the lowest of all project area monitoring stations *(Figure 4-2 and Figure 8-20)*. The geometric mean of all individual samples was 13 counts /100mL, while the 75th and 90th percentiles were 10 and 37 counts /100 mL respectively.

Although bacteria concentrations are lower than other RBMP sites, this beach is still impaired. Water quality improvements are clearly needed, though they will not be as significant as those required at other project area locations.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-21 shows the seasonal variability of bacteria concentrations at North San Vitores / Okura Beach. The highest concentrations were observed between July and October, indicating the importance of wet season sources at North San Vitores / Okura Beach.

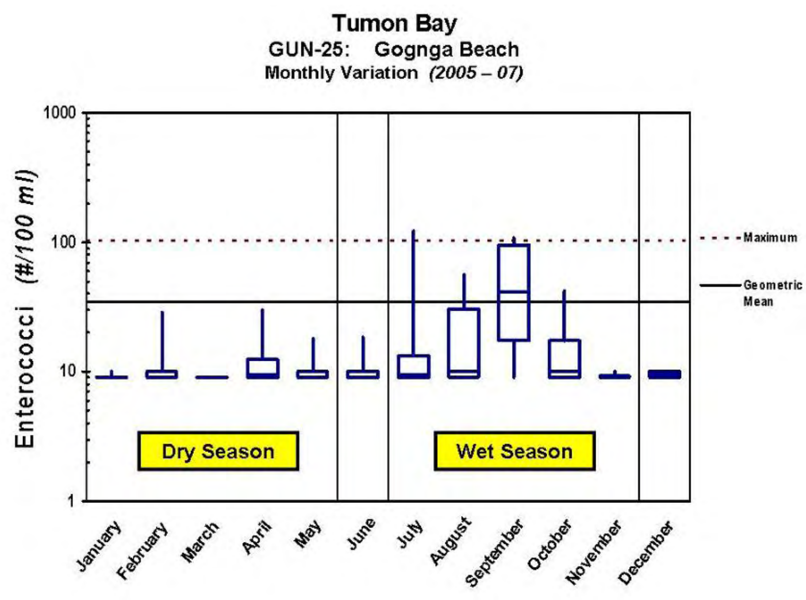

Figure 8-21. Seasonal variation at North San Vitores / Okura Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-22 shows enterococci monitoring data collected at North San Vitores / Okura Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-22, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase appears to be fairly consistent with that observed at other Northern Guam RBMP sites.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-23.

As noted earlier *(Figure 8-21)*, dry season bacteria concentrations observed at North San Vitores / Okura Beach are extremely low. This pattern is consistent across all flow zones. However, Figure 8-23 shows that during the wet season, measured values are at elevated levels in the high, moist, mid-range, and dry zones. The higher wet season values in the dry zone are particularly interesting. This seems to indicate that seeps connected to storm water sources may be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

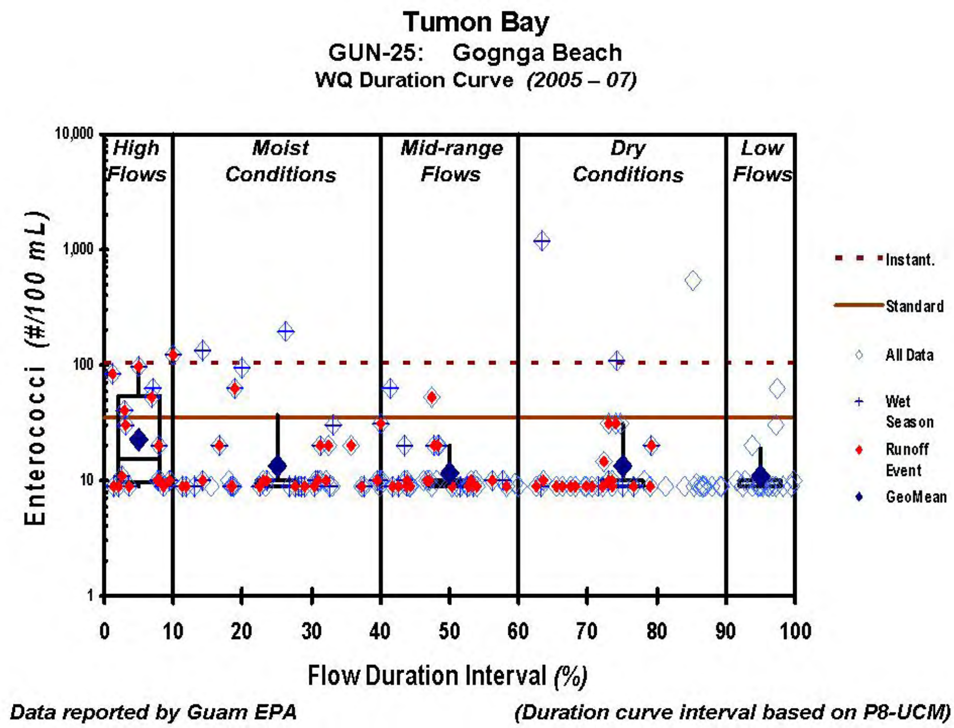

Figure 8-22. Water quality duration curve for North San Vitores / Okura Beach site.

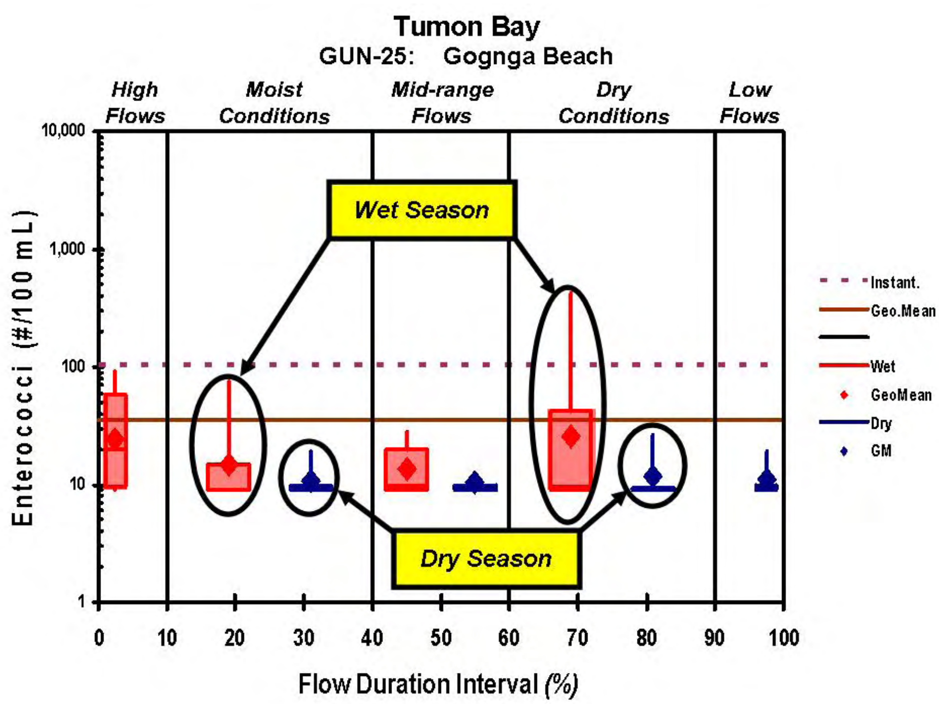

Figure 8-23. Wet versus dry season comparison for North San Vitores / Okura Beach.

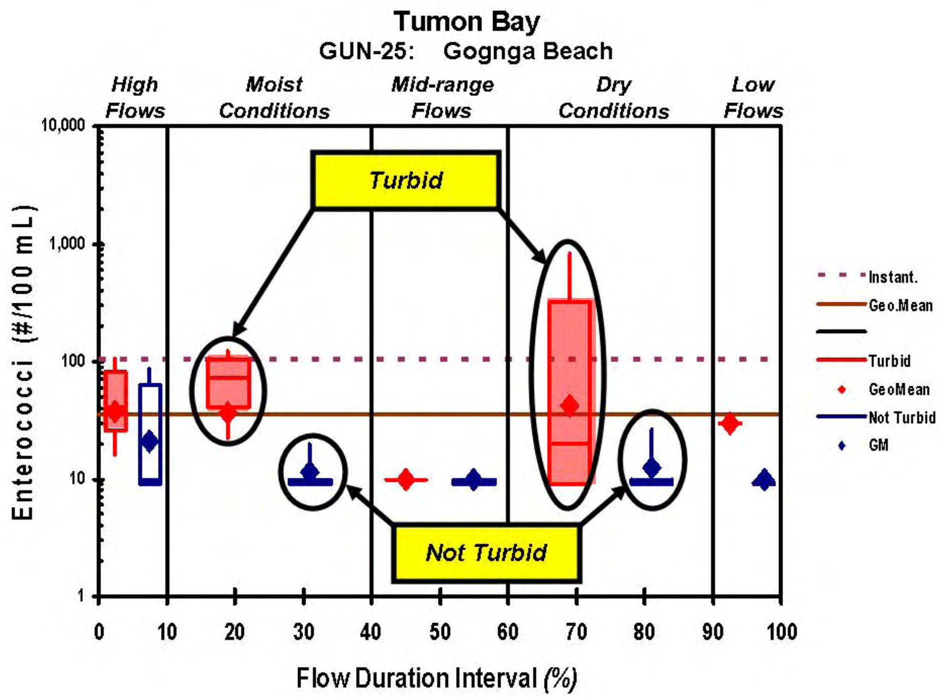

Figure 8-24. Turbid versus non-turbid sample comparison for N. San Vitores / Okura Beach site.

Figure 8-24 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high and moist conditions likely reflect the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at North San Vitores / Okura Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks), storm water (overland runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at North San Vitores / Okura Beach *(Table 8-8)*.

Figure 8-25 provides a closer look at the North San Vitores / Okura Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-25 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-25 also identifies major storm water ponding basins, including the Harmon Sink.

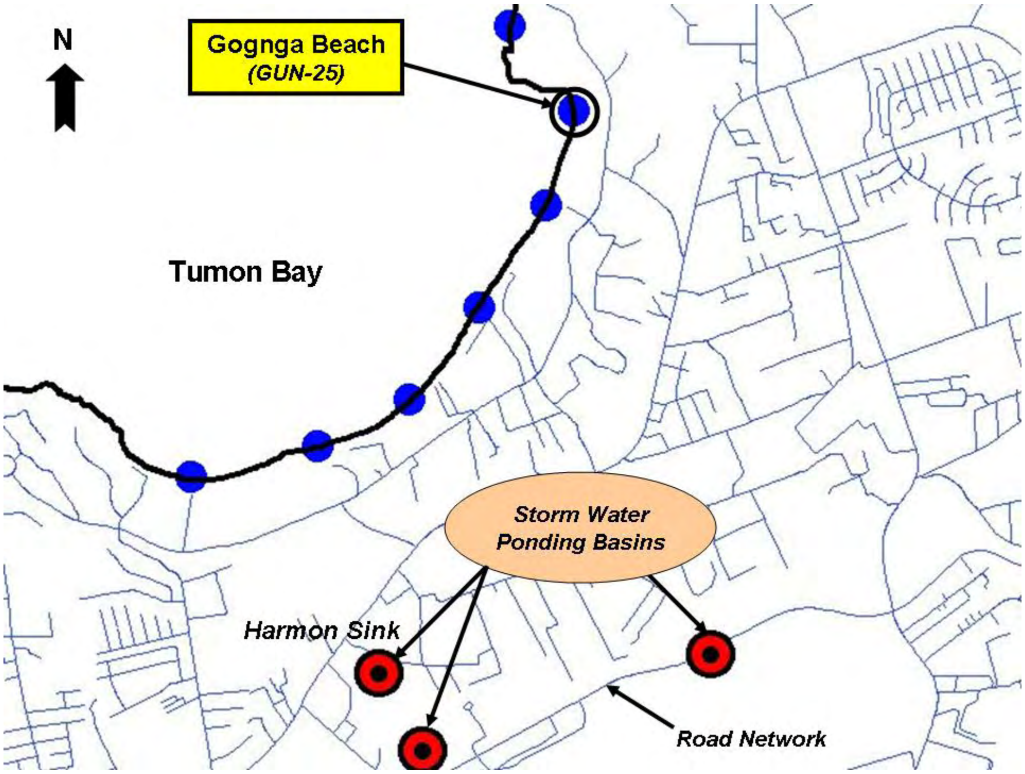

Figure 8-25. Location of North San Vitores / Okura Beach relative to potential source areas.

Table 8-8. Beach specific potential source summary *(Site GUN-25: Gognga Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-25	Runoff	Okura Sinkhole
	Storm drain runoff	Guam Aurora Resort (formerly Guam Hotel Okura)
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Sewage overflow	Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to North San Vitores / Okura Beach. This information is shown in Figure 8-26. Sewer line blockages and breaks, as well as SSOs, could also contribute to elevated bacteria levels. Figure 8-26 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

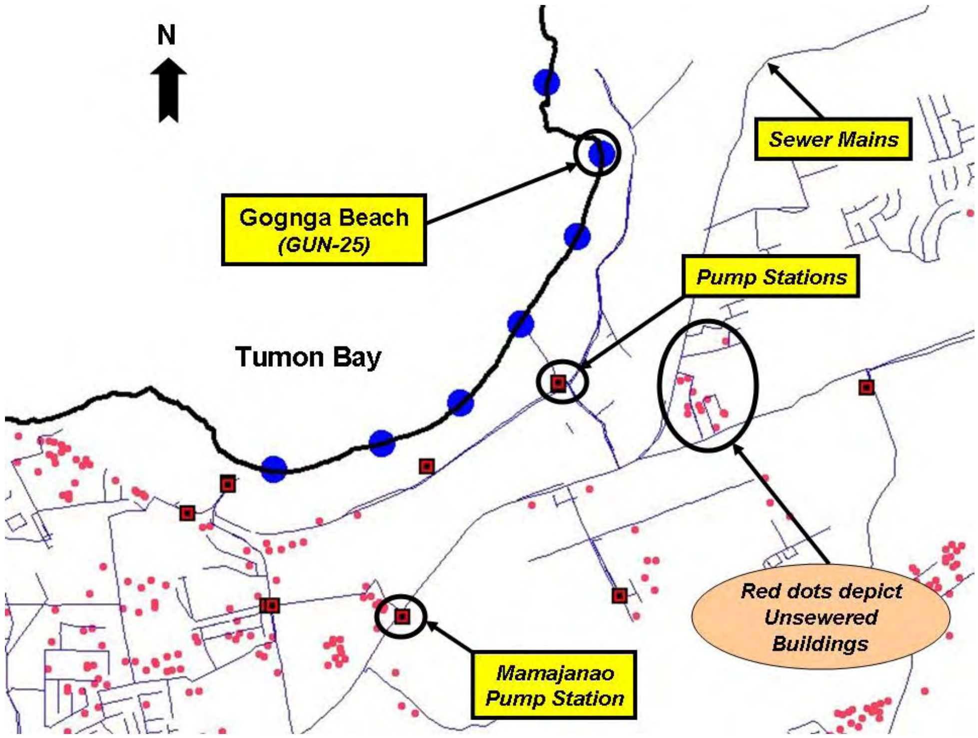

Figure 8-26. Location of N. San Vitores / Okura Beach relative to potential unsewered buildings.

Figure 8-27. Air photo of North San Vitores / Okura Beach vicinity.

Figure 8-27 shows an air photo of the area adjacent to North San Vitores / Okura Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to North San Vitores / Okura Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at North San Vitores / Okura Beach. Specifically, the Okura Sinkhole and storm drain runoff from the Guam Aurora Resort (formerly the Guam Hotel Okura) could exert an influence on bacteria concentrations at this monitoring site.

Trends. Figure 8-28 presents a year-by-year summary of the enterococcus data for the North San Vitores / Okura Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

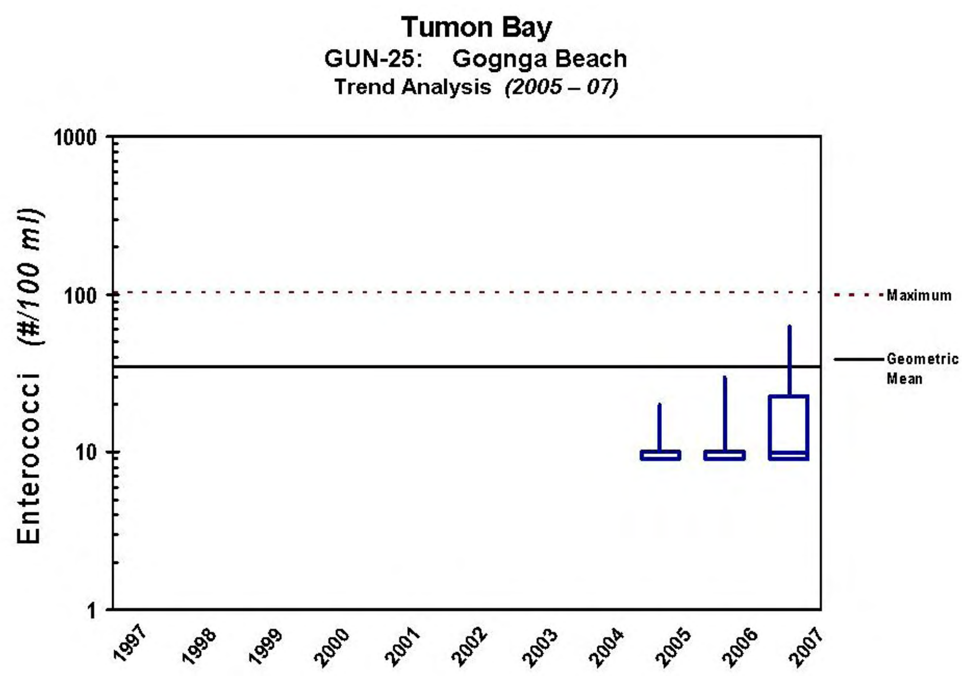

Figure 8-28. Trend analysis for North San Vitores / Okura Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at North San Vitores / Okura Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and October, indicating the importance of wet season sources at North San Vitores / Okura Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At North San Vitores / Okura Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of North San Vitores / Okura Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-9 presents the TMDL for North San Vitores / Okura Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-9. Northern Guam TMDL summary *(Site GUN-25: North San Vitores / Okura Beach)*.

TMDL Component	**Enterococcus Concentration** *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-10 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-10. Needed reductions to meet TMDL *(Site GUN-25: N. San Vitores / Okura Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	---	---	76%	---

8.4 San Vitores Beach (GUN-02)

San Vitores is part of the stretch known as Naton Beach; a strip of beach along the northern most chain of hotels on Tumon Bay *(Figure 8-29)*. This area is also known as tourism central for the Tumon area; an extremely popular location for tourists looking to participate in water activities such as kayaking, beachcombing, and snorkeling.

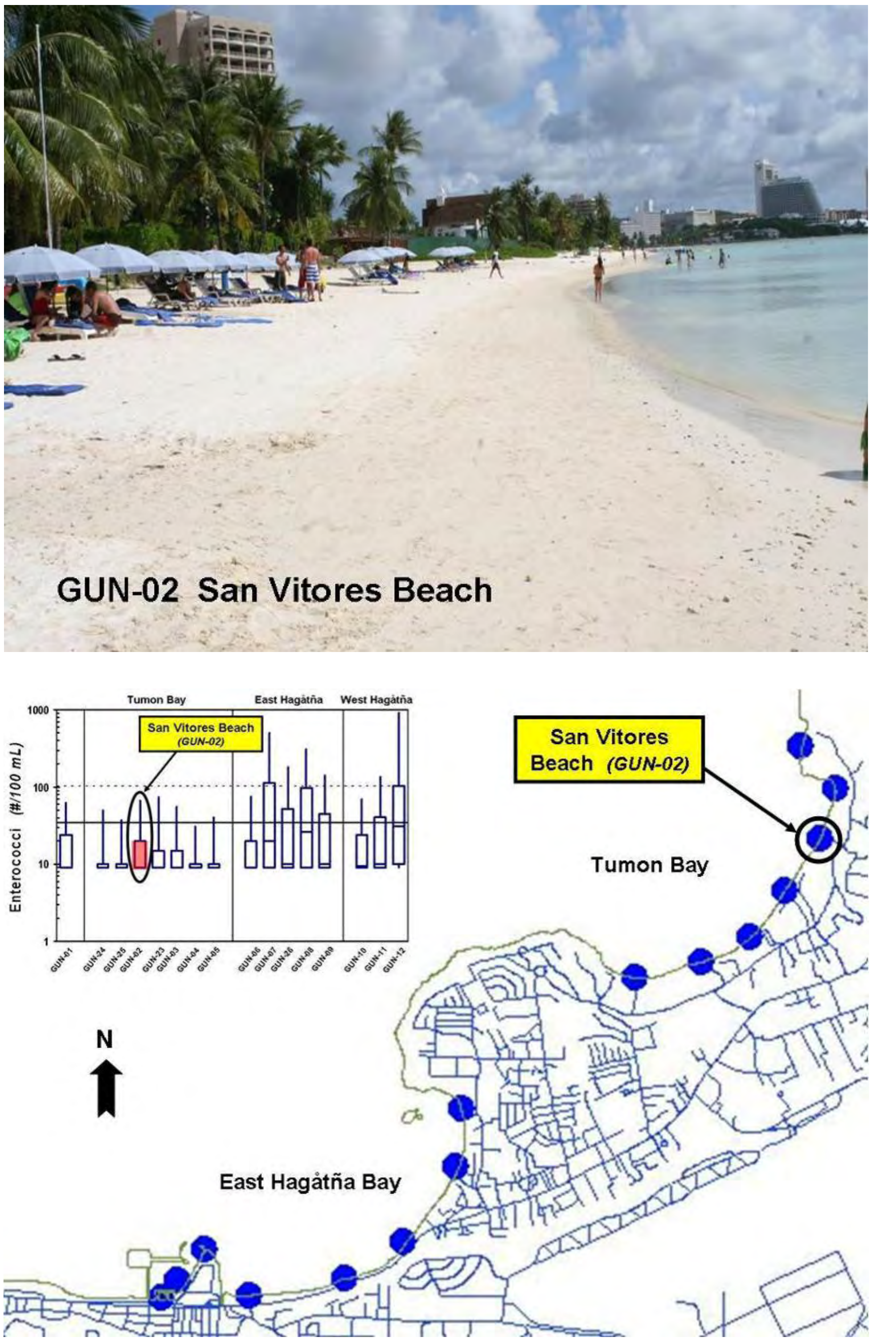

Figure 8-29. Location of San Vitores Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at San Vitores Beach between 1997 and 2007 was typical (13%) of many RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at San Vitores Beach were basically in the same range as a number of other project area monitoring stations *(Figure 4-2 and Figure 8-29)*. The geometric mean of all individual samples was 16 counts /100mL, while the 75th and 90th percentiles were 20 and 66 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-30 shows the seasonal variability of bacteria concentrations at San Vitores Beach. The highest concentrations were observed between June and December, indicating the importance of wet season sources at San Vitores Beach.

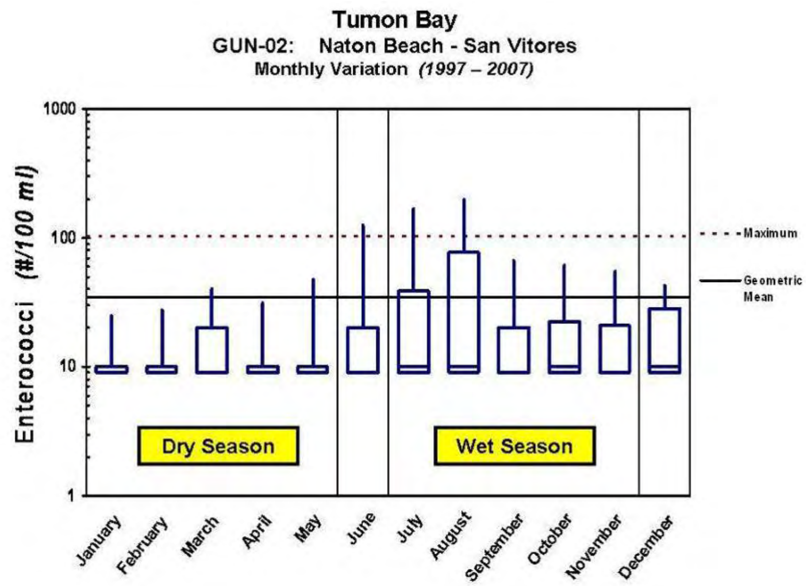

Figure 8-30. Seasonal variation at San Vitores Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-31 shows enterococci monitoring data collected at San Vitores Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-31, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase appears to be higher than that observed at other Tumon Bay monitoring sites. In fact, the geometric mean exceeded the criterion under high flow conditions, which indicates potential need to address storm water sources. This concern is reinforced by the fact that the 75th percentile in the high flow zone is close to the instantaneous maximum criterion value. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during heavy rains) may also be a concern under these conditions.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-32.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. This reinforces the need to focus on storm water sources at San Vitores Beach. However, an interesting observation is the difference between the wet and dry season patterns under mid-range and dry conditions. The higher wet season values in the dry zone indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

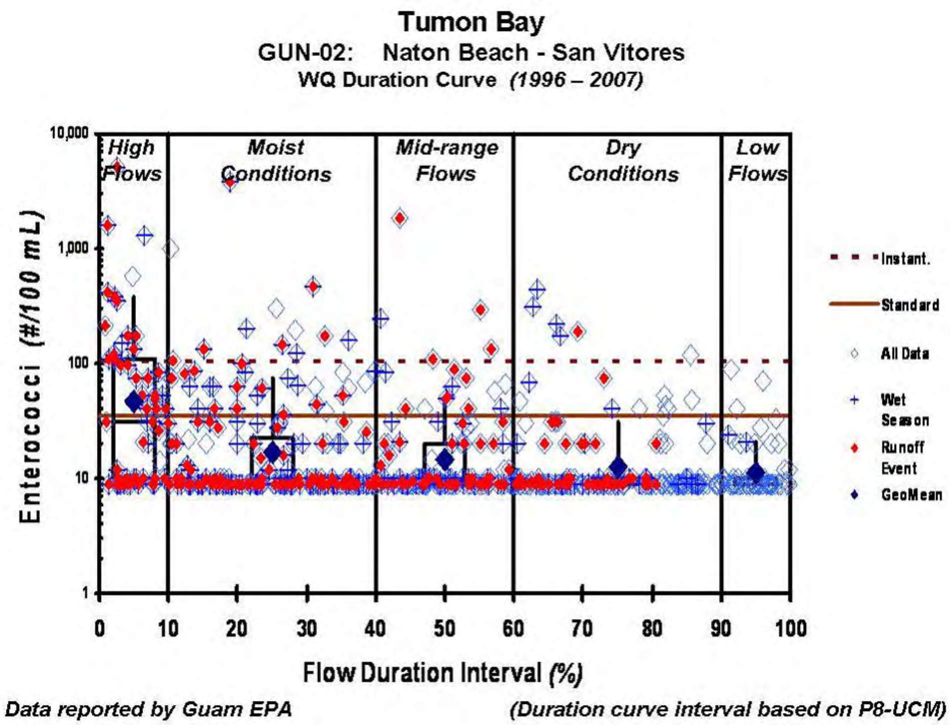

Figure 8-31. Water quality duration curve for San Vitores Beach site.

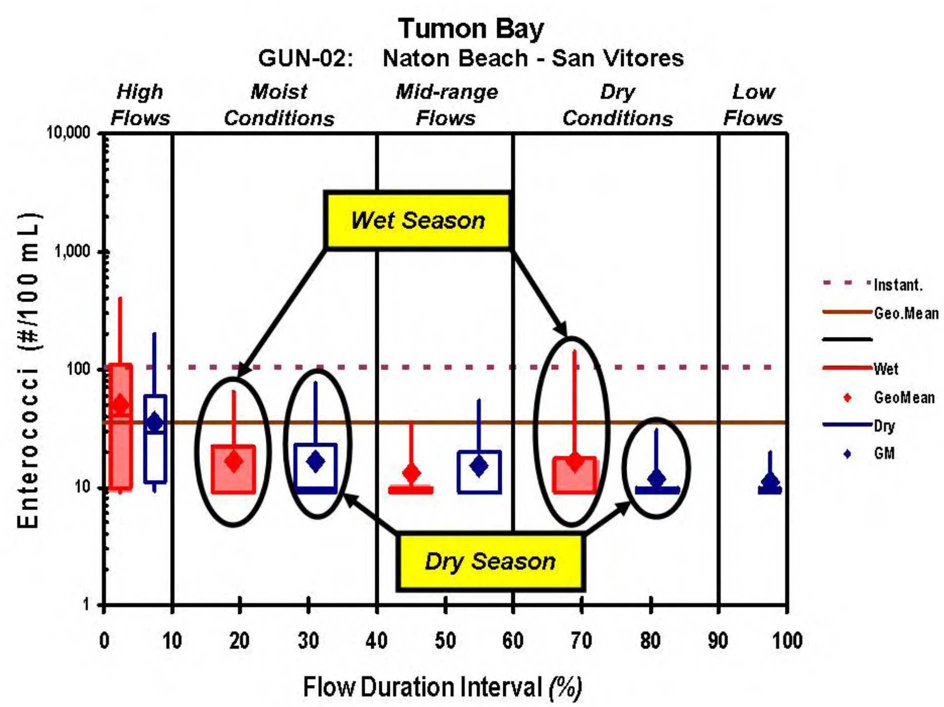

Figure 8-32. Wet versus dry season comparison for San Vitores Beach.

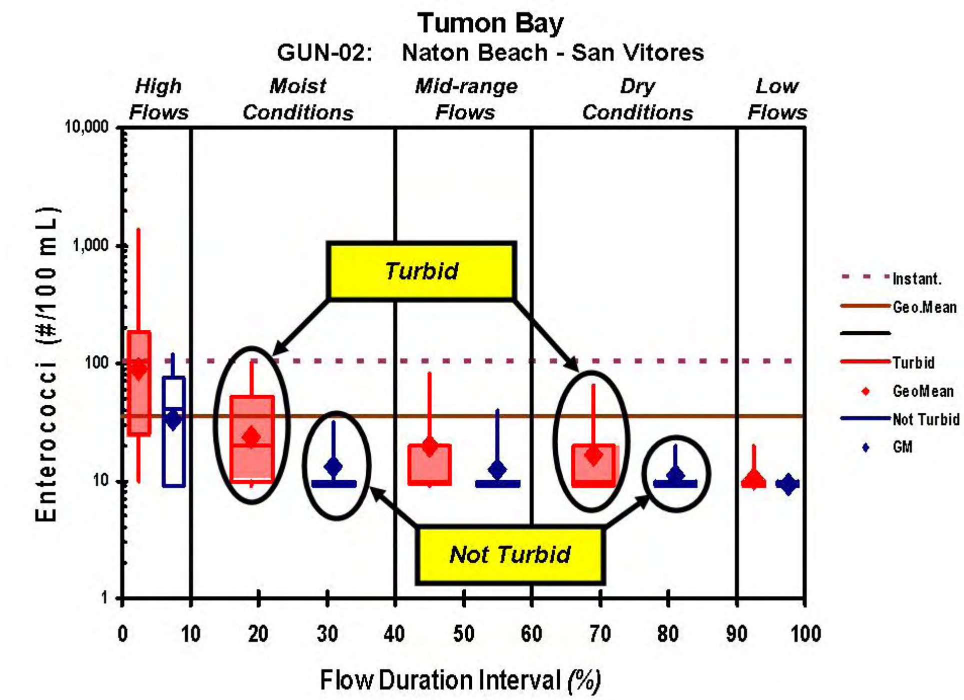

Figure 8-33. Turbid versus non-turbid sample comparison for San Vitores Beach site.

Figure 8-33 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at San Vitores Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff, highway maintenance & runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at San Vitores Beach *(Table 8-11)*.

Figure 8-34 provides a closer look at the San Vitores Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-34 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-34 also identifies major storm water ponding basins, including the Harmon Sink.

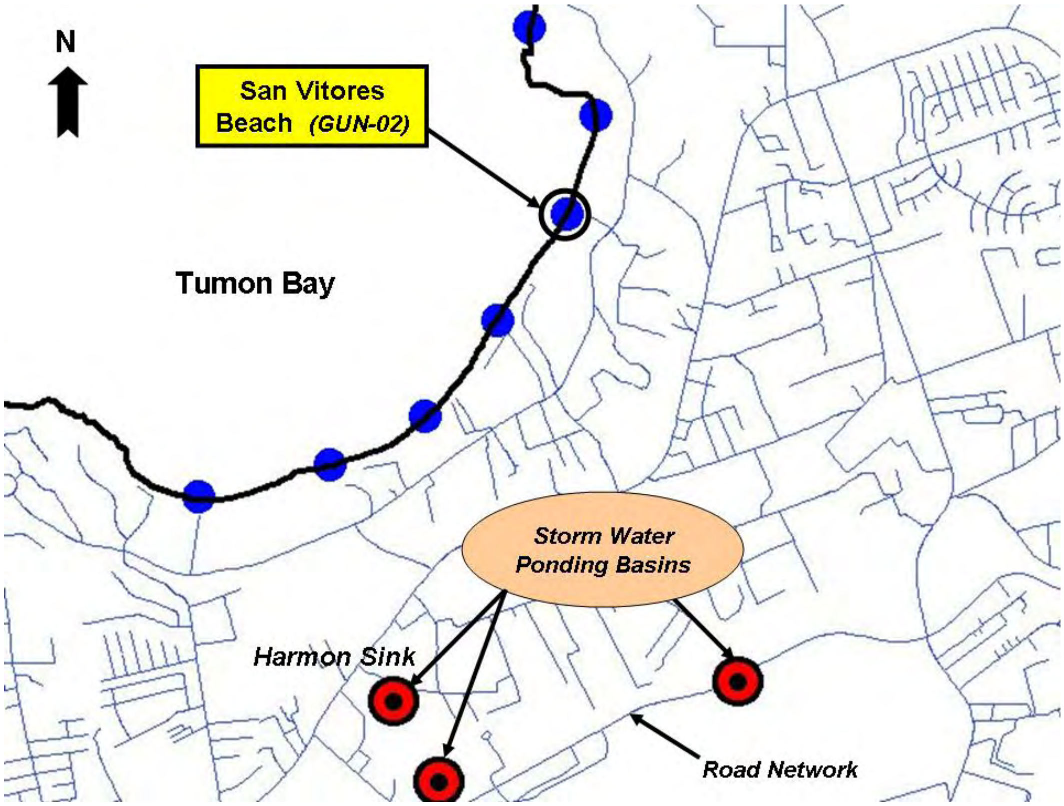

Figure 8-34. Location of San Vitores Beach relative to potential source areas.

Table 8-11. Beach specific potential source summary *(Site GUN-02: San Vitores Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-02	Storm drain runoff	Outrigger Hotel Storm Drain
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Cleanout overflow to storm drain	Rivera St. Holding Tank (near Capital Hotel and Tarza WaterPark) *Holding tank not connected to public sewer, clean out is overflowing to road and storm drain.*
	Sewage overflow	Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at San Vitores Beach. Specifically, there are two areas of concern. First, storm drain runoff from the Outrigger Hotel may be affecting water quality at this site. Second, the Rivera Street holding tank (near the Capital Hotel and Tarza Water Park) is not connected to the public sewer. There have been problems with the clean out overflowing to the road and nearby storm drain. This could explain periodic elevated bacteria concentrations at this location.

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to San Vitores Beach. This information is shown in Figure 8-35. Sewer line blockages and breaks, as well as SSOs, could also contribute to elevated bacteria levels. Figure 8-35 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-36 shows an air photo of the area adjacent to San Vitores Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to San Vitores Beach.

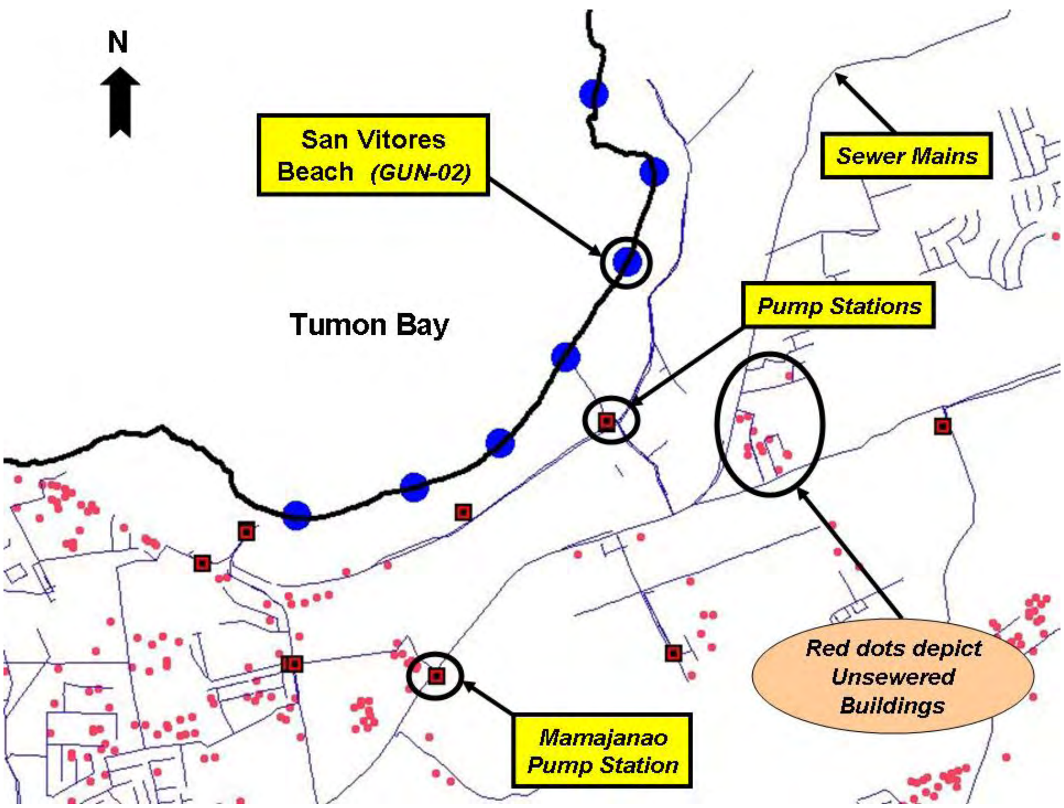

Figure 8-35. Location of San Vitores Beach relative to potential unsewered buildings.

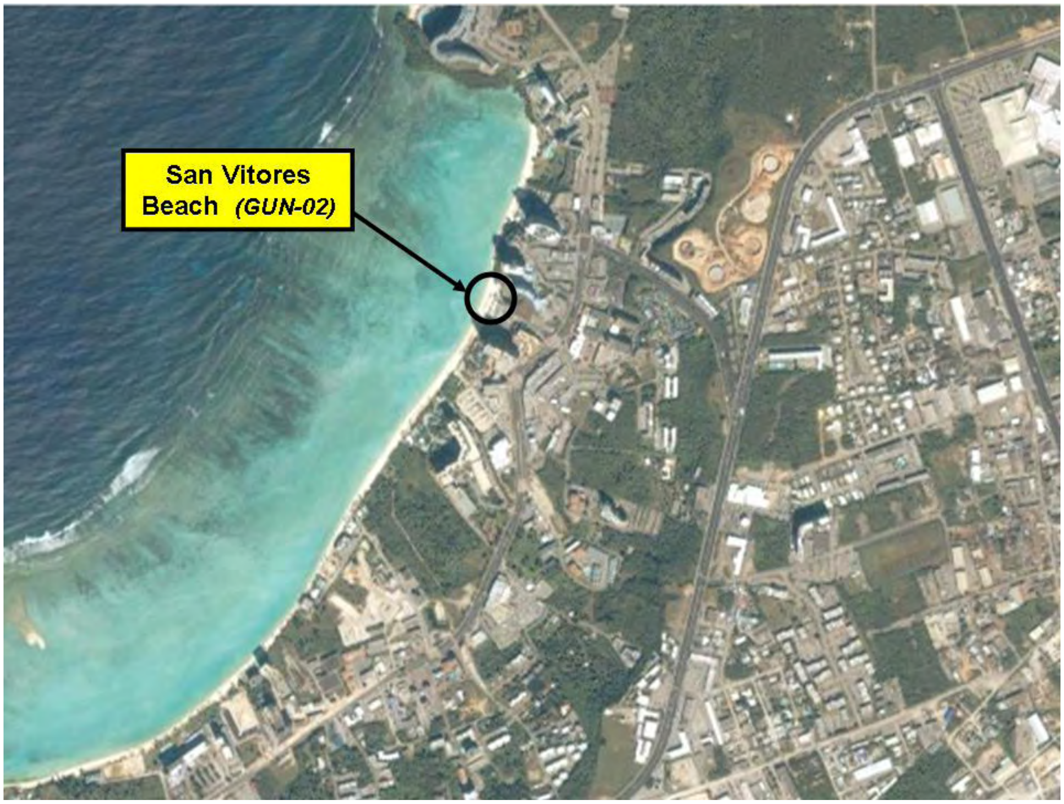

Figure 8-36. Air photo of San Vitores Beach vicinity.

Trends. Figure 8-37 presents a year-by-year summary of the enterococcus data for the San Vitores Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at San Vitores Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between June and December, indicating the importance of wet season sources at San Vitores Beach. This is consistent with the presence of potential storm water sources identified at this location.

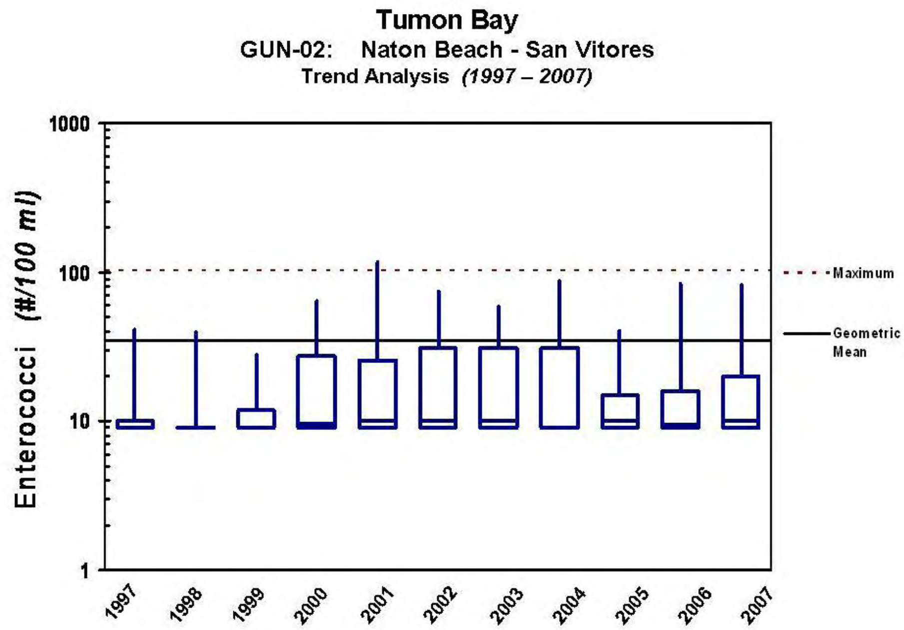

Figure 8-37. Trend analysis for San Vitores Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At San Vitores Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of San Vitores Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-12 presents the TMDL for San Vitores Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-12. Northern Guam Watershed TMDL summary *(Site GUN-02: San Vitores Beach)*.

TMDL Component	**Enterococcus Concentration** *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-13 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-13. Needed reductions to meet TMDL targets *(Site GUN-02: San Vitores Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	3%	---	---	---	---
Based on instantaneous maximum	48%	---	---	---	---
Wet Season					
Based on geometric mean	30%	---	---	---	---
Based on instantaneous maximum	74%	---	---	26%	---

8.5 Fujita Beach (GUN-23)

Fujita Beach is also part of the stretch known as Naton Beach; a strip of beach along the northern most chain of hotels on Tumon Bay *(Figure 8-38)*. Centrally situated in the Tumon area, Fujita Beach is an extremely popular location for tourists looking to participate in water activities such as kayaking, beachcombing, and snorkeling.

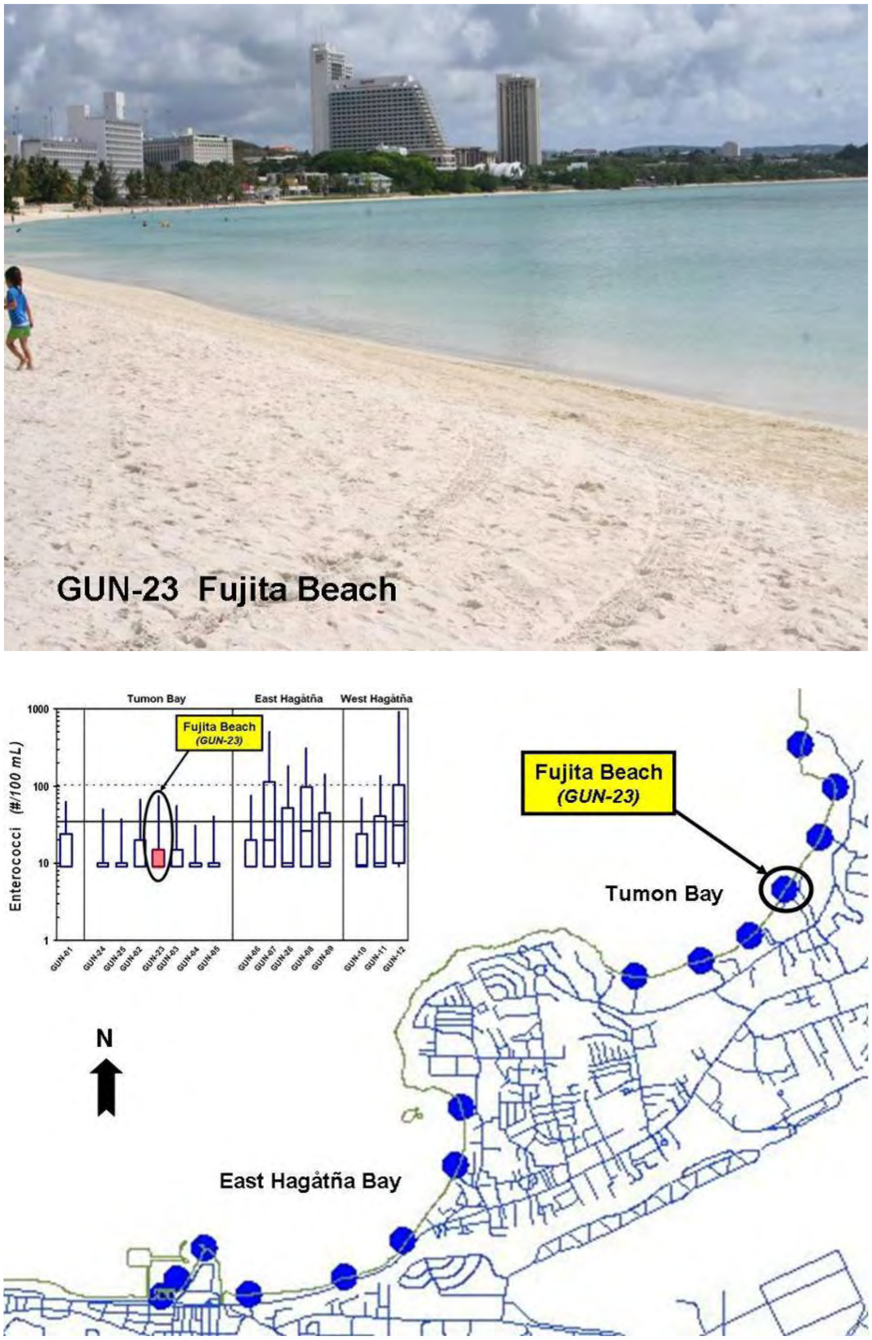

Figure 8-38. Location of Fujita Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Fujita Beach between 2001 and 2007 was typical (13%) of many RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Fujita Beach were basically in the same range as a number of other project area monitoring stations *(Figure 4-2 and Figure 8-38)*. The geometric mean of all individual samples was 15 counts /100mL, while the 75th and 90th percentiles were 15 and 74 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-39 shows the seasonal variability of bacteria concentrations at Fujita Beach. With the exception of March, the highest concentrations were observed between July and October, indicating the importance of wet season sources at Fujita Beach.

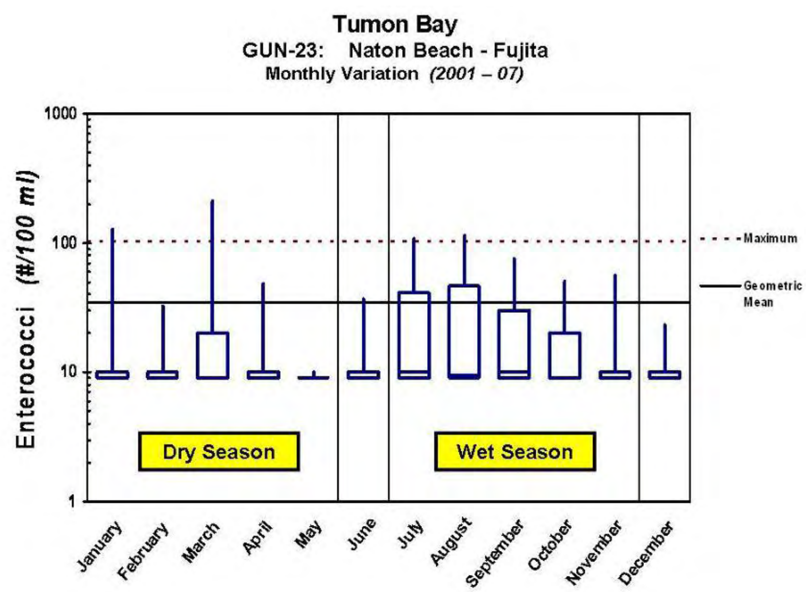

Figure 8-39. Seasonal variation at Fujita Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-40 shows enterococci monitoring data collected at Fujita Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-40, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase appears to be fairly consistent with that observed at other Tumon Bay monitoring sites. However, the

90th percentile exceeds the instantaneous maximum criterion in the high flow zone. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during heavy rains) may be a concern under these conditions.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-41.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow conditions. This reinforces the need to focus on storm water sources at Fujita Beach. However, an interesting observation is the difference between the wet and dry season patterns under mid-range and dry conditions. The higher wet season values in both these zones indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

<u>Relationship to Other Indicators</u>. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

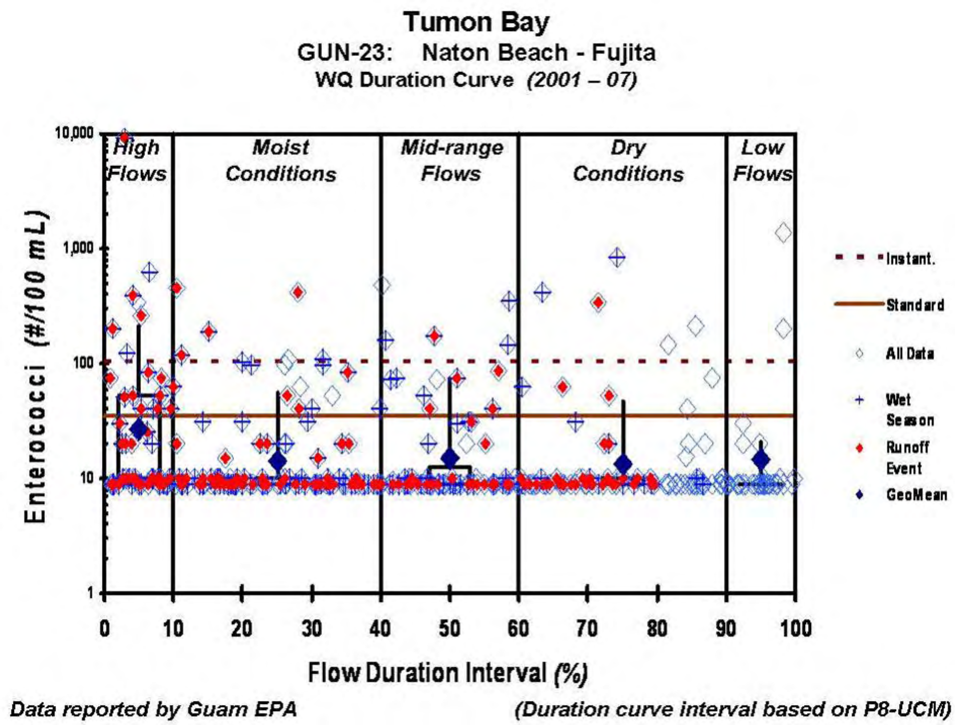

Figure 8-40. Water quality duration curve for Fujita Beach site.

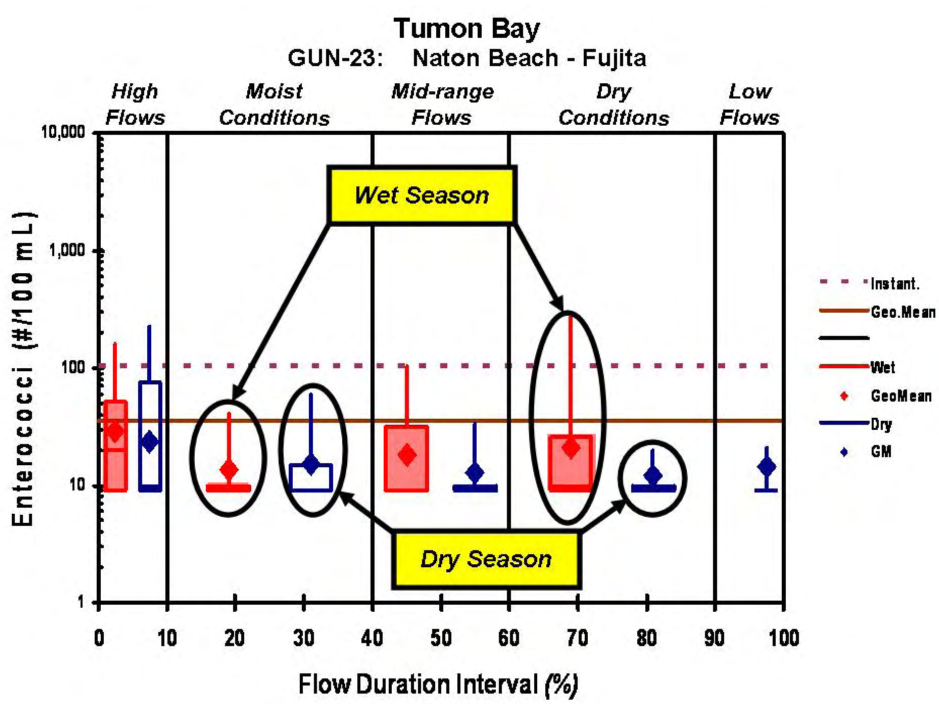

Figure 8-41. Wet versus dry season comparison for Fujita Beach.

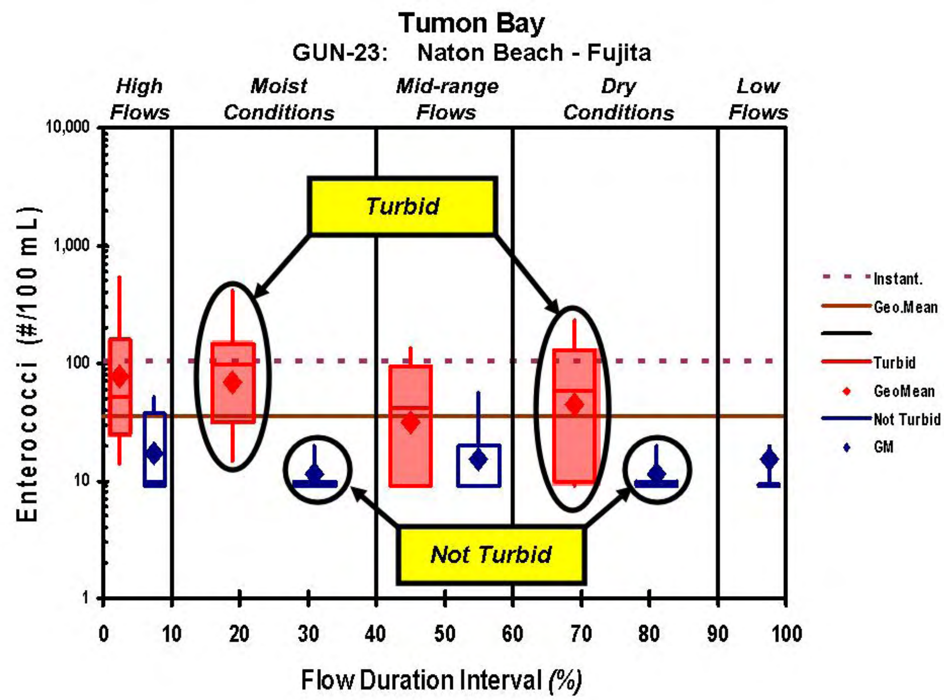

Figure 8-42. Turbid versus non-turbid sample comparison for Fujita Beach site.

Figure 8-42 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

<u>Potential Sources</u>. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Fujita Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff, highway maintenance & runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Fujita Beach *(Table 8-14)*.

Figure 8-43 provides a closer look at the Fujita Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-43 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-43 also identifies major storm water ponding basins, including the Harmon Sink.

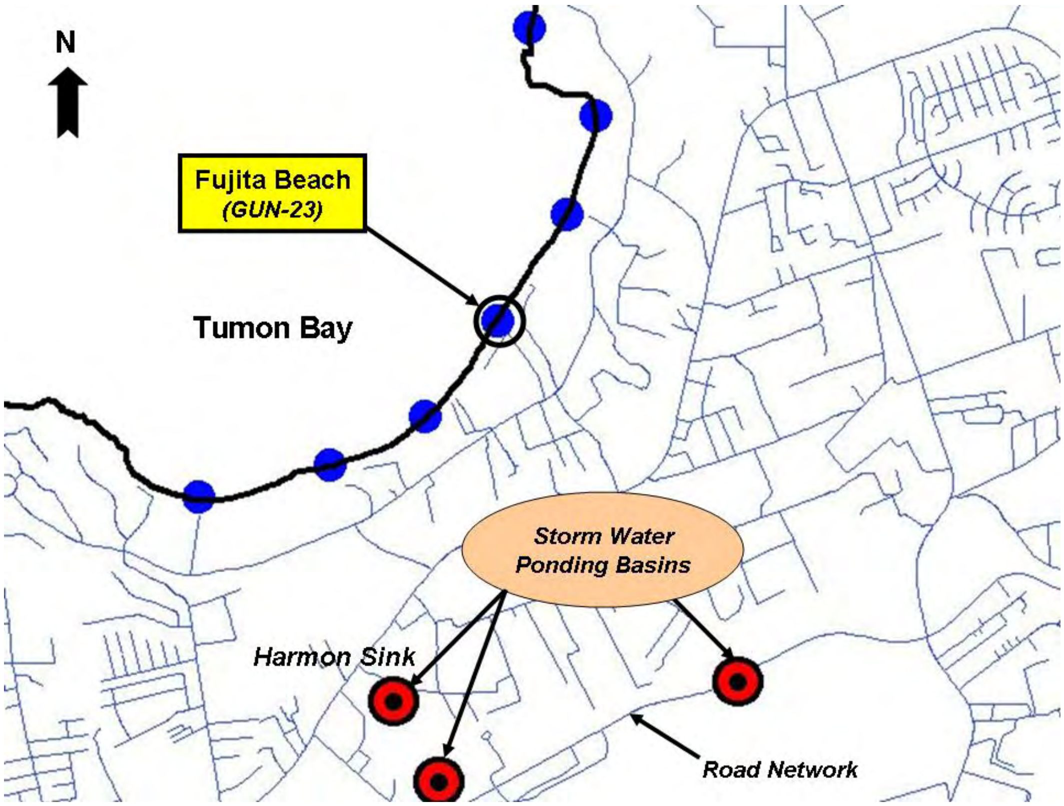

Figure 8-43. Location of Fujita Beach relative to potential source areas.

Table 8-14. Beach specific potential source summary *(Site GUN-23: Fujita Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-23	SIA – SW *	SIA DPW 4 corner of Fujita Rd. and San Vitores Rd. *Fujita Road*
	Sewage overflow	Fujita Sewage Pump Station
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*
	Storm drain runoff	Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
Notes: * SIA - SW: Surface Impoundment Area – Storm Water		

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Fujita Beach. This information is shown in Figure 8-44. Sewer line blockages and breaks, as well as SSOs, could also contribute to elevated bacteria levels. Figure 8-44 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-45 shows an air photo of the area adjacent to Fujita Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Fujita Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Fujita Beach. Specifically, there are two areas of concern. First, there is a storm water surface impoundment area (SIA DPW 4) at the corner of Fujita and San Vitores Roads that may be affecting water quality at this site. Second, the Fujita Pump Station *(Figure 8-44)* is located nearby. There has been occasional sewage overflows associated with this facility, which could explain periodic elevated bacteria concentrations at this location.

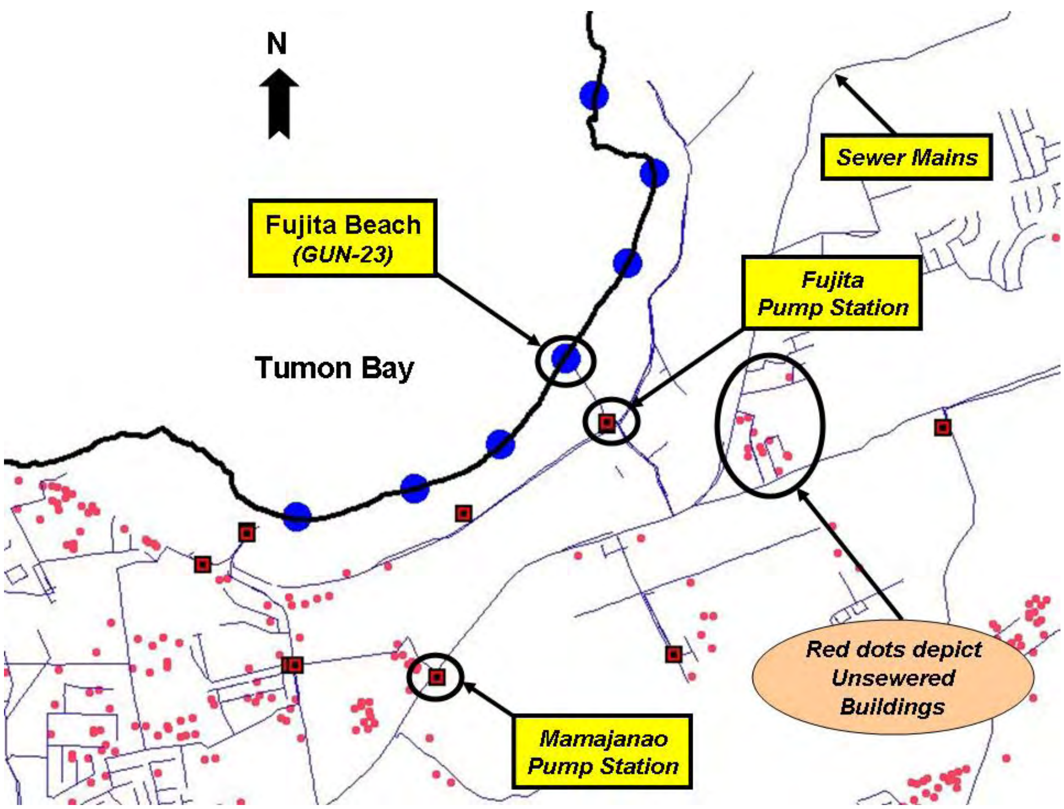

Figure 8-44. Location of Fujita Beach relative to potential unsewered buildings.

Figure 8-45. Air photo of Fujita Beach vicinity.

Trends. Figure 8-46 presents a year-by-year summary of the enterococcus data for the Fujita Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Fujita Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and October, indicating the importance of wet season sources at Fujita Beach. This is consistent with the presence of potential storm water sources identified at this location.

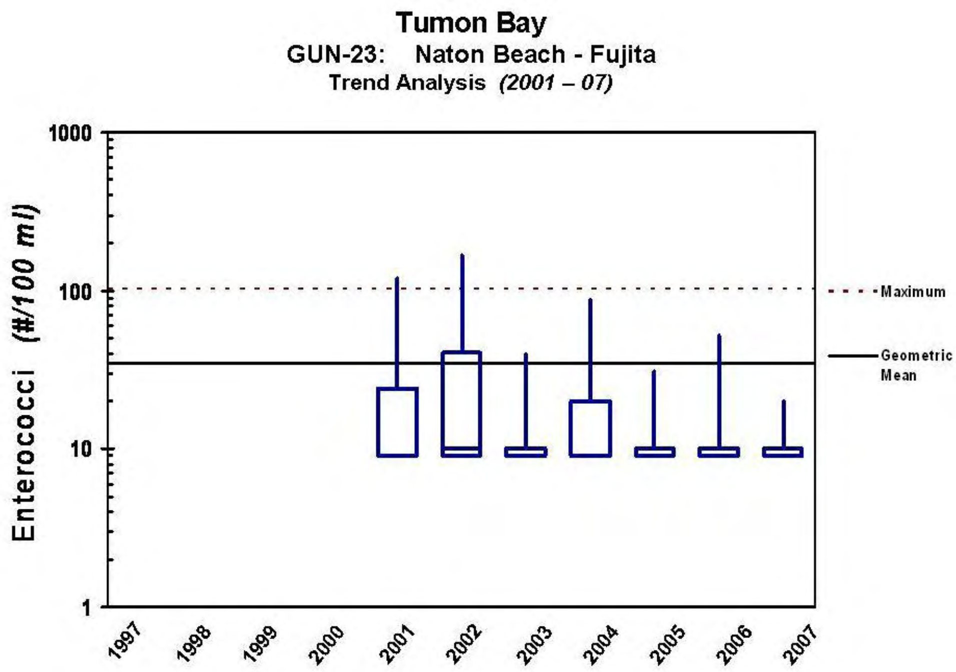

Figure 8-46. Trend analysis for Fujita Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Fujita Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Fujita Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-15 presents the TMDL for Fujita Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-15. Northern Guam Watershed TMDL summary *(Site GUN-23: Fujita Beach)*.

TMDL Component	**Enterococcus Concentration** *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-16 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-16. Needed reductions to meet TMDL targets *(Site GUN-23: Fujita Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	54%	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	35%	---	---	62%	---

8.6 Matapang Beach Park (GUN-03)

Matapang Beach is located in the central portion of the Tumon Bay area *(Figure 8-47)*. It is one of the only two beach parks in Tumon. The water off the coast of Matapang Beach consists of a soft, sandy sea-floor with fairly calm waters making it an excellent place to go swimming for tourists.

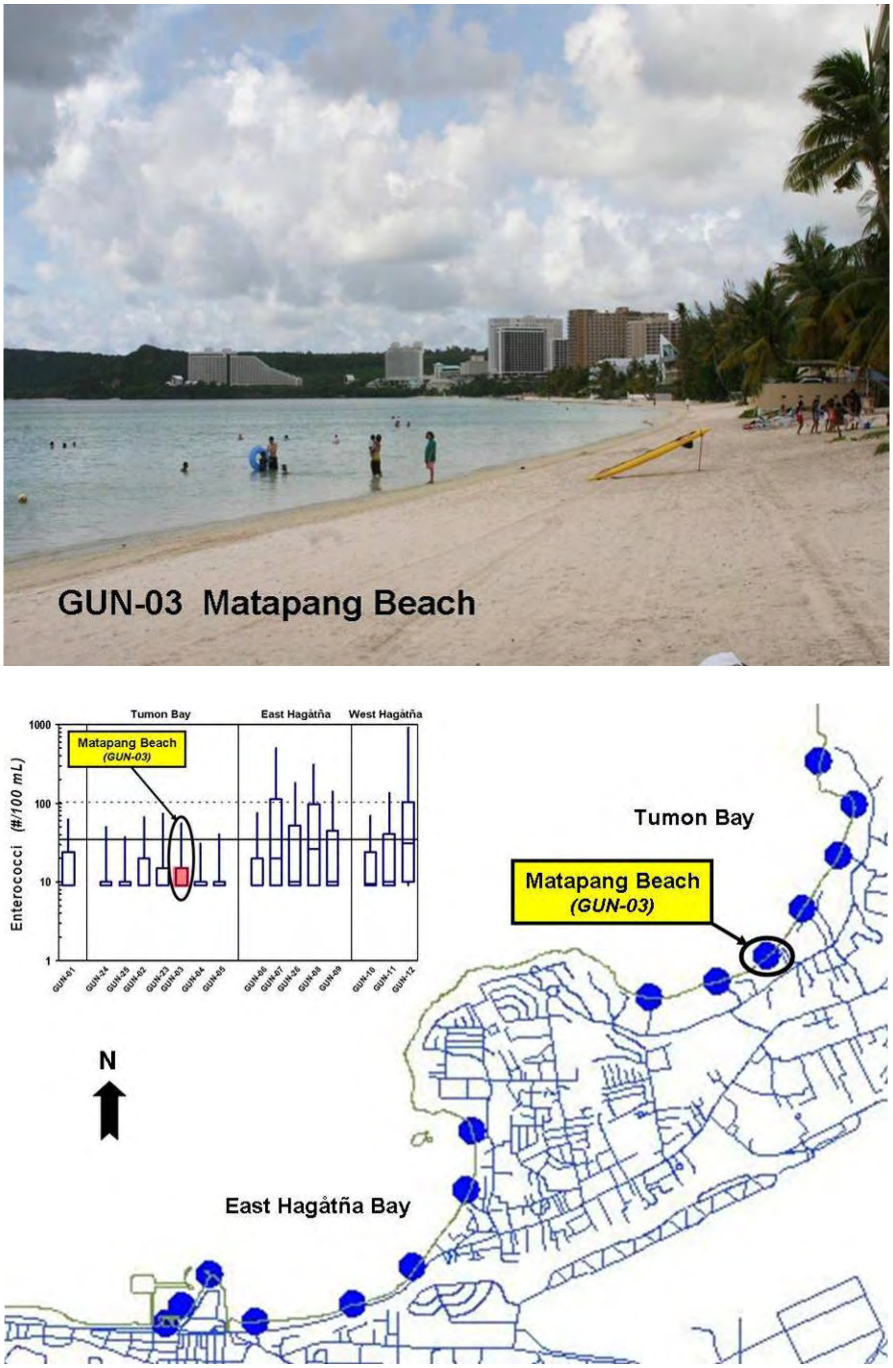

Figure 8-47. Location of Matapang Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Matapang Beach between 1998 and 2007 was typical (12%) of many RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Matapang Beach were basically in the same range as a number of other project area monitoring stations *(Figure 4-2 and Figure 8-47)*. The geometric mean of all individual samples was 15 counts /100mL, while the 75th and 90th percentiles were 15 and 56 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-48 shows the seasonal variability of bacteria concentrations at Matapang Beach. The highest concentrations were observed between July and September, indicating the importance of wet season sources at Matapang Beach.

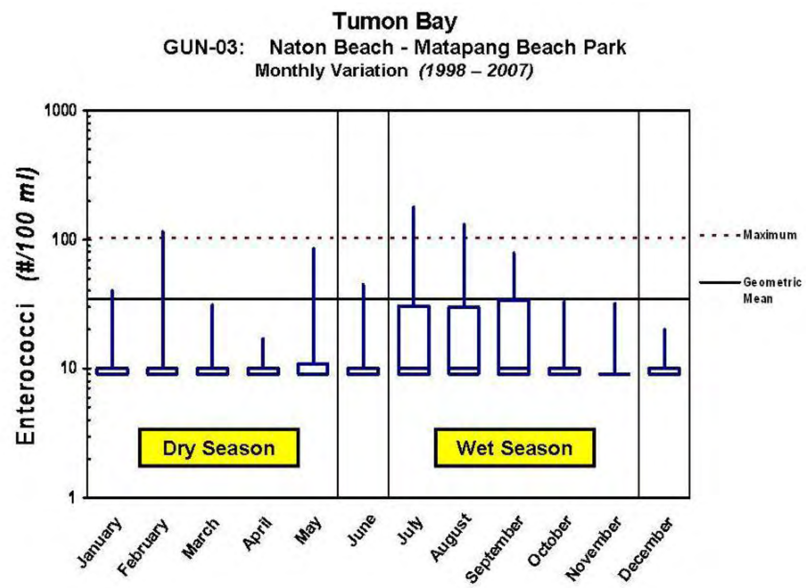

Figure 8-48. Seasonal variation at Matapang Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-49 shows enterococci monitoring data collected at Matapang Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-49, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase appears to be fairly consistent with that observed at other Tumon Bay monitoring sites. However, the 90th percentile exceeds the instantaneous maximum criterion in the high flow zone. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during heavy rains) may be a concern under these conditions.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-50.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. This reinforces the need to focus on storm water sources at Matapang Beach. Furthermore, the low values observed for both the wet and dry seasons in the mid-range and dry zones confirm the fact that storm water sources are the major concern at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

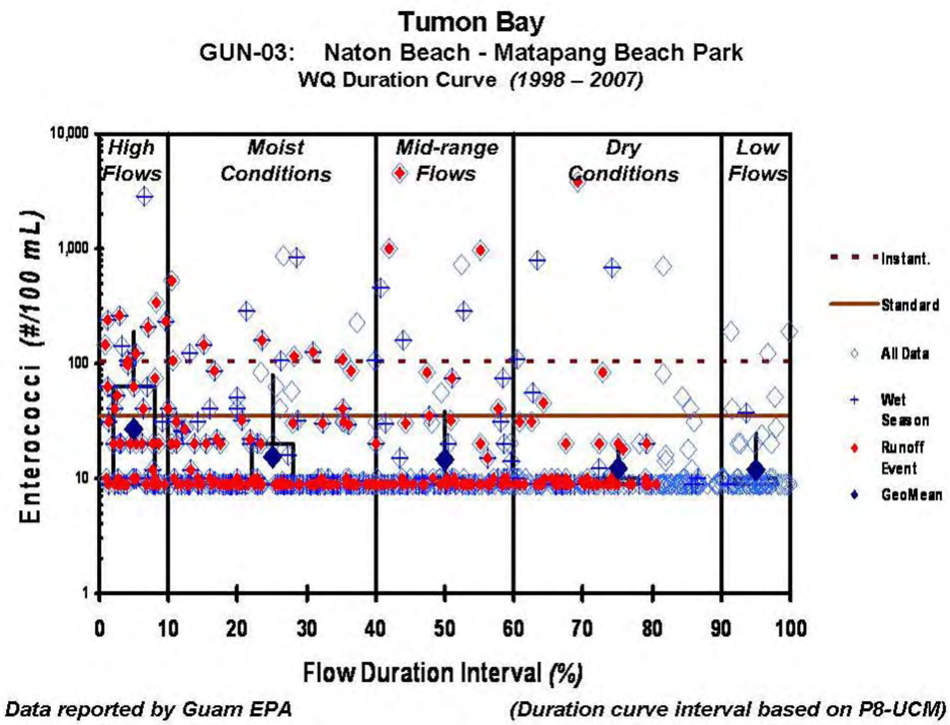

Figure 8-49. Water quality duration curve for Matapang Beach site.

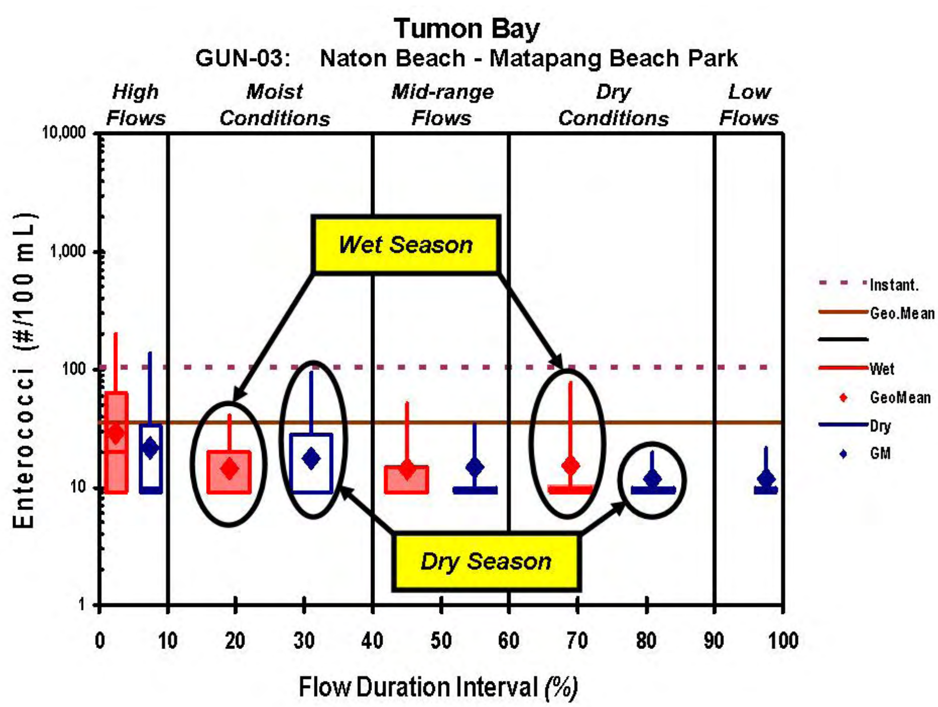

Figure 8-50. Wet versus dry season comparison for Matapang Beach.

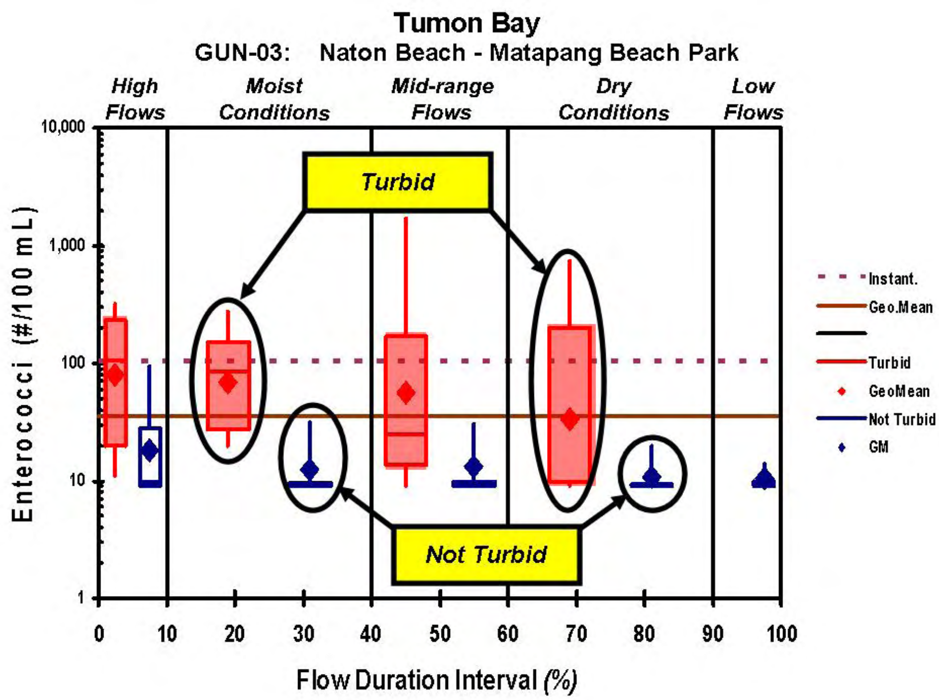

Figure 8-51. Turbid versus non-turbid sample comparison for Matapang Beach site.

Figure 8-51 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Matapang Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff, highway maintenance & runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Matapang Beach *(Table 8-17)*.

Figure 8-52 provides a closer look at the Matapang Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-52 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-52 also identifies major storm water ponding basins, including the Harmon Sink.

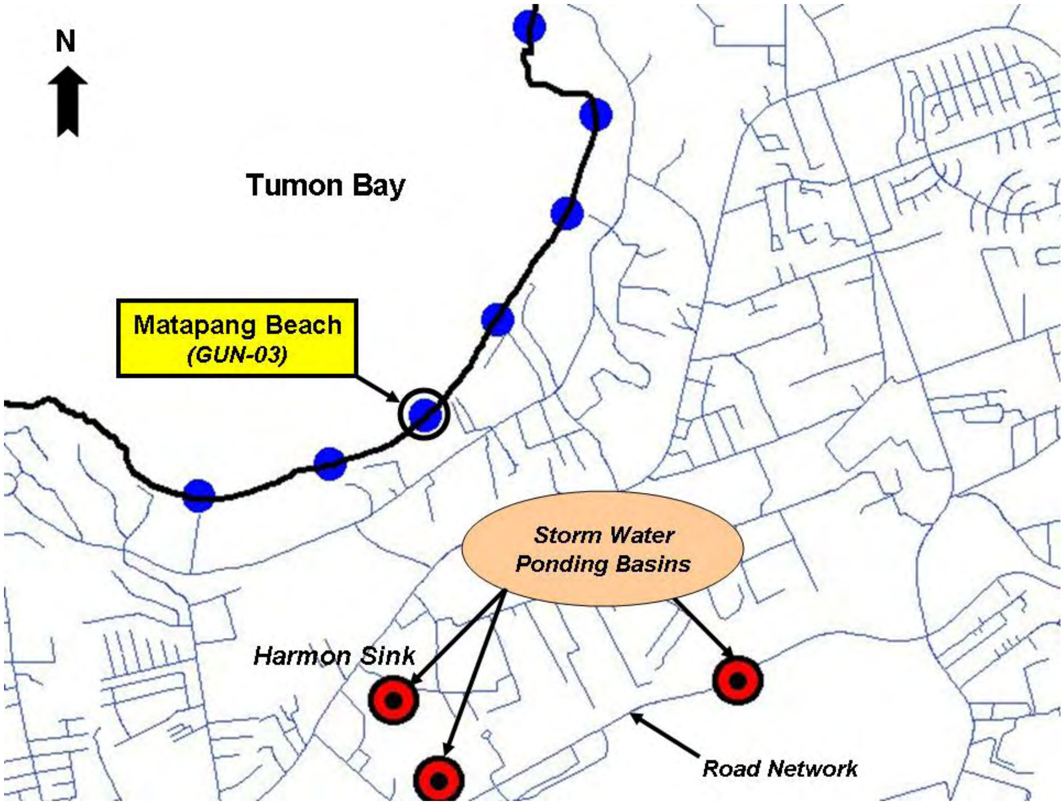

Figure 8-52. Location of Matapang Beach relative to potential source areas.

Table 8-17. Beach specific potential source summary *(Site GUN-03: Matapang Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-03	Stormwater runoff	Cushing Zoo *Animal waste from zoo. Research management options.*
	Storm drain runoff	Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	UIC - SW *	UIC DPW Matapang Beach UIC encompasses entire parking area of park.
	Sewage overflow	Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*
Notes: * UIC - SW: Underground Injection Control – Storm Water		

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Matapang Beach. This information is shown in Figure 8-53. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-53 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-54 shows an air photo of the area adjacent to Matapang Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Matapang Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Matapang Beach. Specifically, there are two areas of concern. First, storm water runoff from the Cushing Zoo may be affecting water quality at this site. Second, a storm water underground injection control (UIC) facility encompasses the entire parking area of Matapang Park. This facility may have an influence on bacteria concentrations at this location.

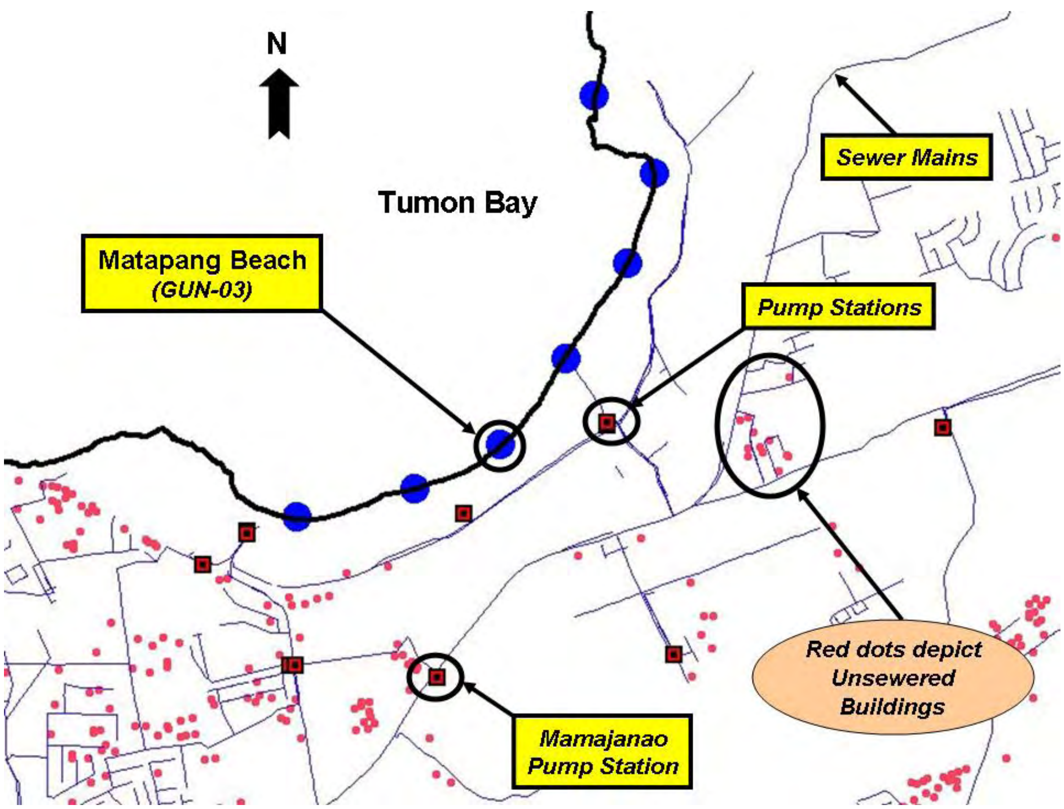

Figure 8-53. Location of Matapang Beach relative to potential unsewered buildings.

Figure 8-54. Air photo of Matapang Beach vicinity.

Trends. Figure 8-55 presents a year-by-year summary of the enterococcus data for the Matapang Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Matapang Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and September, indicating the importance of wet season sources at Matapang Beach. This is consistent with the presence of potential storm water sources identified at this location.

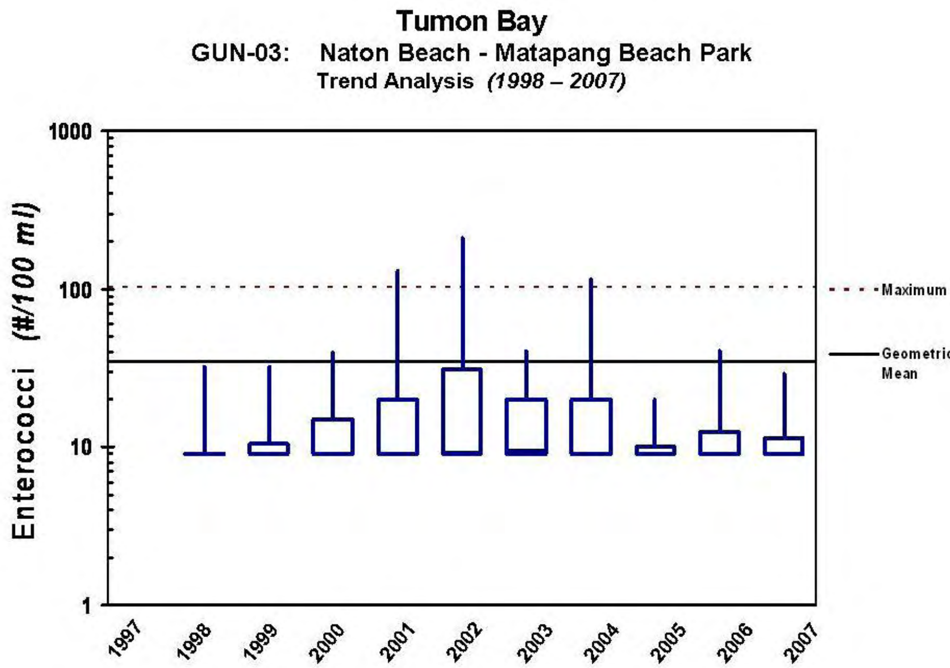

Figure 8-55. Trend analysis for Matapang Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Matapang Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Matapang Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-18 presents the TMDL for Matapang Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-18. Northern Guam Watershed TMDL summary *(Site GUN-03: Matapang Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-19 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-19. Needed reductions to meet TMDL targets *(Site GUN-03: Matapang Beach)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	25%	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	49%	---	---	---	---

8.7 Guma Trankilidat Beach (GUN-04)

Guma Trankilidat Beach is located on Tumon Bay between Ypao Park and the Pacific Islands Club *(Figure 8-56)*. It is situated at the southern end of the bay. Because all of Tumon Bay is protected by a natural reef that stretches out about one mile from the beach shore, this beach can be used for swimming, wind-surfing, snorkeling, kayaking and other water activities.

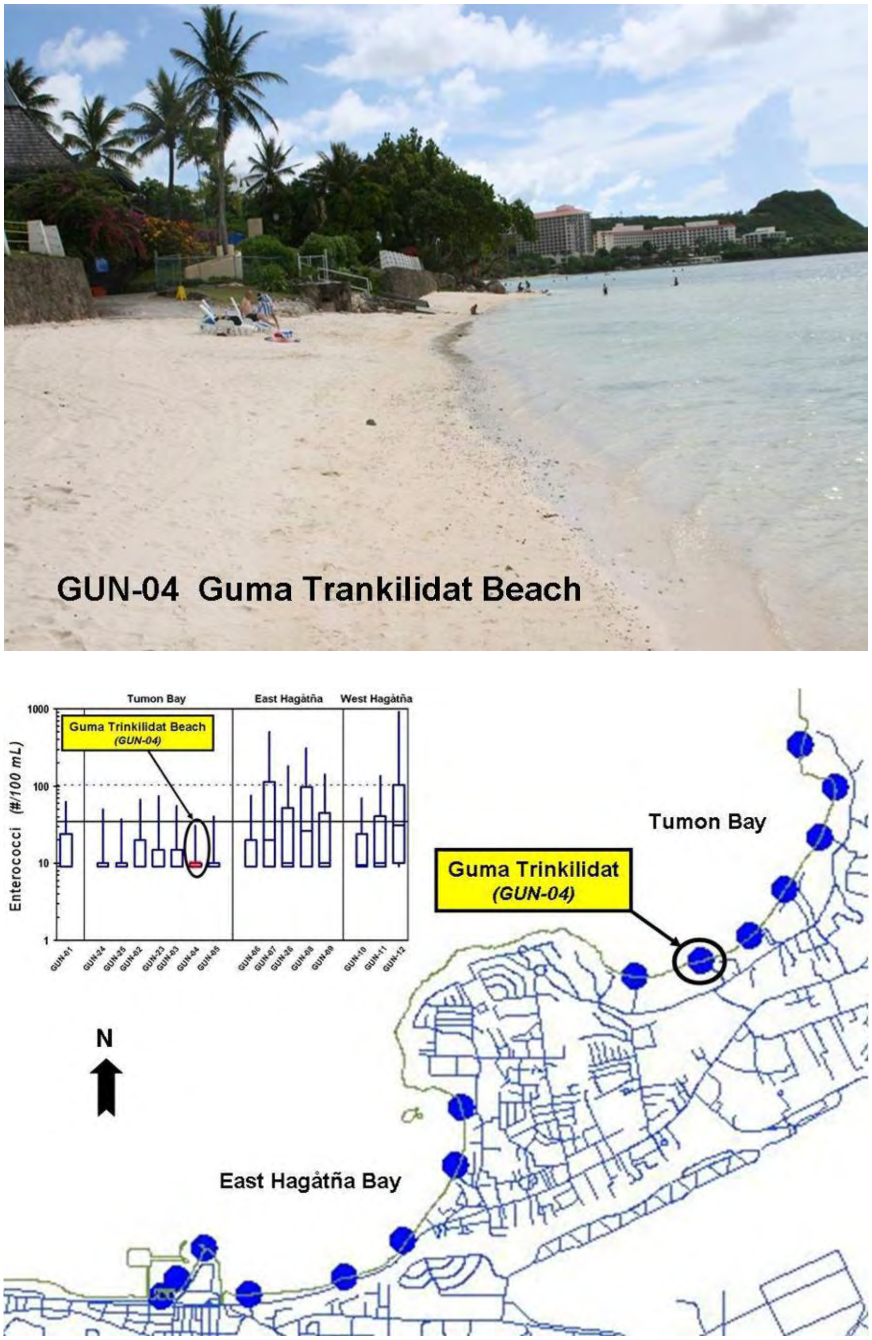

Figure 8-56. Location of Guma Trankilidat Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Guma Trankilidat Beach between 2005 and 2007 was low (4%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Guma Trankilidat Beach were among the lowest of all project area monitoring stations *(Figure 4-2 and Figure 8-56)*. The geometric mean of all individual samples was 13 counts /100mL, while the 75th and 90th percentiles were 10 and 31 counts /100 mL respectively. Although bacteria concentrations are lower than other RBMP sites, this beach is still impaired. Water quality improvements are clearly needed, though they will not be as significant as those required at other project area locations.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-57 shows the seasonal variability of bacteria concentrations at Guma Trankilidat Beach. The highest concentrations were observed between July and September, indicating the importance of wet season sources at Guma Trankilidat Beach.

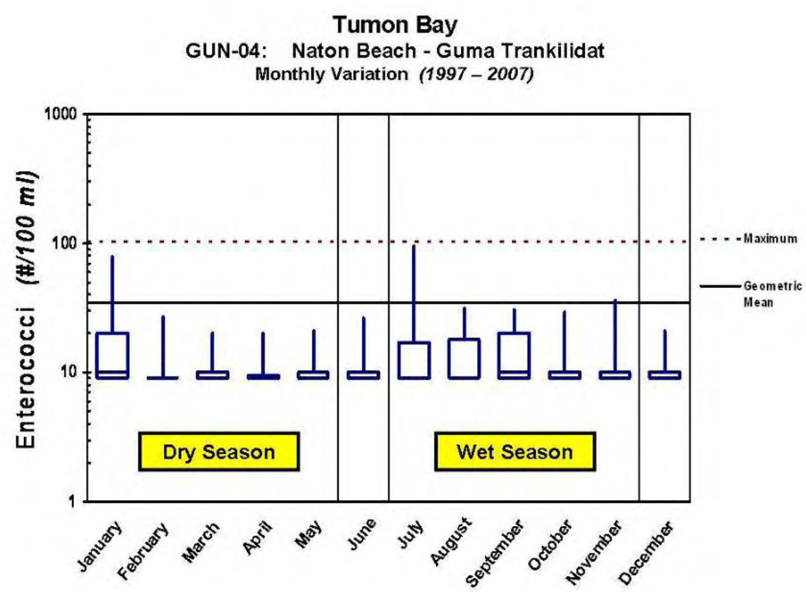

Figure 8-57. Seasonal variation at Guma Trankilidat Beach.

<u>Effect of Flow Conditions</u>. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-58 shows enterococci monitoring data collected at Guma Trankilidat Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-58, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during

heavy rainfall events. The magnitude of the increase appears to be fairly consistent with that observed at other Tumon Bay monitoring sites.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-59.

As noted earlier *(Figure 8-57)*, dry season bacteria concentrations observed at Guma Trankilidat Beach are extremely low. This pattern is consistent across all flow zones. The moderate effect of storm water runoff is evident for both the wet and dry seasons under high flow conditions. This reinforces the need to focus on storm water sources at Guma Trankilidat Beach. Furthermore, the low values observed for both the wet and dry seasons in the moist, mid-range, and dry zones confirm the fact that storm water sources are the major concern at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

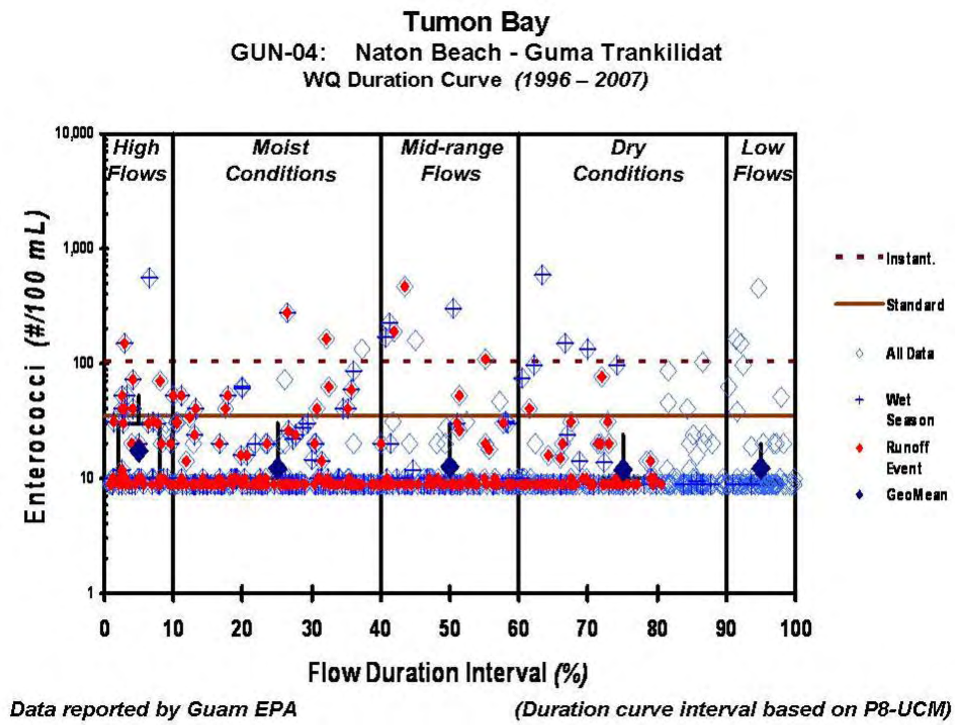

Figure 8-58. Water quality duration curve for Guma Trankilidat Beach site.

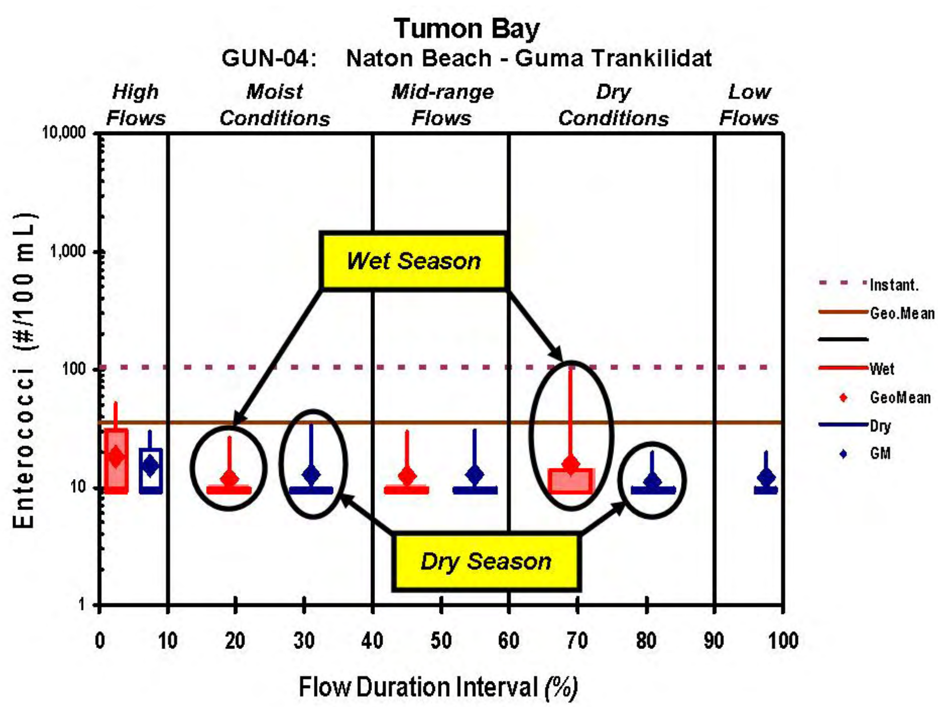

Figure 8-59. Wet versus dry season comparison for Guma Trankilidat Beach.

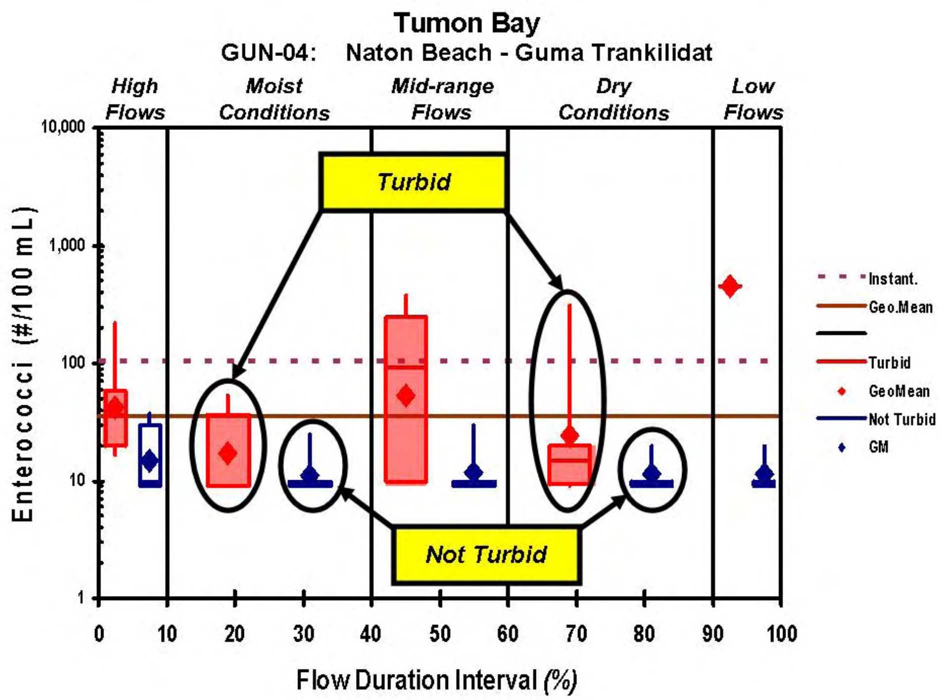

Figure 8-60. Turbid versus non-turbid sample comparison for Guma Trankilidat Beach site.

Figure 8-60 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Guma Trankilidat Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff, highway maintenance & runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Guma Trankilidat Beach *(Table 8-20)*.

Figure 8-61 provides a closer look at the Guma Trankilidat Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-61 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-61 also identifies major storm water ponding basins, including the Harmon Sink.

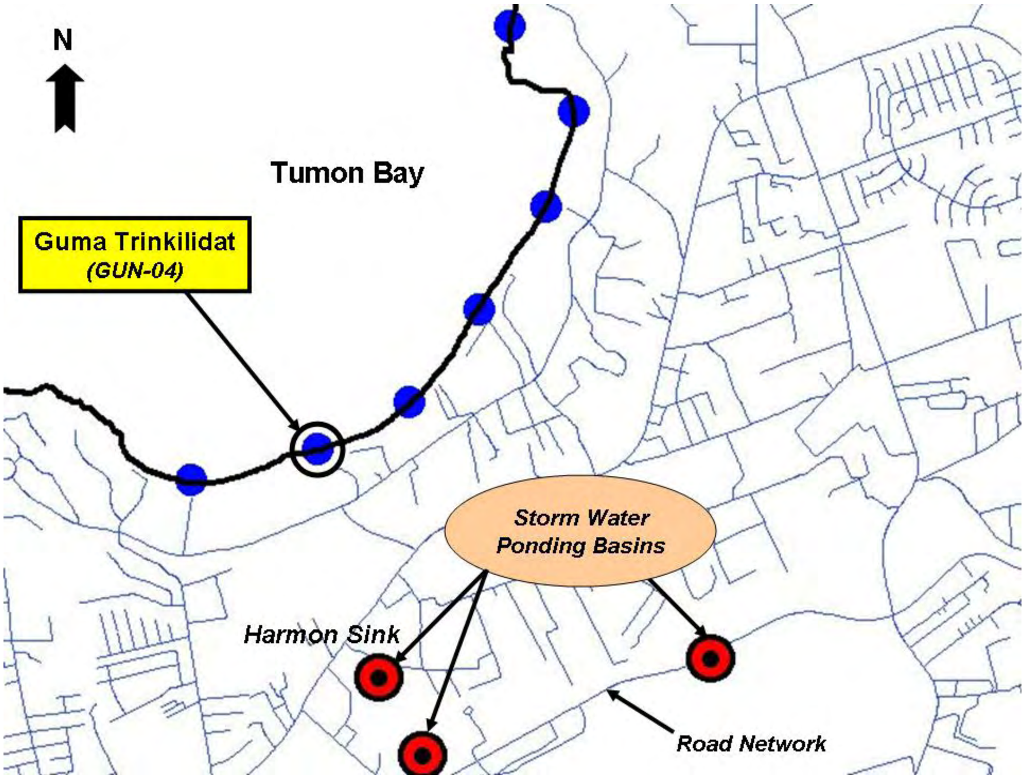

Figure 8-61. Location of Guma Trankilidat Beach relative to potential source areas.

Table 8-20. Beach specific potential source summary *(Site GUN-04: Guma Trankilidat Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-04	Storm drain runoff	Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Sewage overflow	Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Guma Trankilidat Beach. This information is shown in Figure 8-62. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-62 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

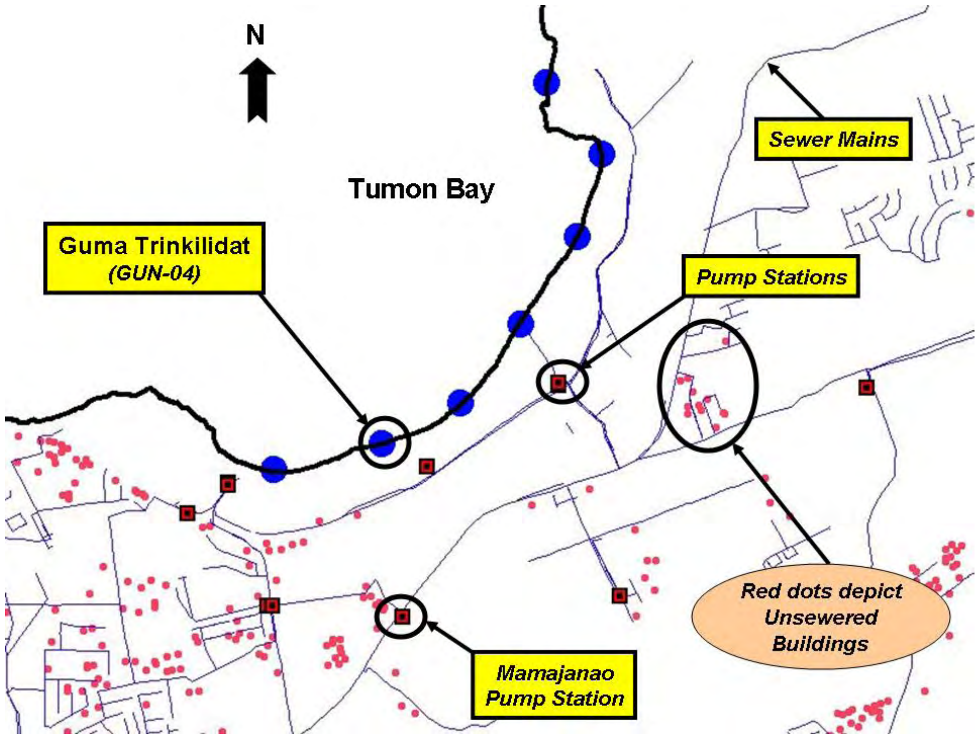

Figure 8-62. Location of Guma Trankilidat Beach relative to potential unsewered buildings.

Figure 8-63. Air photo of Guma Trankilidat Beach vicinity.

Figure 8-63 shows an air photo of the area adjacent to Guma Trankilidat Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Guma Trankilidat Beach.

Trends. Figure 8-64 presents a year-by-year summary of the enterococcus data for the Guma Trankilidat Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

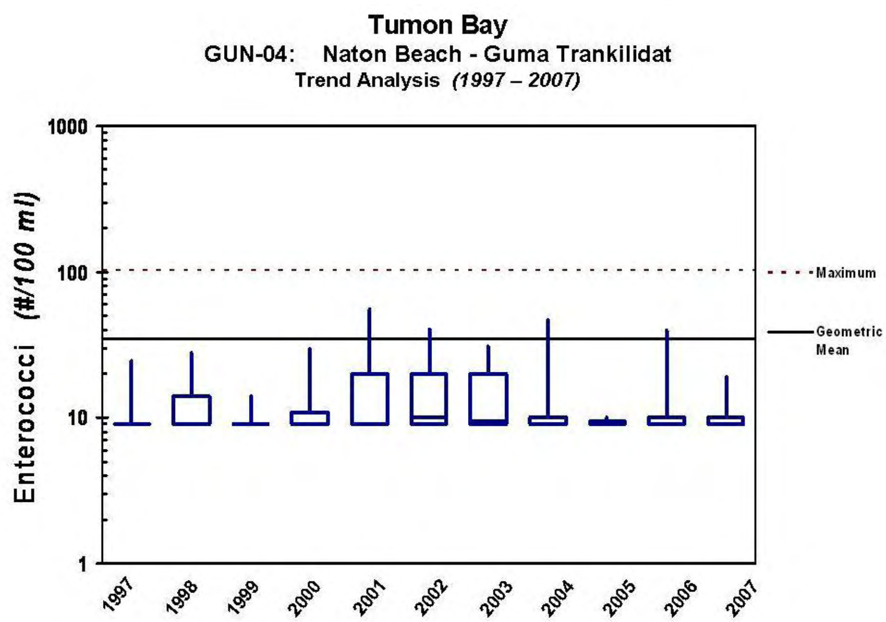

Figure 8-64. Trend analysis for Guma Trankilidat Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Guma Trankilidat Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and September, indicating the importance of wet season sources at Guma Trankilidat Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Guma Trankilidat Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Guma Trankilidat Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-21 presents the TMDL for Guma Trankilidat Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-21. Northern Guam Watershed TMDL summary *(Site GUN-04: Guma Trankilidat Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-22 identifies those conditions under which Guam's water quality criteria for enterococci was exceeded. This information can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions). As noted, reductions could not be determined based on the 90th percentile of the monitoring data. However, advisories have still been issued at this location indicating the need for water quality improvements.

Table 8-22. Needed reductions to meet TMDL targets *(Site GUN-04: Guma Trankilidat Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	*Note ***	*Note ***	*Note ***	*Note ***
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	*Note ***	*Note ***	*Note ***	*Note ***	---

Note: Although reductions could not be determined based on the 90th percentile of monitoring data, exceedances of the instantaneous maximum criteria were observed in zones noted. These exceedances indicate that this beach is threatened until exceedances are eliminated.

8.8 Ypao Beach (GUN-05)

Ypao Beach is situated at the southern end of the Tumon Bay, and is one of the only two beach parks in Tumon. *(Figure 8-65)*. Ypao Beach is one of the island's most popular recreational parks for picnics, sporting activities, and concerts. This beach is highly used for swimming, wind-surfing, kayaking and other popular water activities. Because Tumon Bay is protected by a natural reef, the waters off Ypao Beach offer access to excellent snorkeling spots with a multitude of sea life gathered around live coral on the sea floor.

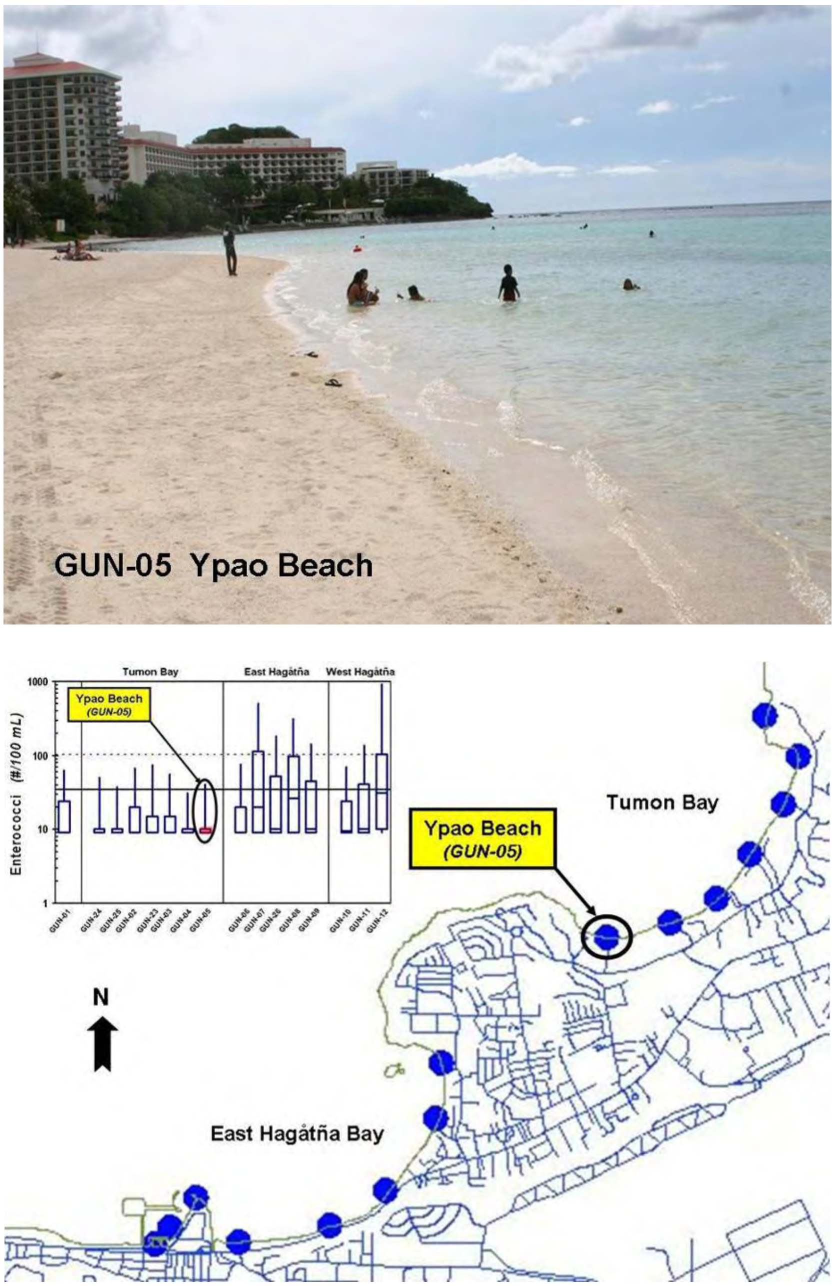

Figure 8-65. Location of Ypao Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Ypao Beach between 1997 and 2007 was low (7%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Ypao Beach were among the lowest of all project area monitoring stations *(Figure 4-2 and Figure 8-65)*. The geometric mean of all individual samples was 13 counts /100mL, while the 75th and 90th percentiles were 10 and 41 counts /100 mL respectively.

Although bacteria concentrations are lower than other RBMP sites, this beach is still impaired. Water quality improvements are clearly needed, though they will not be as significant as those required at other project area locations.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-66 shows the seasonal variability of bacteria concentrations at Ypao Beach. The highest concentrations were observed in July and August, indicating the importance of wet season sources at Ypao Beach.

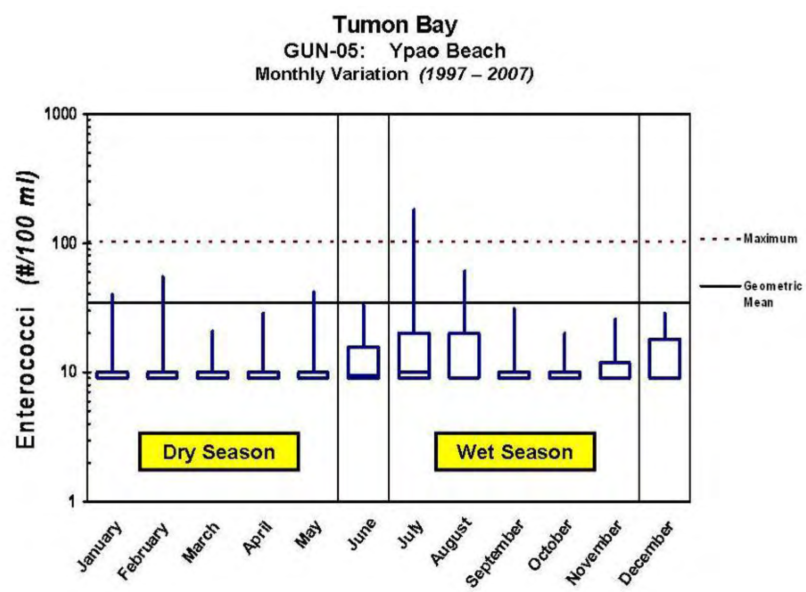

Figure 8-66. Seasonal variation at Ypao Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-67 shows enterococci monitoring data collected at Ypao Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-67, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase appears to be fairly consistent with that observed at other Tumon Bay monitoring sites.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-68.

As noted earlier *(Figure 8-66)*, dry season bacteria concentrations observed at Ypao Beach are extremely low. This pattern is consistent across all flow zones. The moderate effect of storm water runoff is evident for both the wet and dry seasons under high flow conditions. This reinforces the need to focus on storm water sources at Ypao Beach. However, an interesting observation is the difference between the wet and dry season patterns under dry conditions. The higher wet season values in this zone indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

<u>Relationship to Other Indicators</u>. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

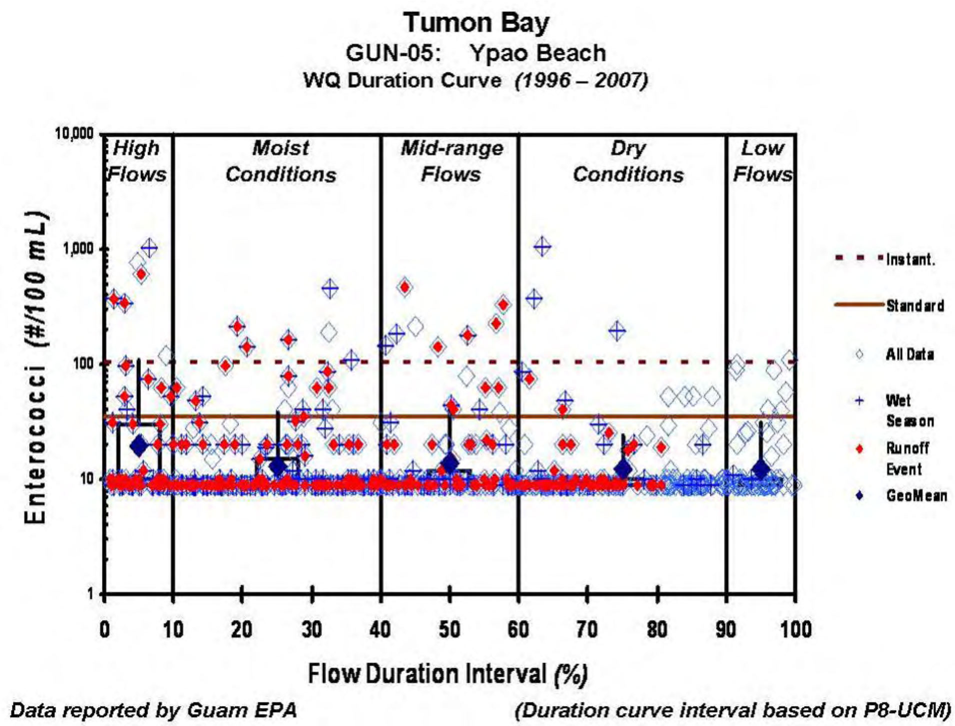

Figure 8-67. Water quality duration curve for Ypao Beach site.

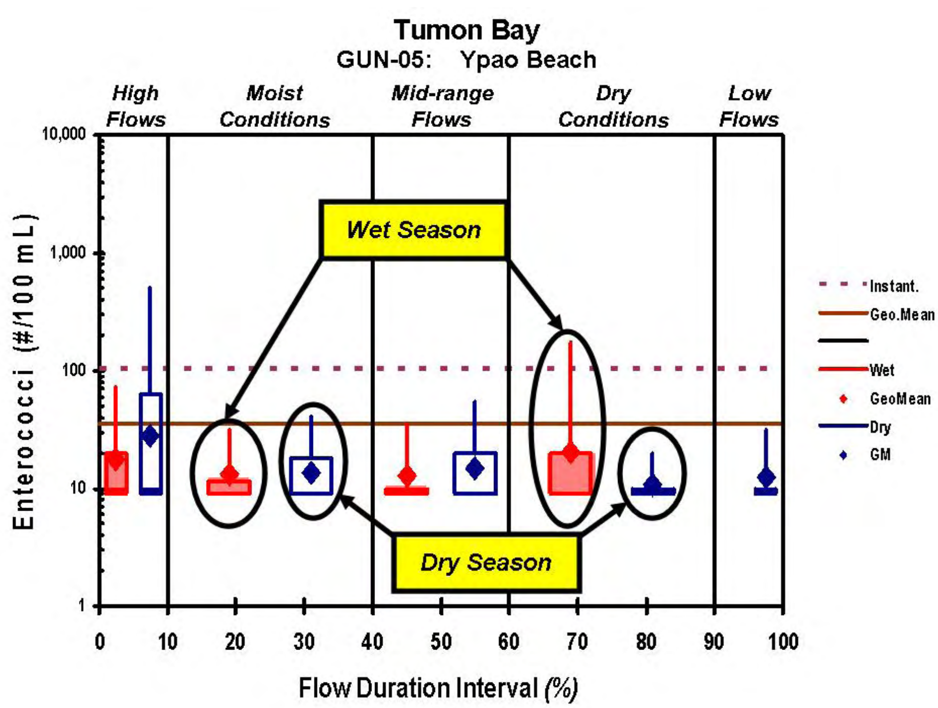

Figure 8-68. Wet versus dry season comparison for Ypao Beach.

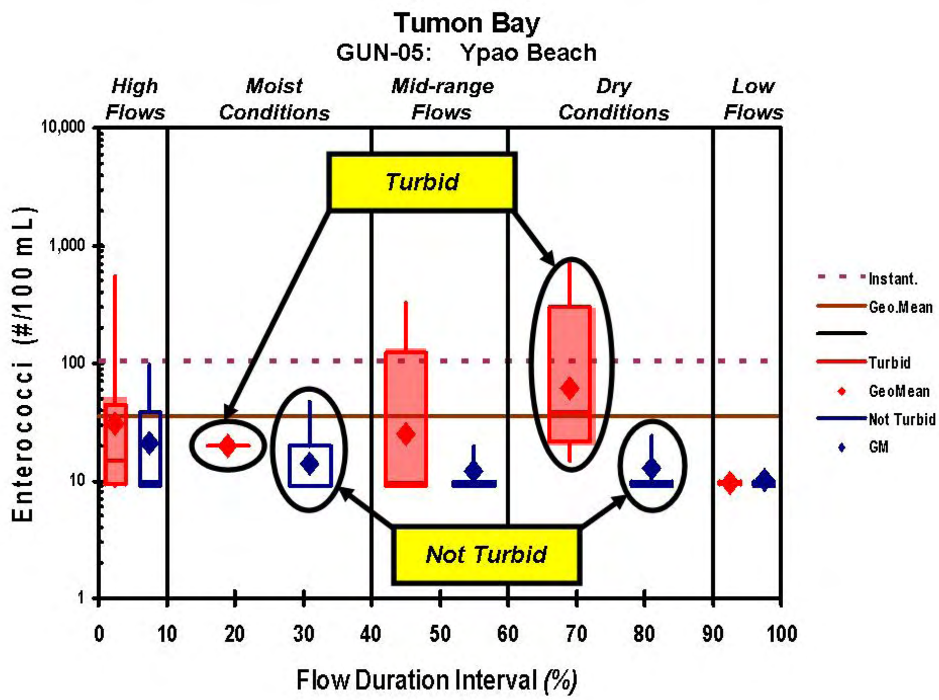

Figure 8-69. Turbid versus non-turbid sample comparison for Ypao Beach site.

Figure 8-69 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Ypao Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff, highway maintenance & runoff, construction), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Ypao Beach *(Table 8-23)*.

Figure 8-70 provides a closer look at the Ypao Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-70 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-70 also identifies major storm water ponding basins, including the Harmon Sink.

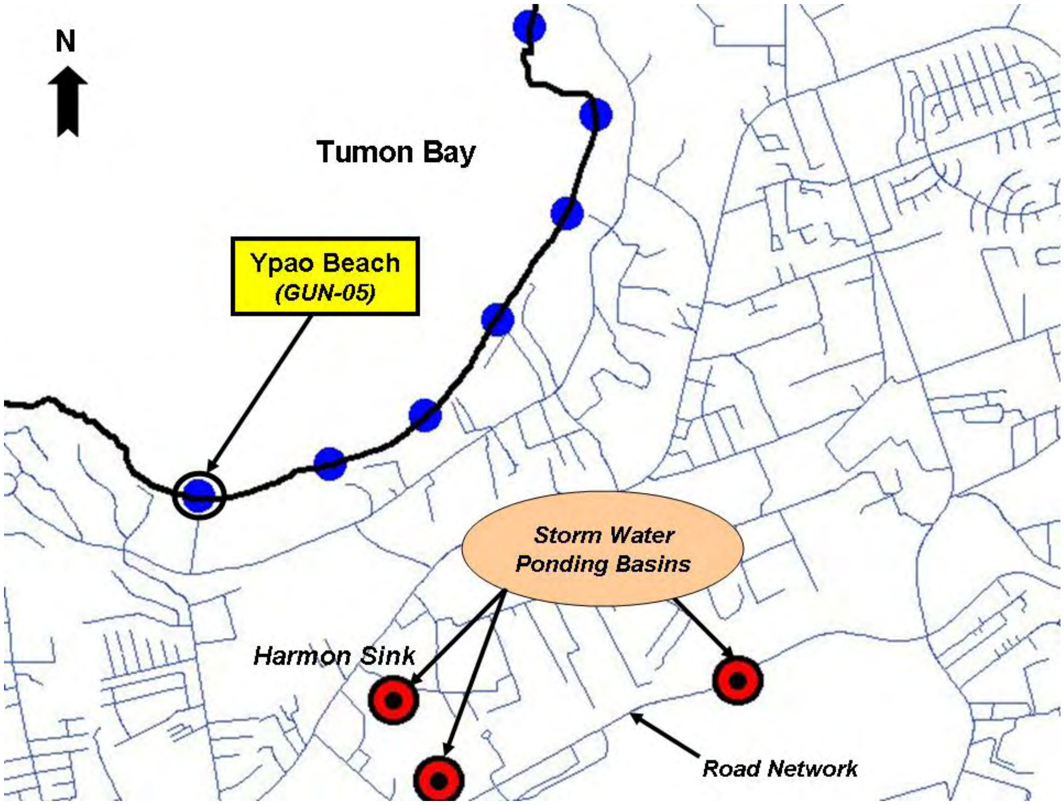

Figure 8-70. Location of Ypao Beach relative to potential source areas.

Table 8-23. Beach specific potential source summary *(Site GUN-05: Ypao Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-05	Sewage overflow	Ypao Sewage Pump Station
		Manhole- sewer overflow *FID #952*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*
	Storm drain runoff	Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Ypao Beach. This information is shown in Figure 8-71. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-71 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-72 shows an air photo of the area adjacent to Ypao Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Ypao Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Ypao Beach. Specifically, there are two areas of concern. First, there is a manhole (FID #952) that has had sewage overflow problems, which may be affecting water quality at this site. Second, the Ypao Pump Station *(Figure 8-71)* is located nearby. There has been occasional sewage overflows associated with this facility, which could explain periodic elevated bacteria concentrations at this location.

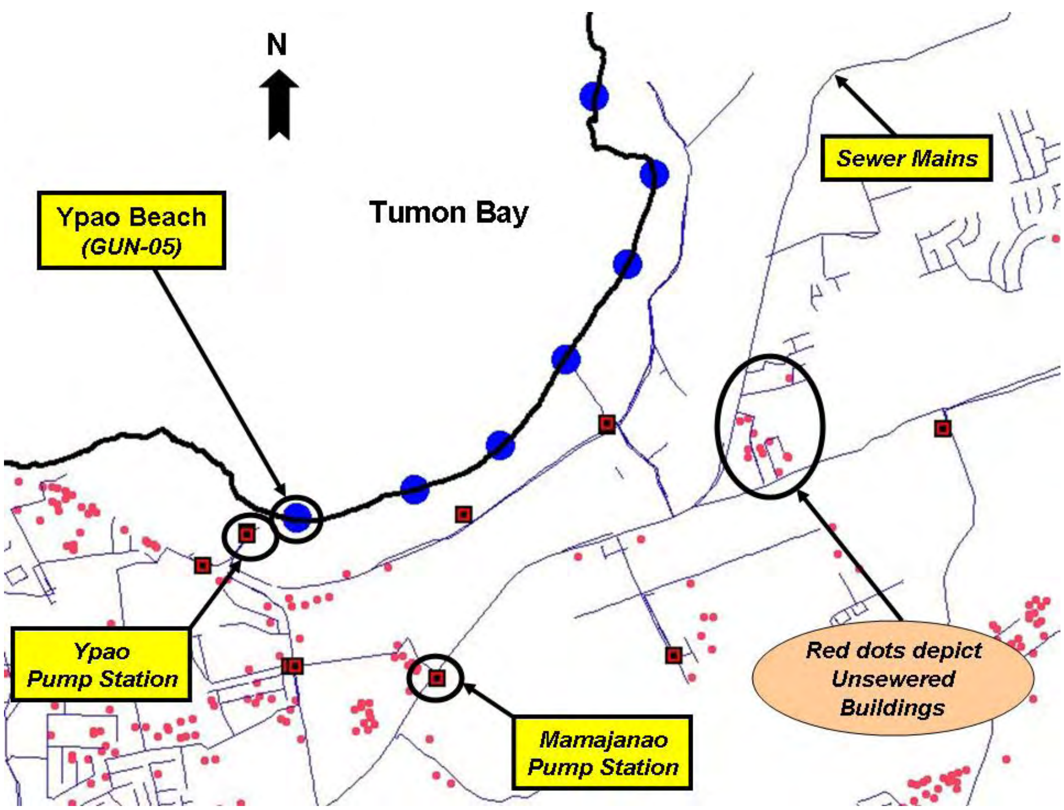

Figure 8-71. Location of Ypao Beach relative to potential unsewered buildings.

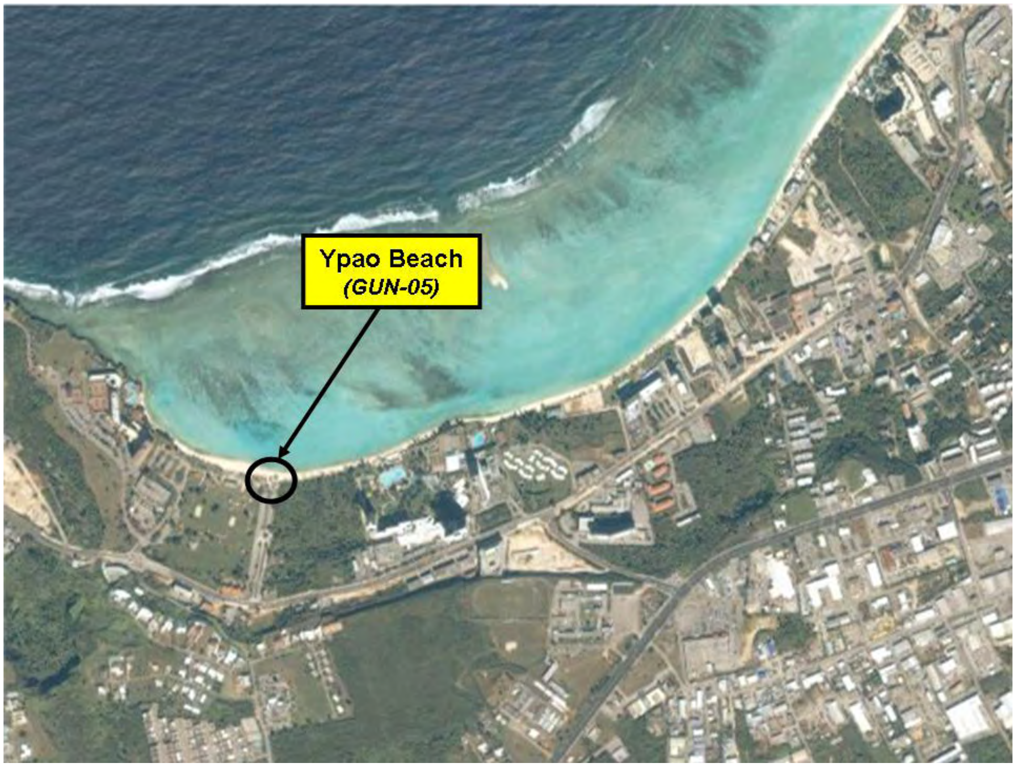

Figure 8-72. Air photo of Ypao Beach vicinity.

Trends. Figure 8-73 presents a year-by-year summary of the enterococcus data for the Ypao Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90^{th} percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Ypao Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and August, indicating the importance of wet season sources at Ypao Beach. This is consistent with the presence of potential storm water sources identified at this location.

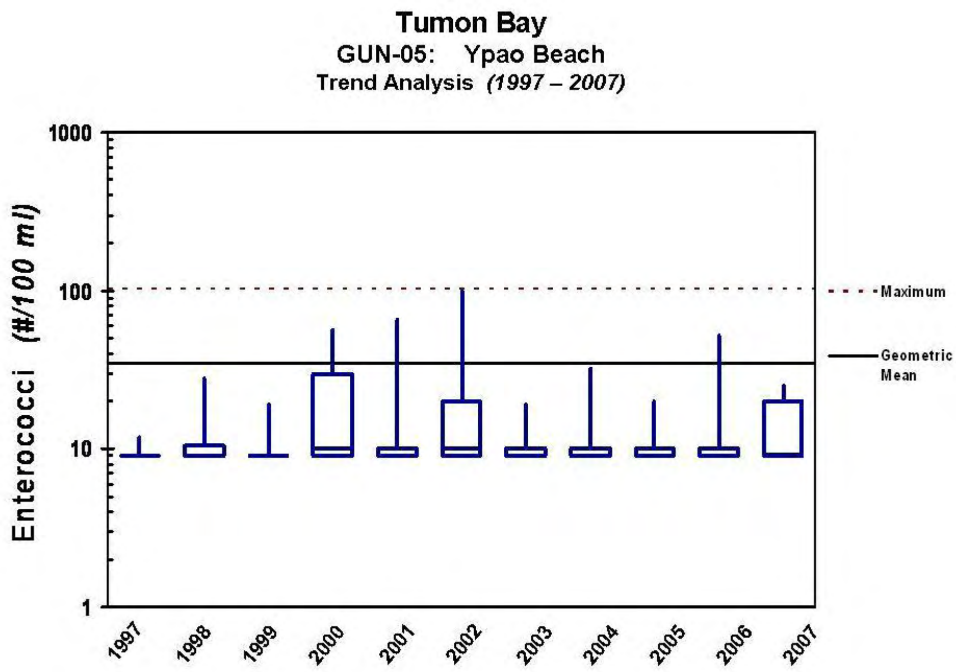

Figure 8-73. Trend analysis for Ypao Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Ypao Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Ypao Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-24 presents the TMDL for Ypao Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-24. Northern Guam Watershed TMDL summary *(Site GUN-05: Ypao Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-25 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-25. Needed reductions to meet TMDL targets *(Site GUN-05: Ypao Beach)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	80%	---	---	---	---
Wet Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	---	---	41%	---

8.9 Sleepy Lagoon (GUN-06)

Sleepy Lagoon Beach is the northernmost monitoring site on East Hagåtña Bay *(Figure 8-74)*. It is a very popular destination for water sports including parasailing, kayaking, and jet skiing. Several hotels are located along the shoreline to the north and south of Sleepy Lagoon Beach. The upland area to the east of Sleepy Lagoon Beach is predominantly residential with some commercial business along main roads.

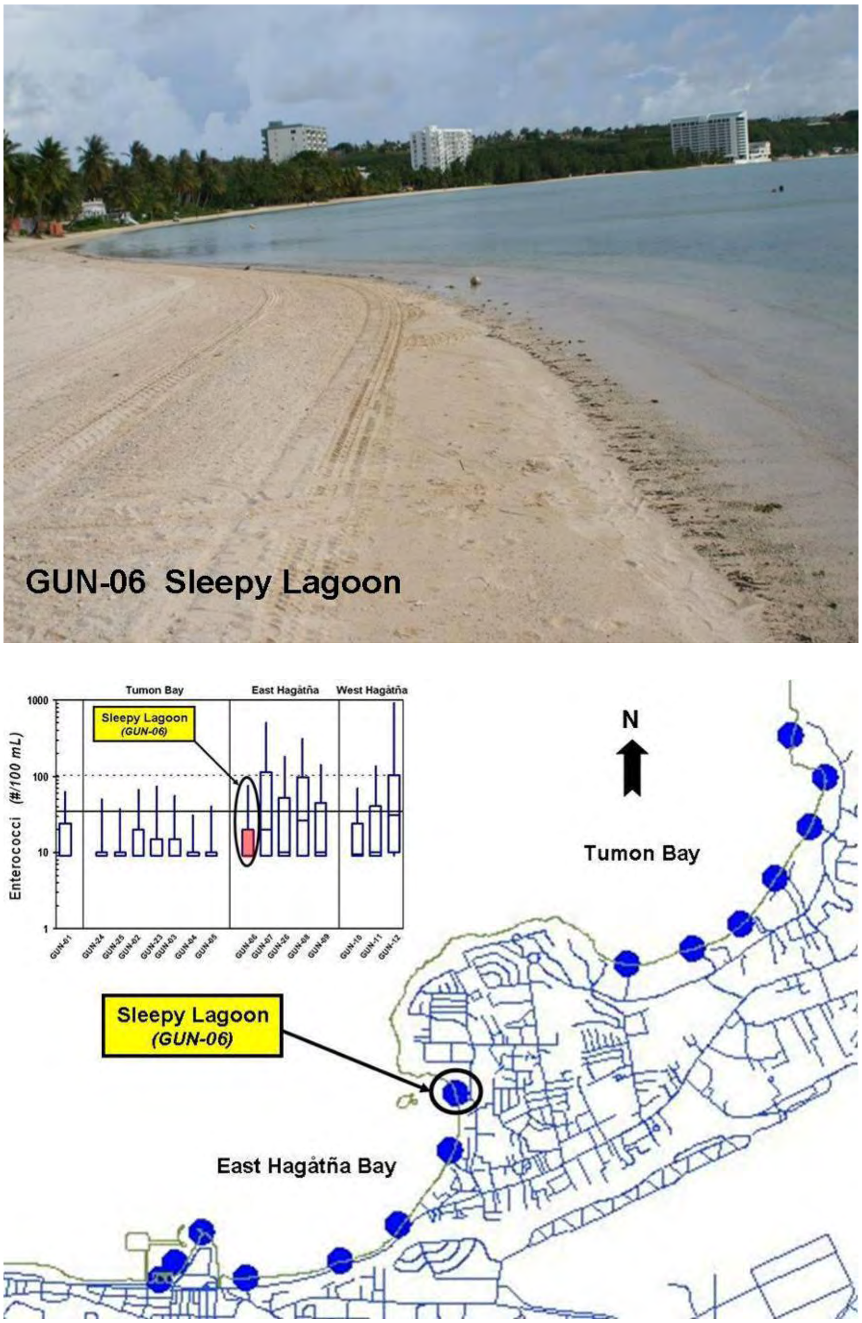

Figure 8-74. Location of Sleepy Lagoon Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Sleepy Lagoon Beach between 1997 and 2007 was slightly higher (16%) than other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Sleepy Lagoon Beach were basically in the same range as a number of other project area monitoring stations *(Figure 4-2 and Figure 8-74)*. The geometric mean of all individual samples was 17 counts /100mL, while the 75th and 90th percentiles were 20 and 76 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-75 shows the seasonal variability of bacteria concentrations at Sleepy Lagoon Beach. The highest concentrations were observed between July and March, indicating the importance of both wet and dry season sources at Sleepy Lagoon Beach.

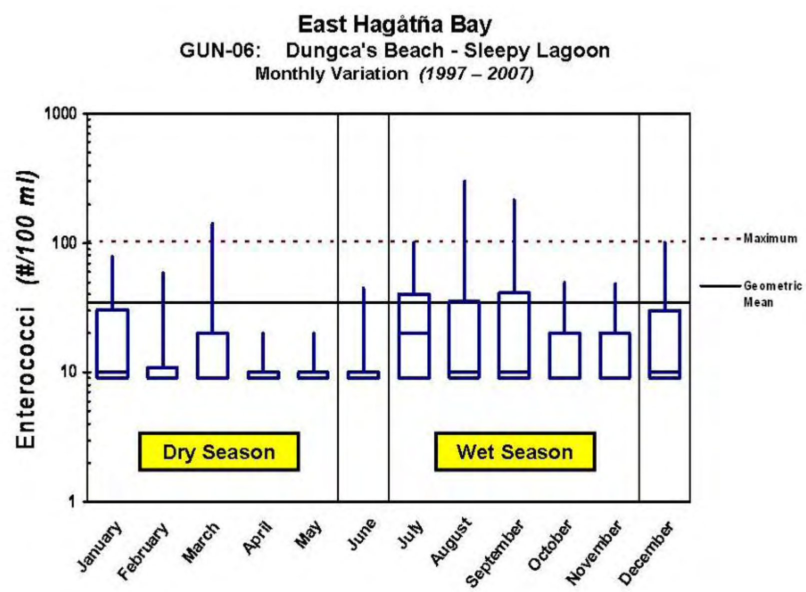

Figure 8-75. Seasonal variation at Sleepy Lagoon Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-76 shows enterococci monitoring data collected at Sleepy Lagoon Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-76, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean

exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that over 30 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during heavy rains) may also be a concern under these conditions.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75^{th} and 90^{th} percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-77.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. This reinforces the need to focus on storm water sources at Sleepy Lagoon Beach. However, an interesting observation is the difference between the wet and dry season patterns under dry conditions. The higher wet season values in the dry zone indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

Figure 8-78 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

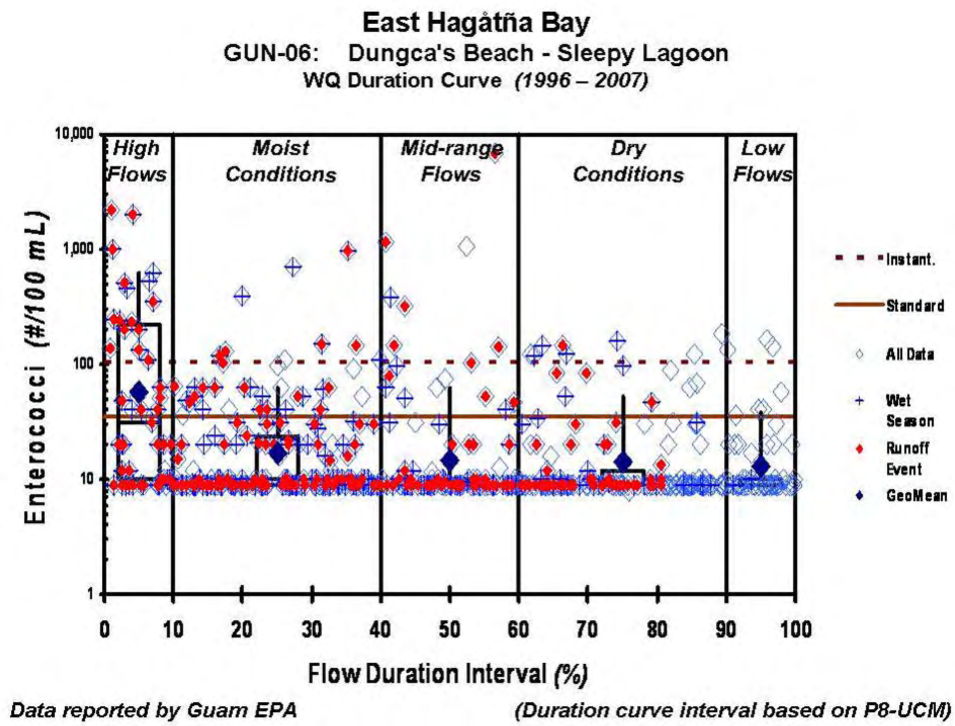

Figure 8-76. Water quality duration curve for Sleepy Lagoon Beach site.

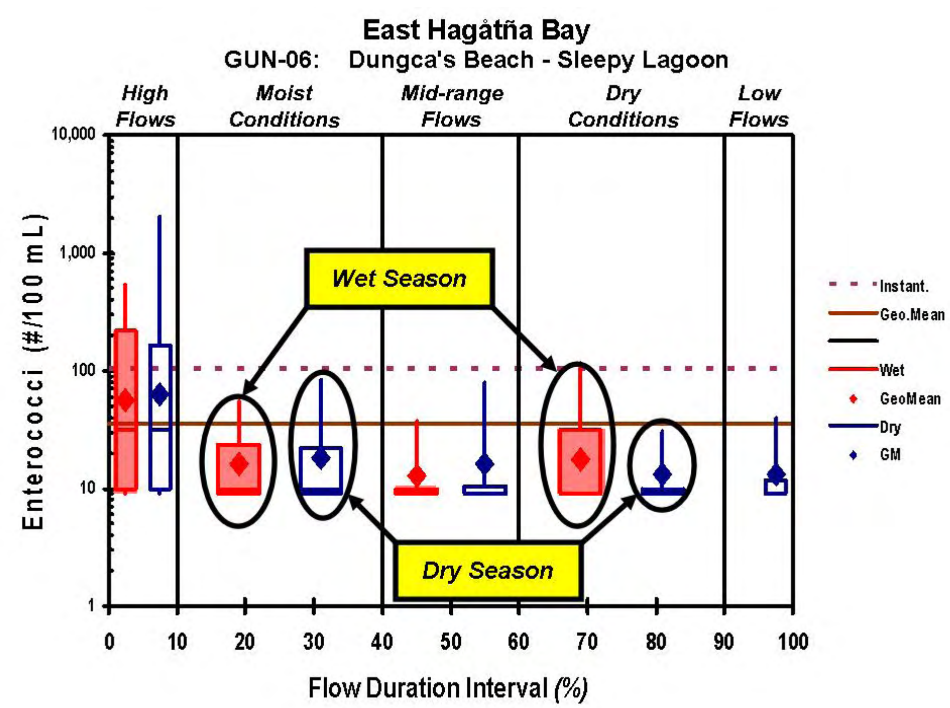

Figure 8-77. Wet versus dry season comparison for Sleepy Lagoon Beach.

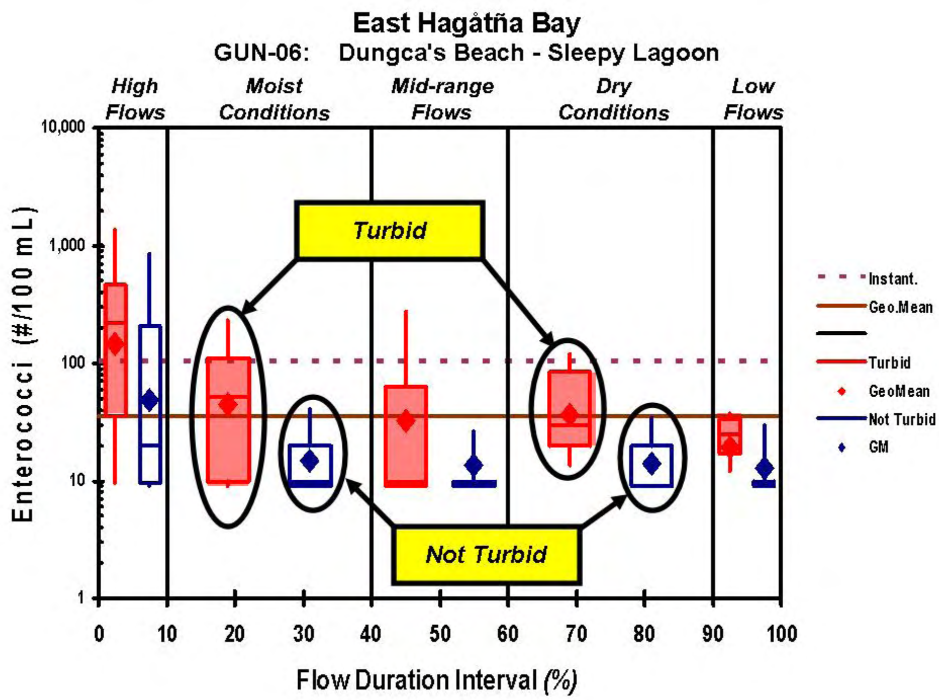

Figure 8-78. Turbid versus non-turbid sample comparison for Sleepy Lagoon Beach site.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Sleepy Lagoon Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water runoff, and other sources (recreation & tourism activities, debris & bottom deposits). In addition, GEPA staff identified specific potential sources that could affect water quality at Sleepy Lagoon Beach *(Table 8-26)*.

Figure 8-79 provides a closer look at the Sleepy Lagoon Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-79 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-79 also identifies major storm water ponding basins, including the Harmon Sink.

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Sleepy Lagoon Beach. This information is shown in Figure 8-80. In addition, sewer line blockages and breaks, as well as SSOs, could contribute to elevated bacteria levels. Figure 8-80 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

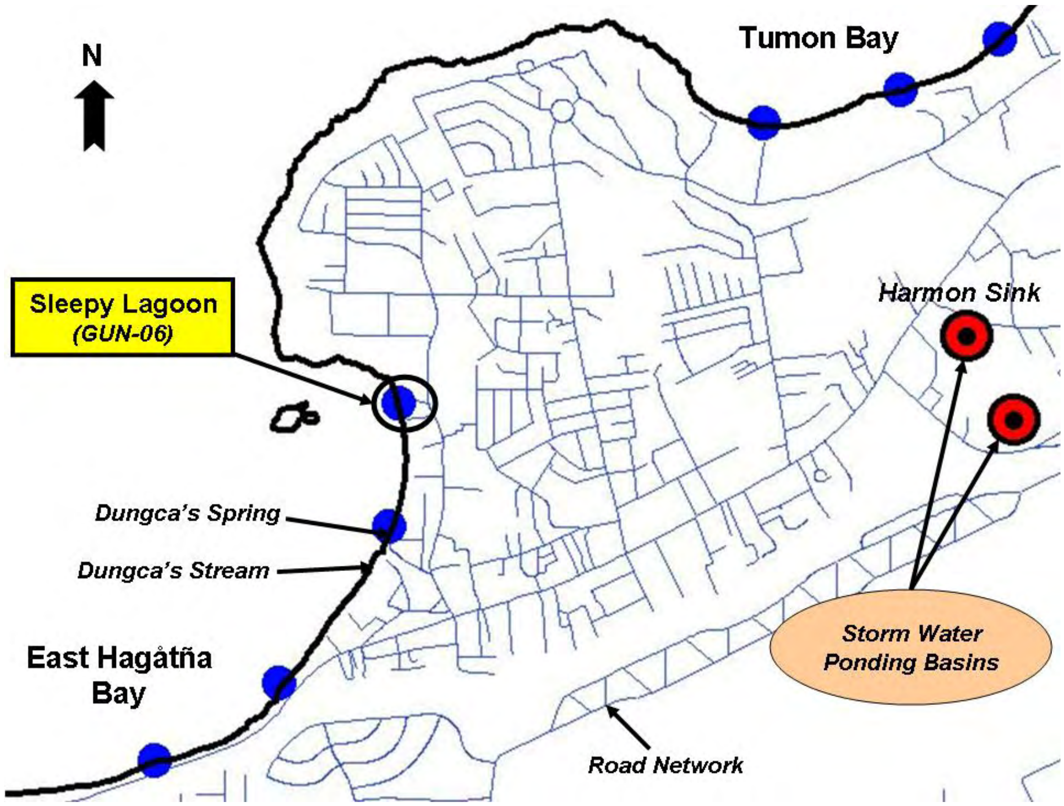

Figure 8-79. Location of Sleepy Lagoon Beach relative to potential source areas.

Table 8-26. Beach specific potential source summary *(Site GUN-06: Sleepy Lagoon Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-06	Sewage overflow	Manhole- sewer overflow *Frequent overflows to storm drain leading to East Hagåtña Bay.*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*
	Wastewater	Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
	Storm drain runoff	Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*

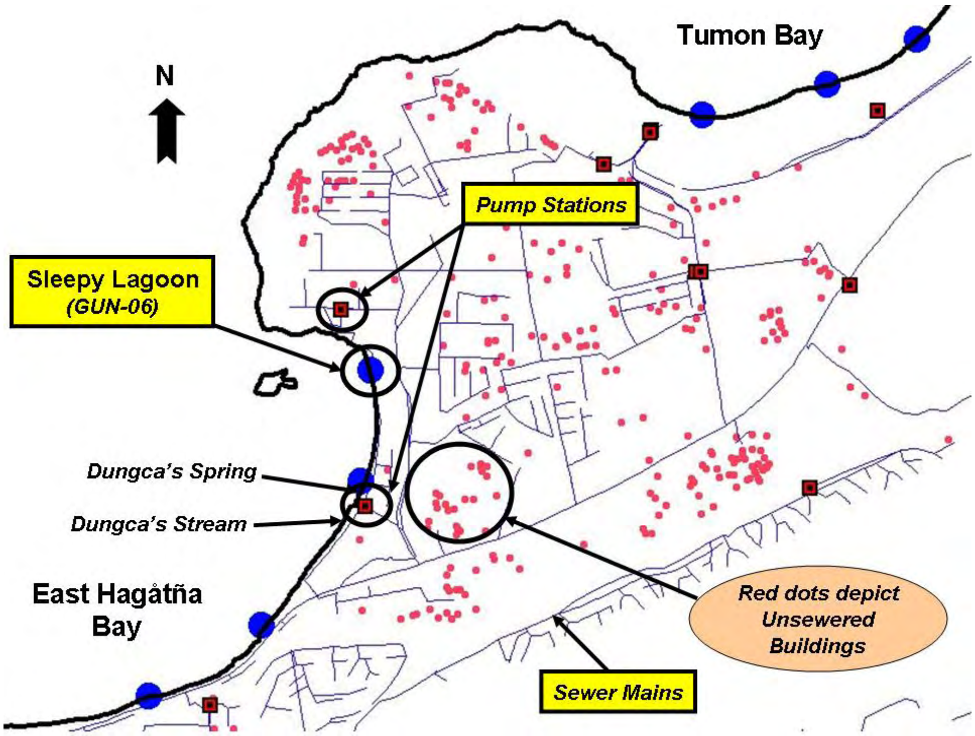

Figure 8-80. Location of Sleepy Lagoon Beach relative to potential unsewered buildings.

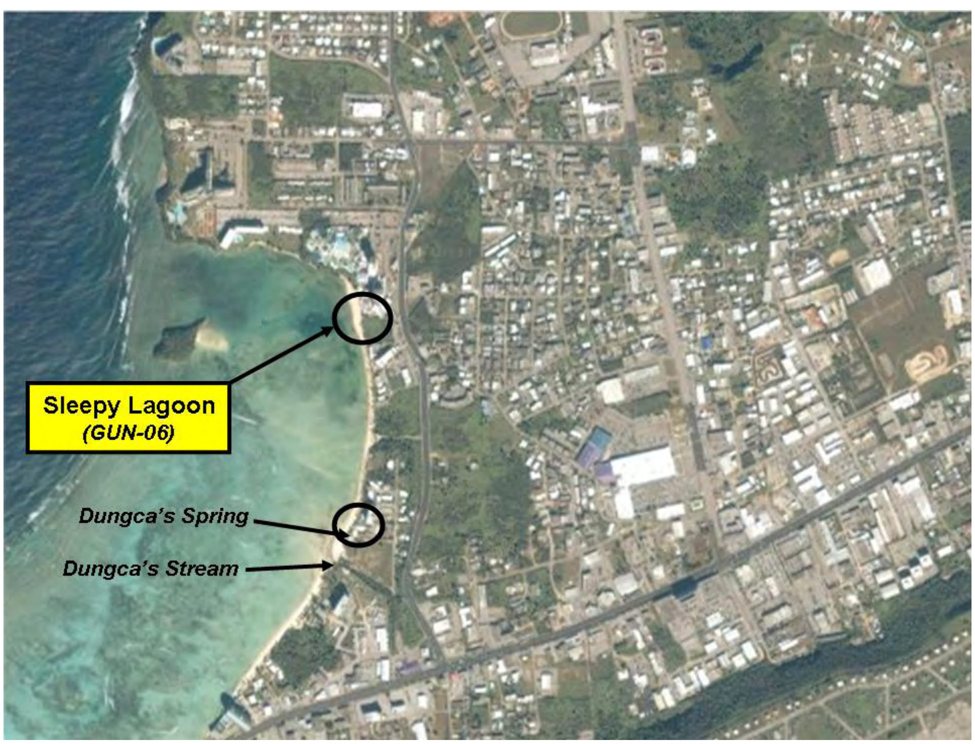

Figure 8-81. Air photo of Sleepy Lagoon Beach vicinity.

Figure 8-81 shows an air photo of the area adjacent to Sleepy Lagoon Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Sleepy Lagoon Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Sleepy Lagoon Beach. Specifically, there are a number of concerns in the vicinity of Dungca's Beach described in Section 8.10. These potential source areas, under the right wind and tide conditions, could also have an adverse effect on water quality at Sleepy Lagoon Beach.

Trends. Figure 8-82 presents a year-by-year summary of the enterococcus data for the Sleepy Lagoon Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

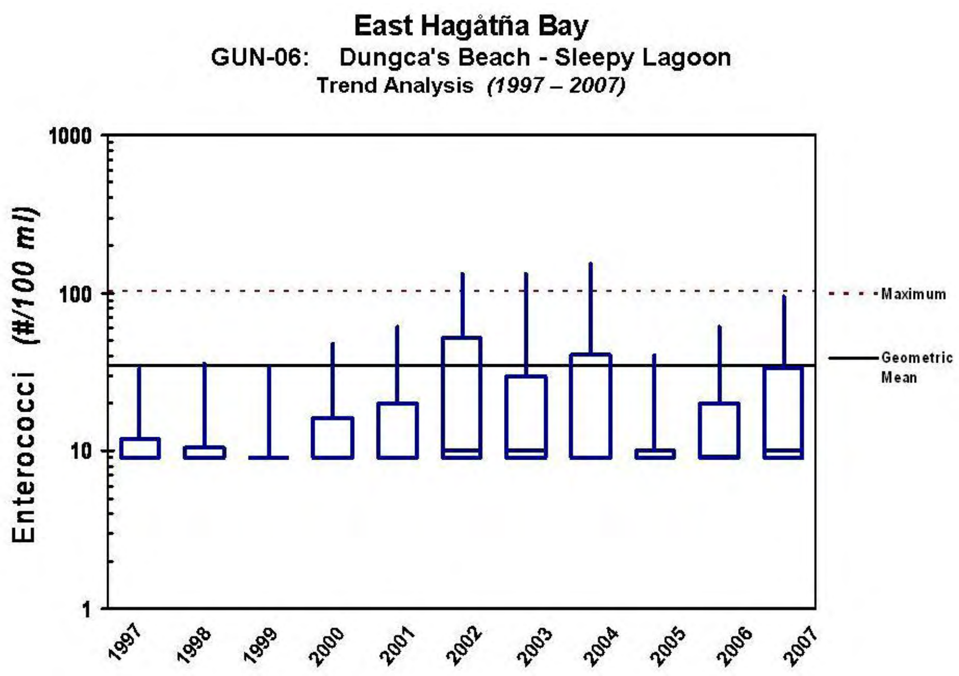

Figure 8-82. Trend analysis for Sleepy Lagoon Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Sleepy Lagoon Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and March, indicating the importance of both wet and dry season sources at Sleepy Lagoon Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Sleepy Lagoon Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Sleepy Lagoon Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-27 presents the TMDL for Sleepy Lagoon Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-27. Northern Guam Watershed TMDL summary *(Site GUN-06: Sleepy Lagoon Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-28 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-28. Needed reductions to meet TMDL targets *(Site GUN-06: Sleepy Lagoon Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	44%	---	---	---	---
Based on instantaneous maximum	95%	---	---	---	---
Wet Season					
Based on geometric mean	36%	---	---	---	---
Based on instantaneous maximum	81%	---	---	10%	---

8.10 Dungca's Beach (GUN-07)

Dungca's Beach is situated along the northern coast of the East Hagåtña Bay beach front *(Figure 8-83)*. It is a very popular destination for water sports including banana boat rides, parasailing, kayaking, and jet skiing. Several hotels are located along the shoreline to the north and south of Dungca's Beach. The upland area to the east of Dungca's Beach is predominantly residential with some commercial business along main roads.

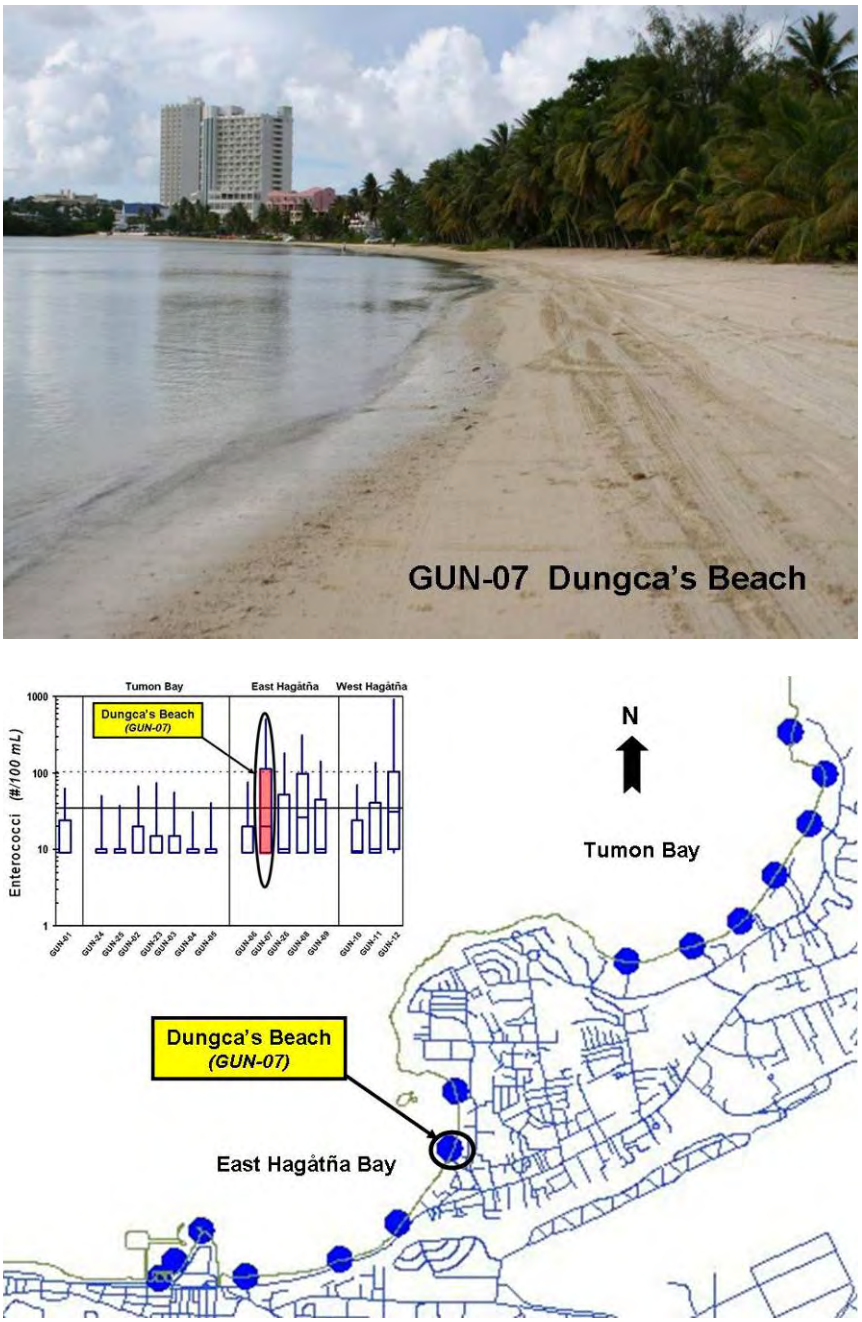

Figure 8-83. Location of Dungca's Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Dungca's Beach between 1997 and 2007 was very high (55%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Dungca's Beach were also quite high compared to other project area monitoring stations *(Figure 4-2 and Figure 8-83)*. The geometric mean of all individual samples was 38 counts /100mL, while the 75th and 90th percentiles were 112 and 506 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-84 shows the seasonal variability of bacteria concentrations at Dungca's Beach. High concentrations were observed all year, indicating the importance of both wet and dry season sources at Dungca's Beach.

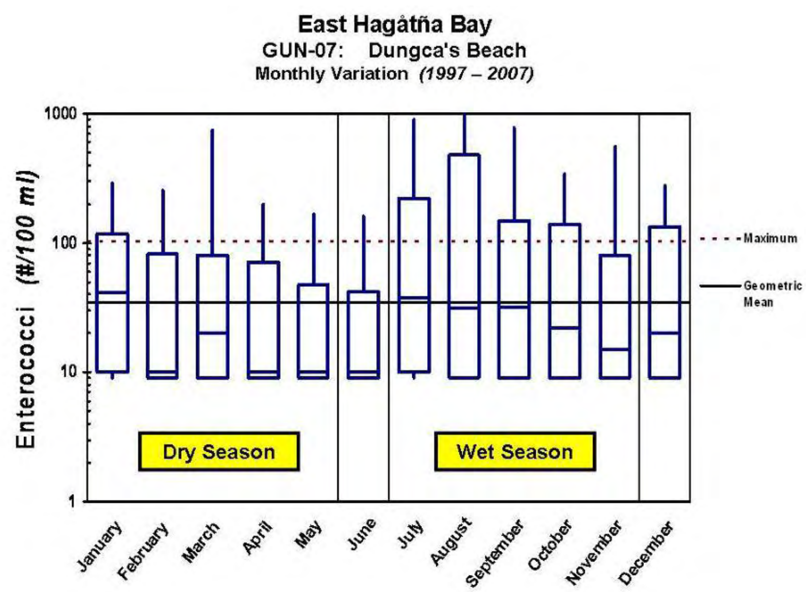

Figure 8-84. Seasonal variation at Dungca's Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-85 shows enterococci monitoring data collected at Dungca's Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-85, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is significantly higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean exceeded the criterion under both high flow and moist conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that over 60 percent of all values in the high flow zone and 30 percent of all values in the moist zone exceed the instantaneous maximum criterion value. Furthermore, the 90^{th} percentile exceeds the instantaneous maximum criterion value across all zones, indicating that sources other than storm water are adversely affecting bacteria concentrations at Dungca's Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75^{th} and 90^{th} percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-86.

The effect of storm water runoff is evident for both the wet and dry seasons under high flow and moist conditions. One noteworthy observation is the elevated dry season geometric mean and 90^{th} percentile under high flow conditions. This could be due to bacteria sources associated with overland flow and storm water ponding basins. High flows in the dry season tend to be primarily influenced by storm events. In contrast, high flows during the wet season result from a combination of storm events and more saturated groundwater conditions.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

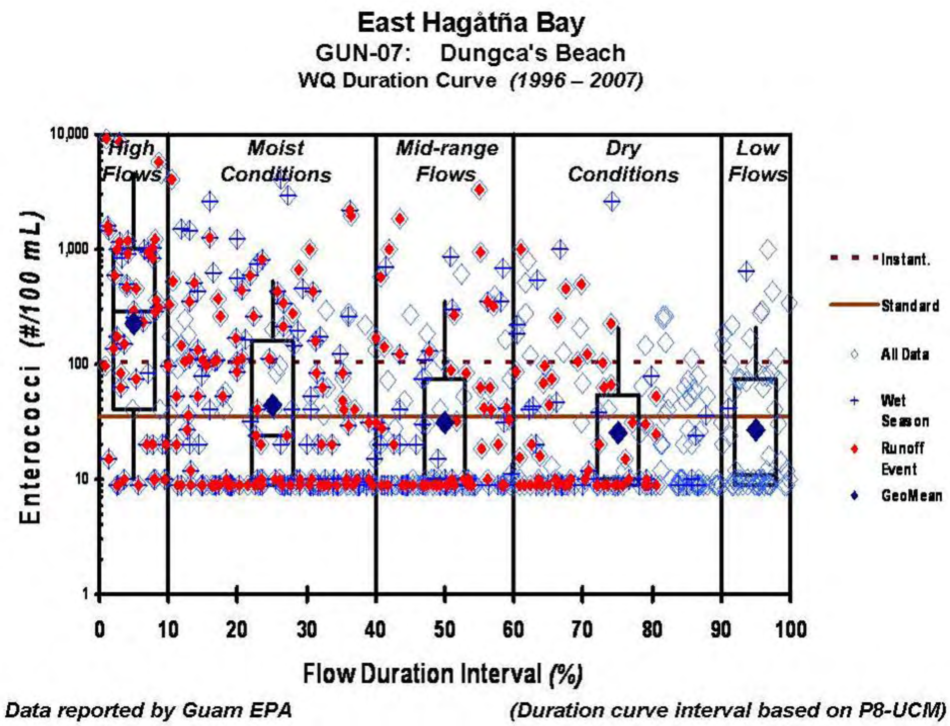

Figure 8-85. Water quality duration curve for Dungca's Beach site.

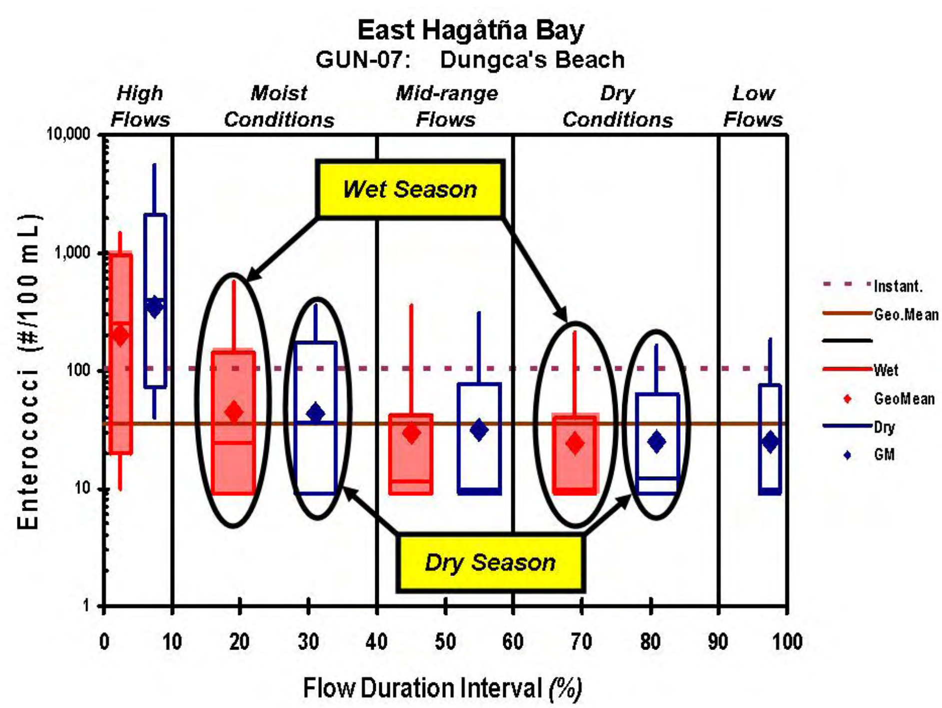

Figure 8-86. Wet versus dry season comparison for Dungca's Beach.

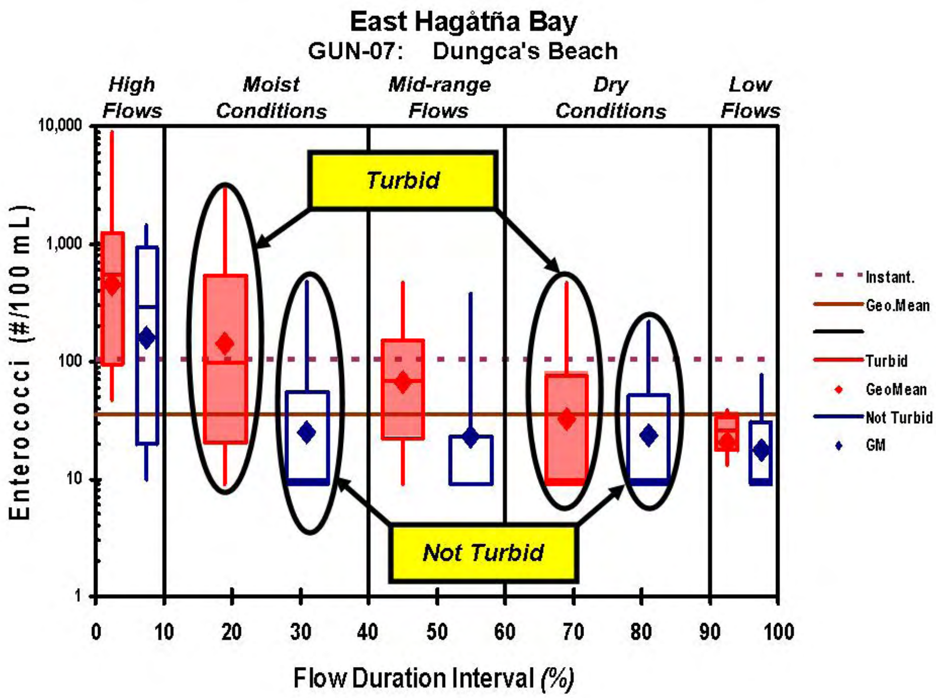

Figure 8-87. Turbid versus non-turbid sample comparison for Dungca's Beach site.

Figure 8-87 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Dungca's Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff; highway, road, & bridge runoff), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Dungca's Beach *(Table 8-29)*.

Table 8-29. Beach specific potential source summary *(Site GUN-07: Dungca's Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-07	Storm drain runoff	Dungca's River - an open Storm Drain *This system drains runoff from Marine Drive from Airport Road.*
		Guam Premier Outlet (GPO) storm water *Runoff from GPO drains to Marine Drive and out Dungca's River/open storm drain.*
		Ben Franklin *Pipe drains to Dungca's River / open storm drain.*
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Sewage overflow	Manhole- sewer overflow • *via Dungca's River / open storm drain.* • *Frequent overflows to storm drain leading to East Hagåtña Bay.*
		Manhole- sewer overflow *(5 locations)* *via Marine Drive Storm drainage to Dungca's River / open storm drain.*
		Manhole- sewer overflow *(2 locations)* *Near airport in Tiyan housing Lower E. Sunset Road.*
		GWA sewer main lines inadequate slope (east to Rt 30 intersection) *Inadequate slope of road results in grit accumulation and sewer overflows.*
		Bayside sewage Pump Station
		Tiyan 2 sewage Pump Station *Near airport in Tiyan housing Lower E. Sunset Road.*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*
	Wastewater	Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
	No on-site drainage	Ocean Jet Club *No on-site drainage at repair shop, no fuel storage containment.*
	Failing oil / water separator	Mark's Motor Repair Shop

Figure 8-88 provides a closer look at the Dungca's Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-88 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-88 also identifies major storm water ponding basins, including the Harmon Sink.

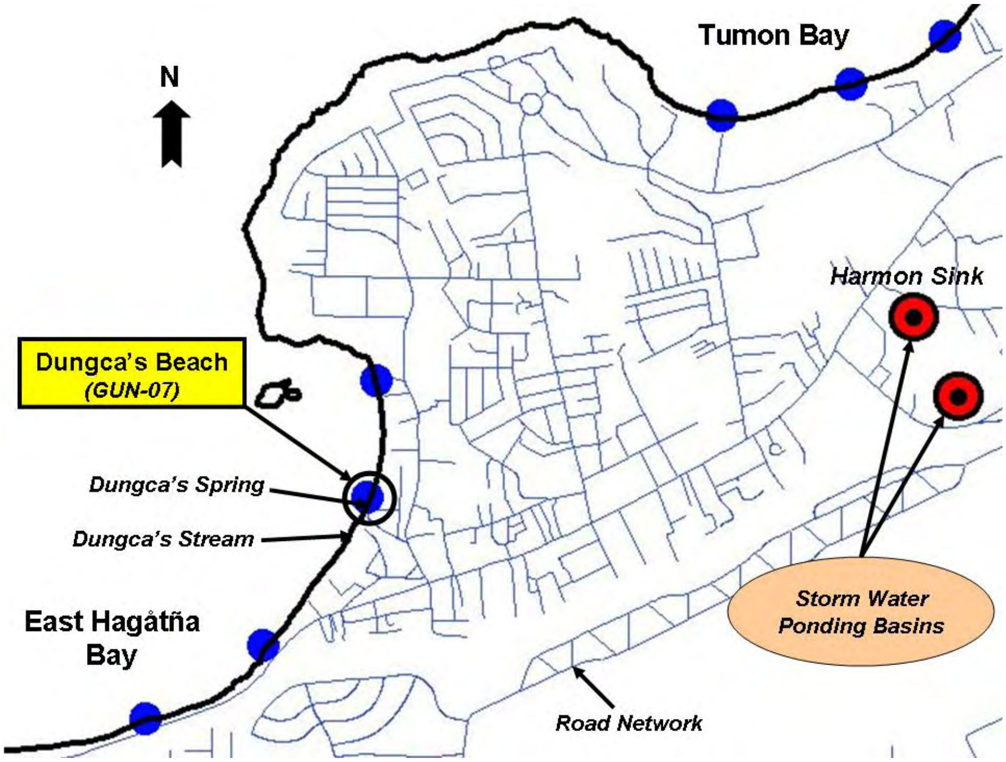

Figure 8-88. Location of Dungca's Beach relative to potential upland storm water source areas.

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Dungca's Beach. This information is shown in Figure 8-89. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels under these conditions. Figure 8-89 shows the location of both sewer mains and pump stations. Figure 8-90 shows an air photo of the area adjacent to Dungca's Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Dungca's Beach.

The source assessment (Section 5.3) discussed the potential effect of seepage from storm water ponding basins and infiltration chambers on beach water quality. The Harmon Sink, which collects storm water from a surrounding industrial park and adjacent airport, is of particular concern. There has been concern that contaminants entering the Sink may be carried to recreational beaches by groundwater discharging in the coastal zone.

Dye receptors in the WERI study were placed at seeps and springs in both East Hagåtña and Tumon Bays. Dye from the Harmon Sink surface injection was detected earliest at two locations on East Hagåtña Bay near Dungca's Beach: Dungca's Stream and Dungca's Spring (just north of Dungca's Stream). The study hypothesized that the relatively fast transport to East Hagåtña Bay is controlled by relatively open, regional-scale fracture pathways.

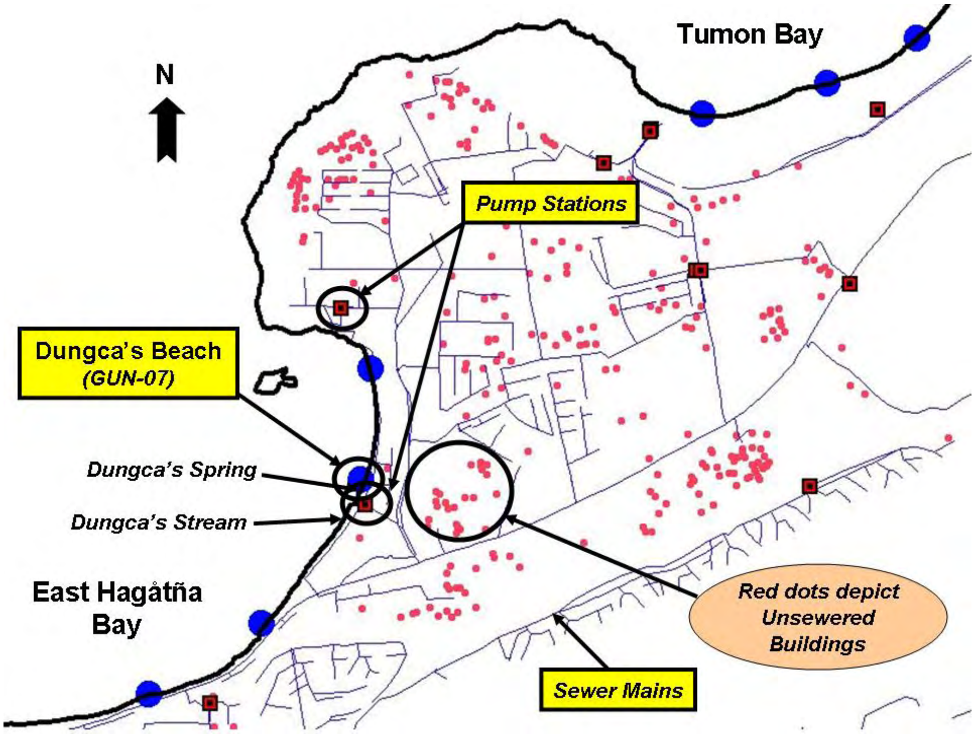

Figure 8-89. Location of Dungca's Beach relative to potential unsewered buildings.

Figure 8-90. Air photo of Dungca's Beach vicinity.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Dungca's Beach. Specifically, there are a number of manholes that have had sewage overflow problems, which may be affecting water quality at this site. Many of these overflows discharge to Dungca's Stream, ultimately causing an adverse effect on water quality at Dungca's Beach.

The Bayside Pump Station *(Figure 8-89)* is located nearby. There has been occasional sewage overflows associated with this facility, which would also explain elevated bacteria concentrations at this location. Furthermore, two GPA sewer mains are situated such that, inadequate slope results in grit accumulation and sanitary sewer overflows (SSOs) that may affect water quality at this location. Finally, storm drains from several commercial locations channel storm water to Dungca's Stream and East Hagåtña Bay; another potential source of problems at Dungca's Beach.

Trends. Figure 8-91 presents a year-by-year summary of the enterococcus data for the Dungca's Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90^{th} percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

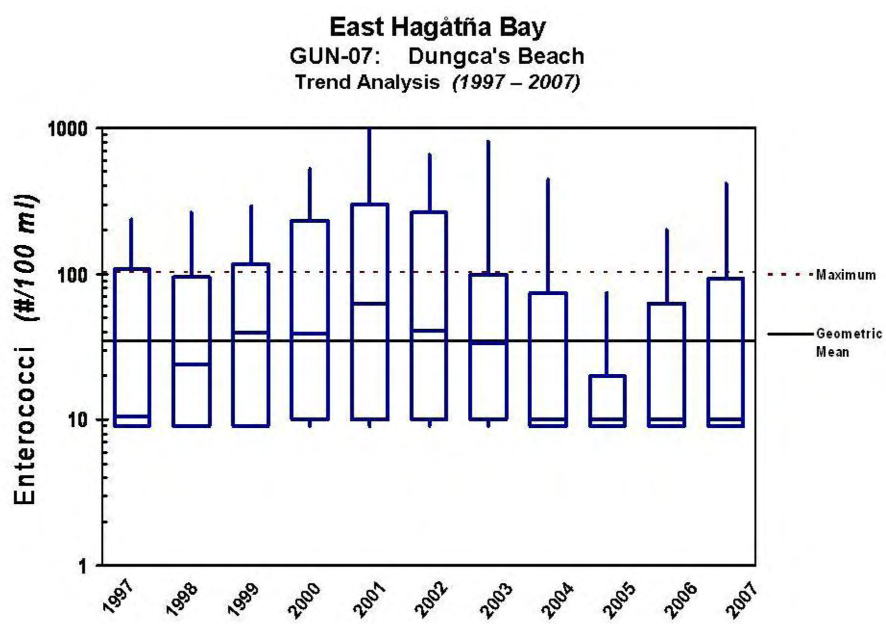

Figure 8-91. Trend analysis for Dungca's Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Dungca's Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the high concentrations are observed all year, indicating the importance of both wet and dry season sources at Dungca's Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Dungca's Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Dungca's Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-30 presents the TMDL for Dungca's Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-30. Northern Guam Watershed TMDL summary *(Site GUN-07: Dungca's Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-31 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-31. Needed reductions to meet TMDL targets *(Site GUN-07: Dungca's Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	90%	20%	---	---	---
Based on instantaneous maximum	98%	71%	67%	37%	43%
Wet Season					
Based on geometric mean	82%	20%	---	---	---
Based on instantaneous maximum	93%	82%	71%	51%	---

8.11 Alupang Towers Beach (GUN-26)

Alupang Towers Beach is along the southern edge of East Hagåtña Bay *(Figure 8-92)*. It is at the eastern end of the long strip of beach along Marine Drive that continues to Paseo Beach Park. The beach is situated adjacent to the Alupang Towers Hotel. It is a popular destination for water activities including parasailing, kayaking, and jet skiing. The upland area to the east of the beach is predominantly residential with some commercial business along main roads.

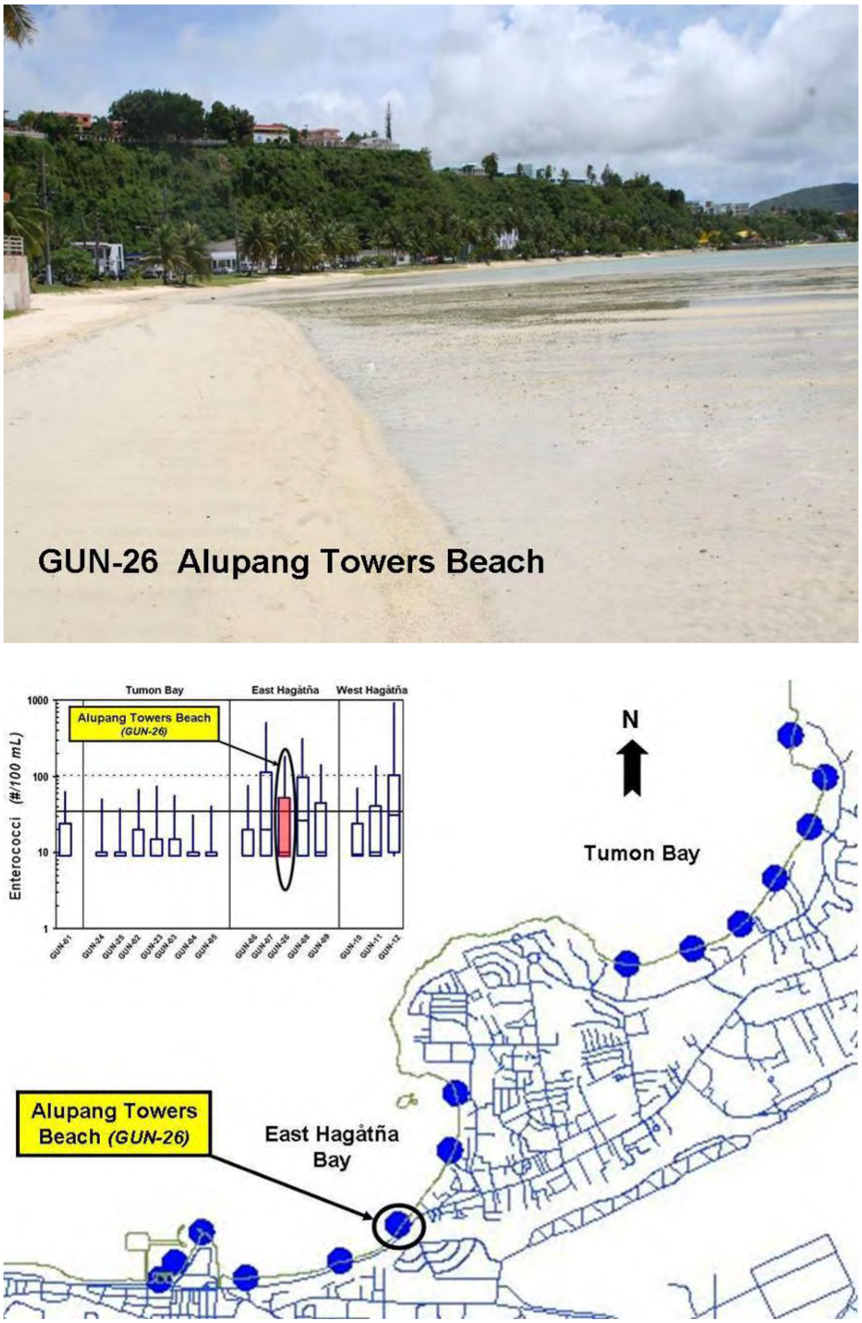

Figure 8-92. Location of Alupang Towers Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Alupang Towers Beach between 2005 and 2007 was relatively high (37%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Alupang Towers Beach were also higher than other project area monitoring stations *(Figure 4-2 and Figure 8-92)*. The geometric mean of all individual samples was 26 counts /100mL, while the 75th and 90th percentiles were 52 and 180 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-93 shows the seasonal variability of bacteria concentrations at Alupang Towers Beach. The highest concentrations were observed between July and March, indicating the importance of both wet and dry season sources at Alupang Towers Beach.

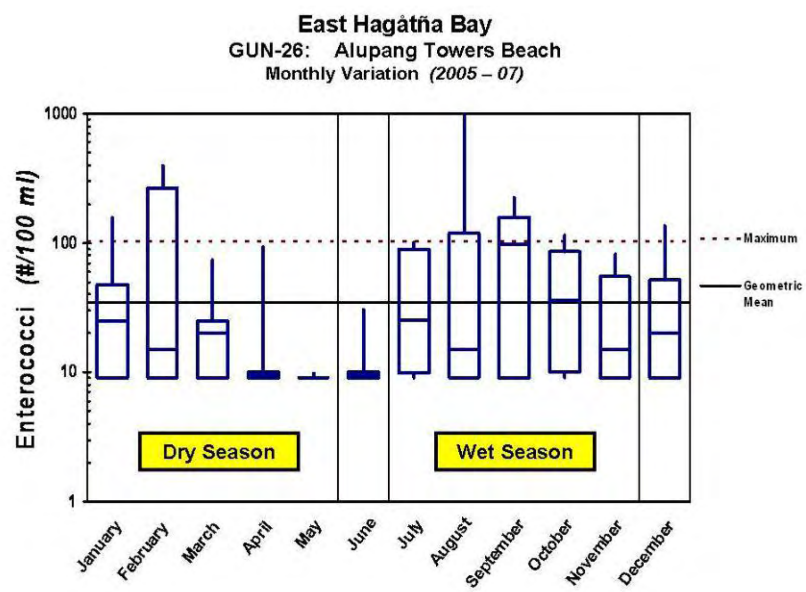

Figure 8-93. Seasonal variation at Alupang Towers Beach.

<u>*Effect of Flow Conditions*</u>*.* A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-94 shows enterococci monitoring data collected at Alupang Towers Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-94, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean

exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that over 30 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. Furthermore, the 90th percentile exceeds the instantaneous maximum criterion value across all zones except low flows, indicating that sources other than storm water are adversely affecting bacteria concentrations at Alupang Towers Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-95.

The patterns observed for both wet and dry seasons in the moist and mid-range zones are quite similar. Storm water and other sources appear to have approximately the same effect under those conditions at Alupang Towers Beach. However, the difference between the wet and dry season patterns under dry conditions is noteworthy. The higher wet season values in the dry zone indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

<u>Relationship to Other Indicators</u>. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection, such as tidal stage and presence or absence of turbidity. The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action.

This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems. Figure 8-96 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

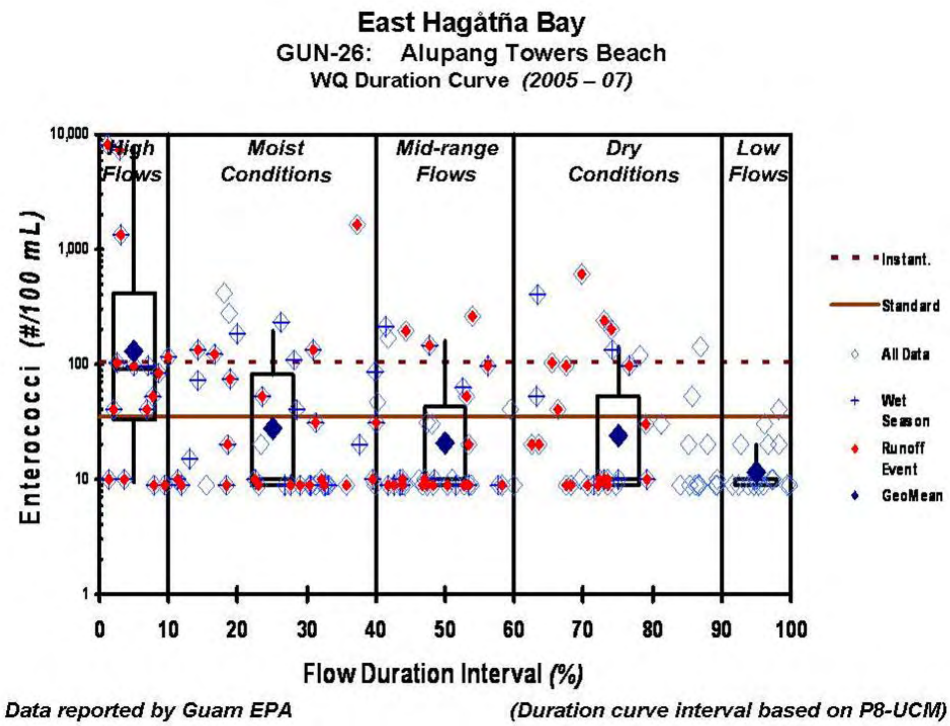

Figure 8-94. Water quality duration curve for Alupang Towers Beach site.

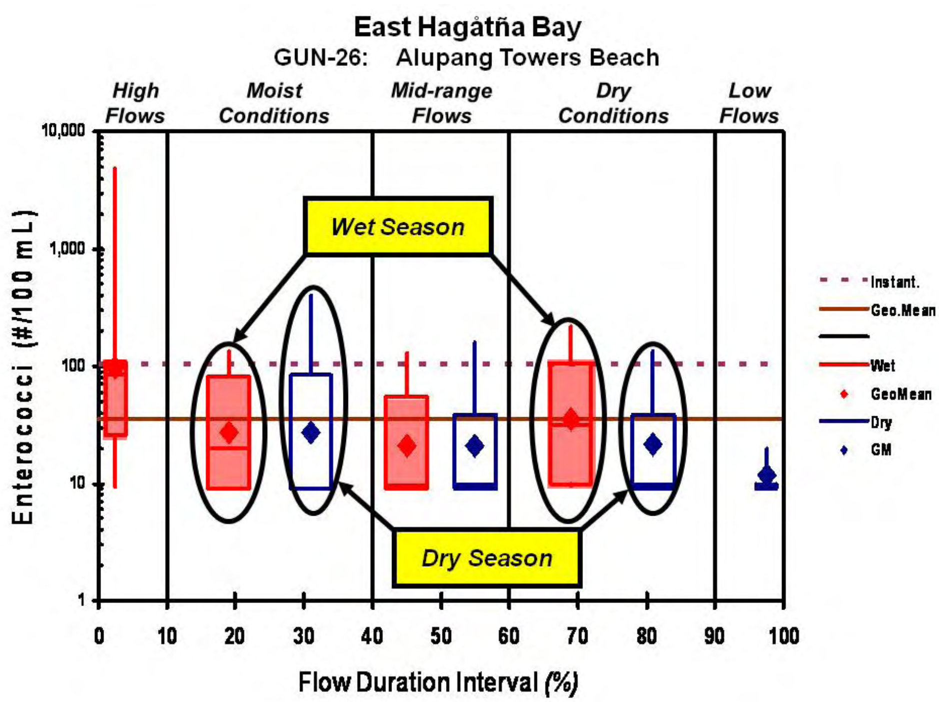

Figure 8-95. Wet versus dry season comparison for Alupang Towers Beach.

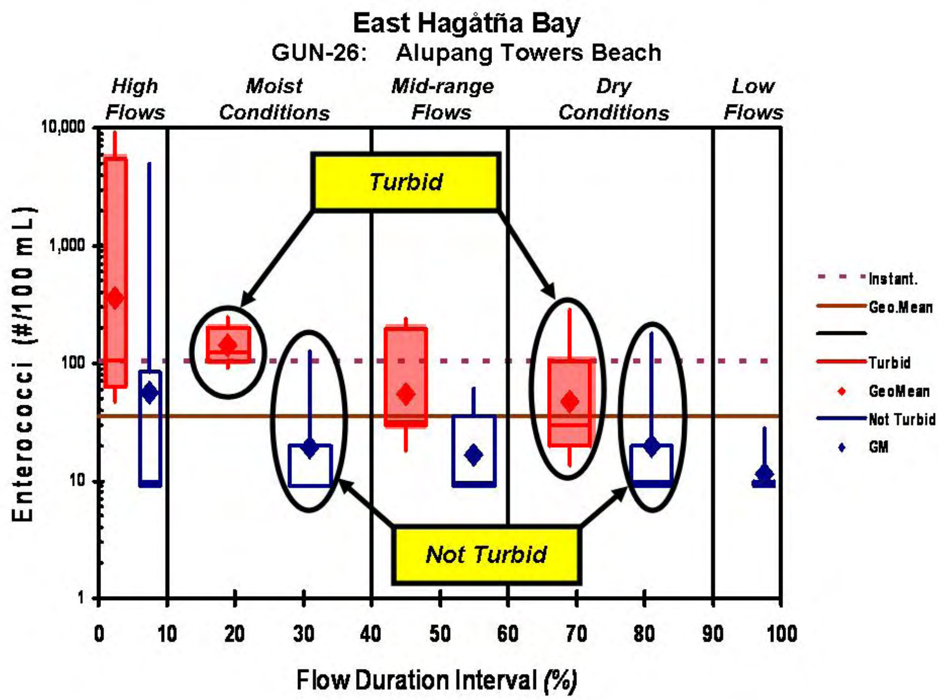

Figure 8-96. Turbid versus non-turbid sample comparison for Alupang Towers Beach site.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Alupang Towers Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff; highway, road, & bridge runoff), and other sources (recreation & tourism activities). In addition, GEPA staff identified specific potential sources that could affect water quality at Alupang Towers Beach *(Table 8-32)*.

Table 8-32. Beach specific potential source summary *(Site GUN-26: Alupang Towers Beach)*.

Site ID	Type	Source Name ***(notes)***
GUN-26	Storm drain runoff	DPW storm drain *Storm drain for Tiyan and airport area.*
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	No on-site drainage	Ocean Jet Club *No on-site drainage at repair shop, no fuel storage containment.*
	Wastewater	Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
	Sewage overflow	GWA sewer main lines inadequate slope *Inadequate slope of road results in grit accumulation and sewer overflows.*
		Manhole- sewer overflow • *Overflows to ground. Located in housing behind Tiyan Guam Police Dept.* • *Frequent overflows to storm drain leading to East Hagåtña Bay.*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

Figure 8-97 provides a closer look at the Alupang Towers Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-97 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. Figure 8-97 also identifies major storm water ponding basins, including the Harmon Sink.

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Alupang Towers Beach. This information is shown in Figure 8-98. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-98 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

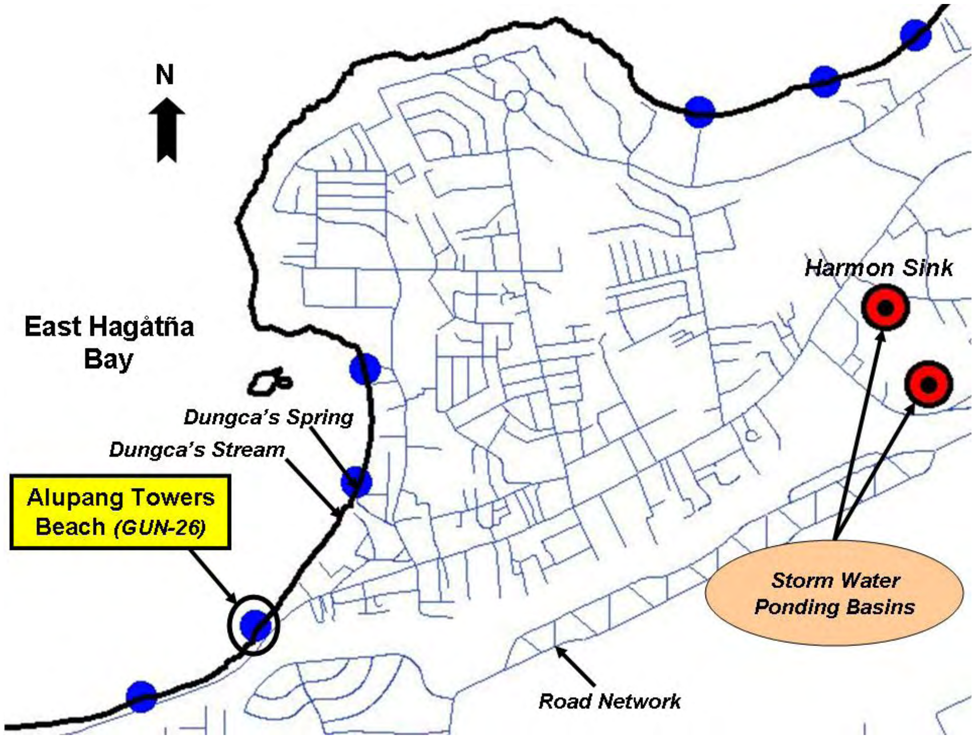

Figure 8-97. Location of Alupang Towers Beach relative to potential source areas.

Figure 8-99 shows an air photo of the area adjacent to Alupang Towers Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Alupang Towers Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Alupang Towers Beach. Specifically, there are a number of concerns in the vicinity of Dungca's Beach described in Section 8.10 including seepage from Harmon Sink. These potential source areas, under the right wind and tide conditions, could have an adverse effect on water quality at Alupang Towers Beach.

Furthermore, two GPA sewer mains are situated such that, inadequate slope results in grit accumulation and sanitary sewer overflows (SSOs) that may affect this location. There is also a major DPW storm drain that channels runoff from Tiyan and the airport area to a discharge point close to Trinchera Beach. Storm water from this drain may influence bacteria concentrations at this site. Lastly, there is a manhole that has had sewage overflow problems, which may be affecting water quality at this site.

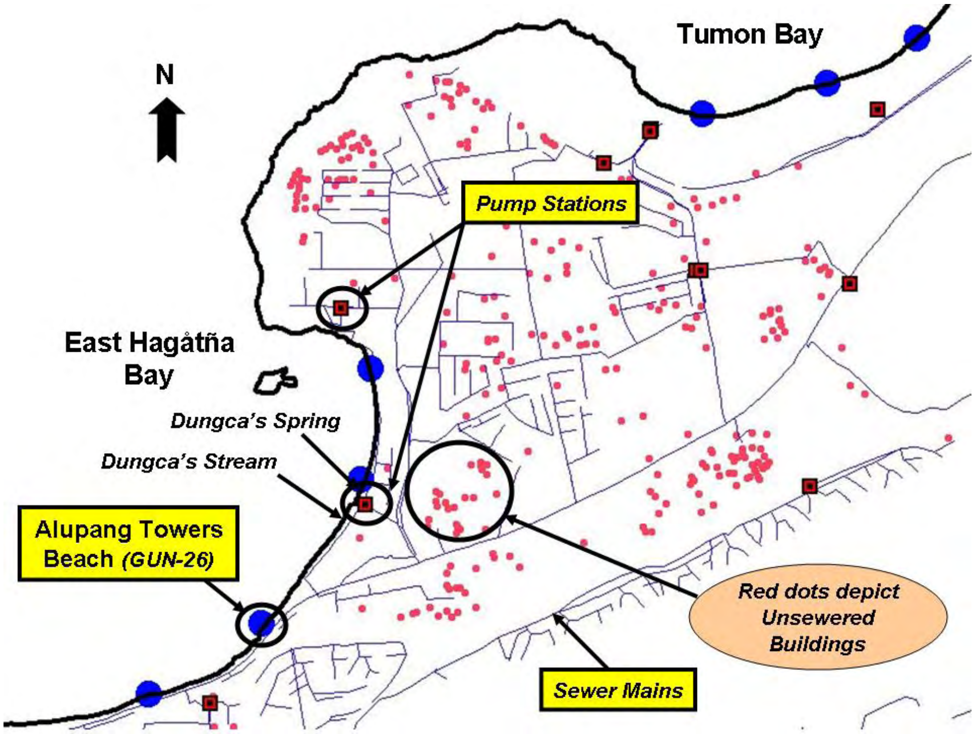

Figure 8-98. Location of Alupang Towers Beach relative to potential unsewered buildings.

Figure 8-99. Air photo of Alupang Towers Beach vicinity.

Trends. Figure 8-100 presents a year-by-year summary of the enterococcus data for the Alupang Towers Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

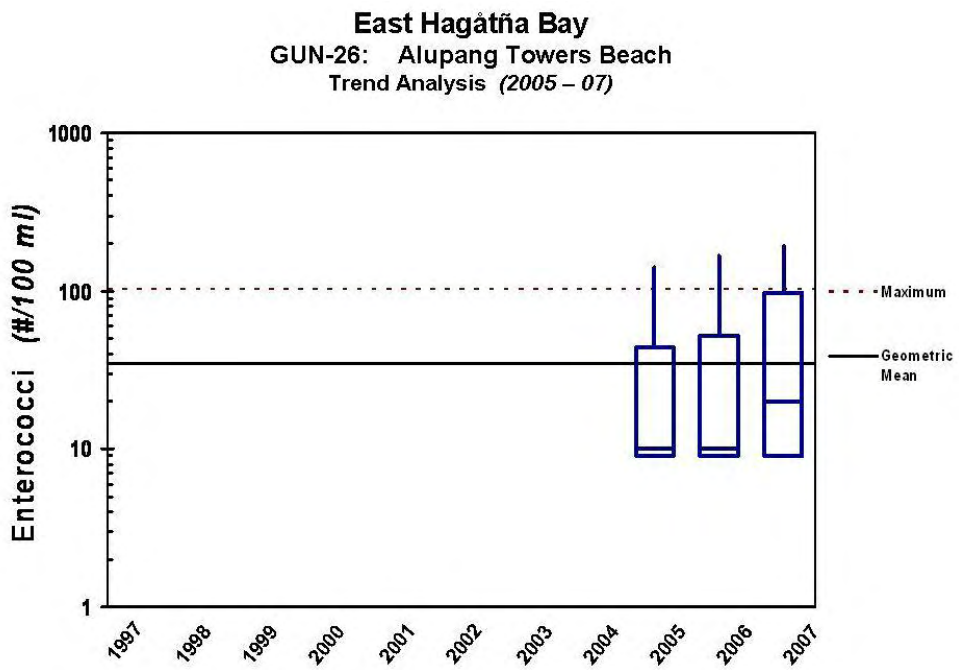

Figure 8-100. Trend analysis for Alupang Towers Beach site.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Alupang Towers Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and March, indicating the importance of both wet and dry season sources at Alupang Towers Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Alupang Towers Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Alupang Towers Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-33 presents the TMDL for Alupang Towers Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-33. Northern Guam Watershed TMDL summary *(Site GUN-26: Alupang Towers Beach)*.

TMDL Component	**Enterococcus Concentration** *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-34 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-34. Needed reductions to meet TMDL targets *(Site GUN-26: Alupang Towers Beach)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	Moist	Mid	Dry	Low
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	---	74%	34%	23%	---
Wet Season					
Based on geometric mean	64%	---	---	---	---
Based on instantaneous maximum	98%	23%	21%	52%	---

8.12 Trinchera Beach (GUN-08)

Trinchera Beach makes up the southern half of East Hagåtña Bay *(Figure 8-101)*. It is the long strip of beach along Marine Drive between the Alupang Beach Hotel and Paseo Beach Park. The beach is a popular destination for jet skiing, parasailing, and other water vehicle type activities. It is accessed by a number of small parking lots along Marine Drive with pavilions and benches along Marine Drive.

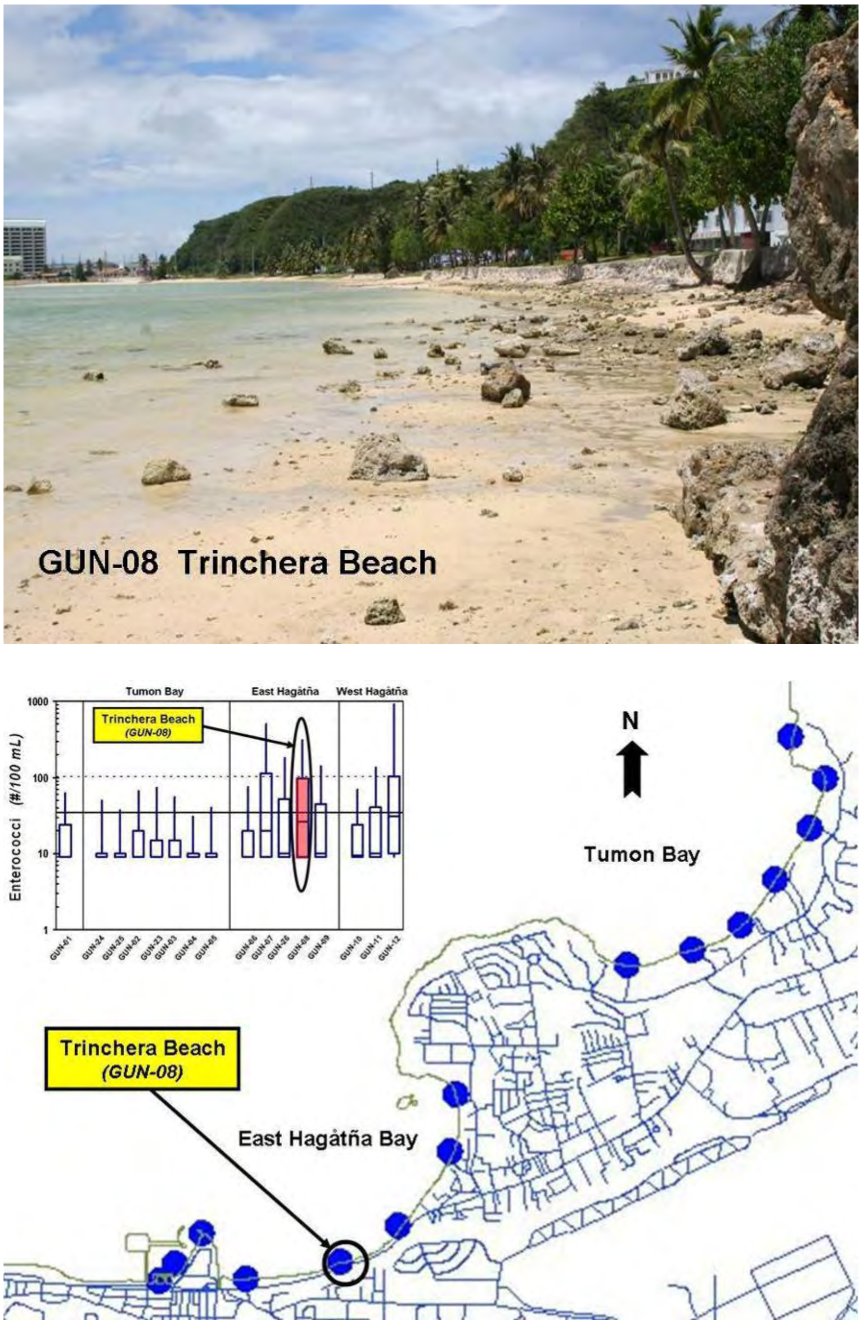

Figure 8-101. Location of Trinchera Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Trinchera Beach between 1997 and 2007 was very high (56%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Trinchera Beach were also quite high compared to other project area monitoring stations *(Figure 4-2 and Figure 8-101)*. The geometric mean of all individual samples was 37 counts /100mL, while the 75th and 90th percentiles were 97 and 314 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-102 shows the seasonal variability of bacteria concentrations at Trinchera Beach. High concentrations were observed all year, indicating the importance of both wet and dry season sources at Trinchera Beach.

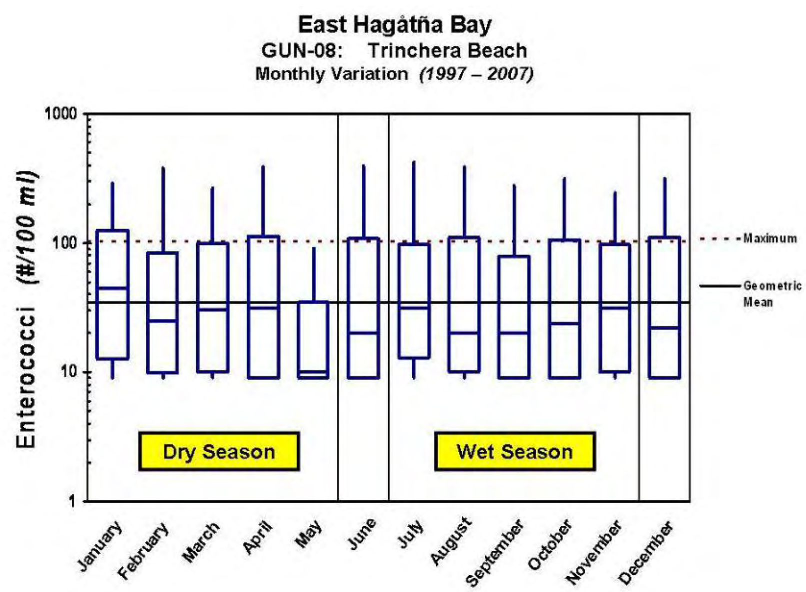

Figure 8-102. Seasonal variation at Trinchera Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-103 shows enterococci monitoring data collected at Trinchera Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-103, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean

exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that nearly 50 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. Furthermore, the geometric mean exceeds the criterion value in the mid-range zone, and is close to it in the moist and dry zones. In addition, the 90th percentile exceeds the instantaneous maximum criterion value across all zones. This indicates that sources other than storm water are adversely affecting bacteria concentrations at Trinchera Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-104.

The patterns observed for both wet and dry seasons in the high, moist, mid-range and dry zones are all quite similar. Storm water and other sources appear to have approximately the same effect under those conditions at Trinchera Beach. This confirms observations made regarding Figure 8-102 and Figure 8-103. Numerous sources appear to affect bacteria concentrations at this site and seasonal differences do not appear to be a factor.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

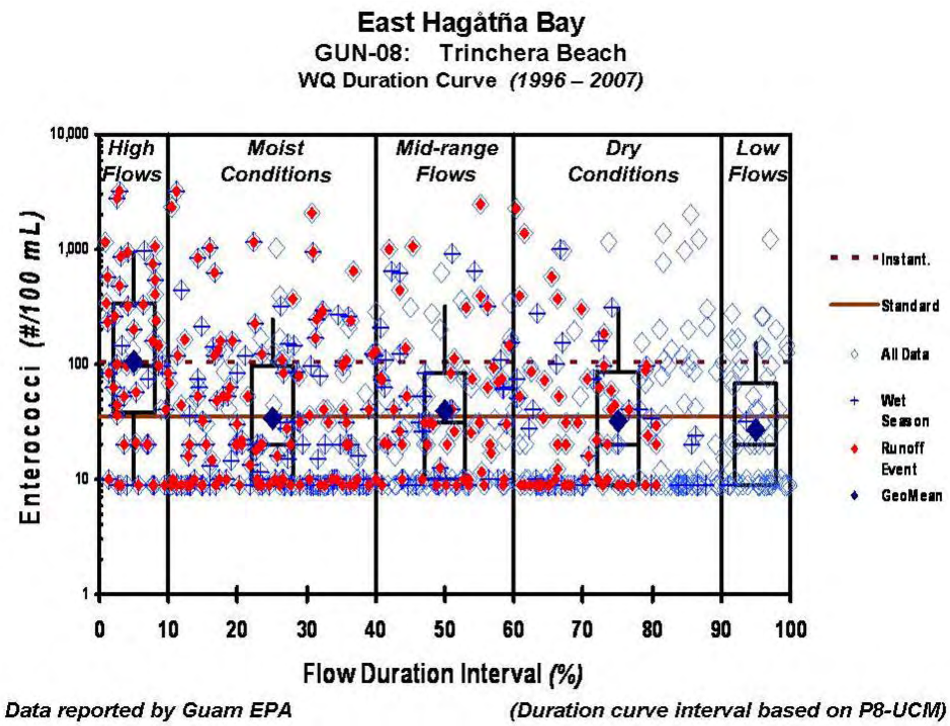

Figure 8-103. Water quality duration curve for Trinchera Beach site.

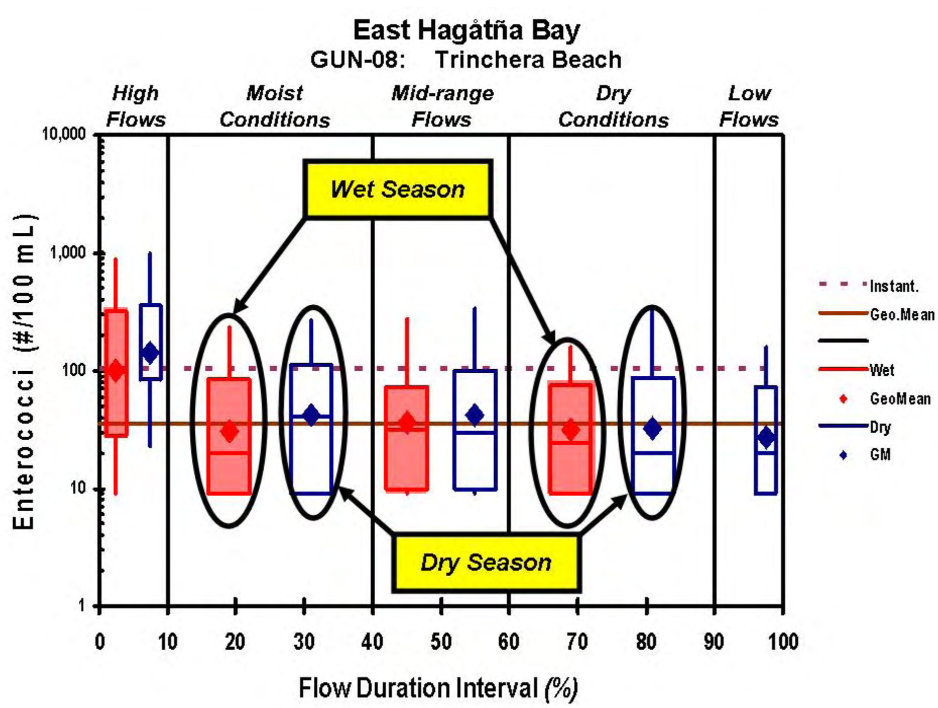

Figure 8-104. Wet versus dry season comparison for Trinchera Beach.

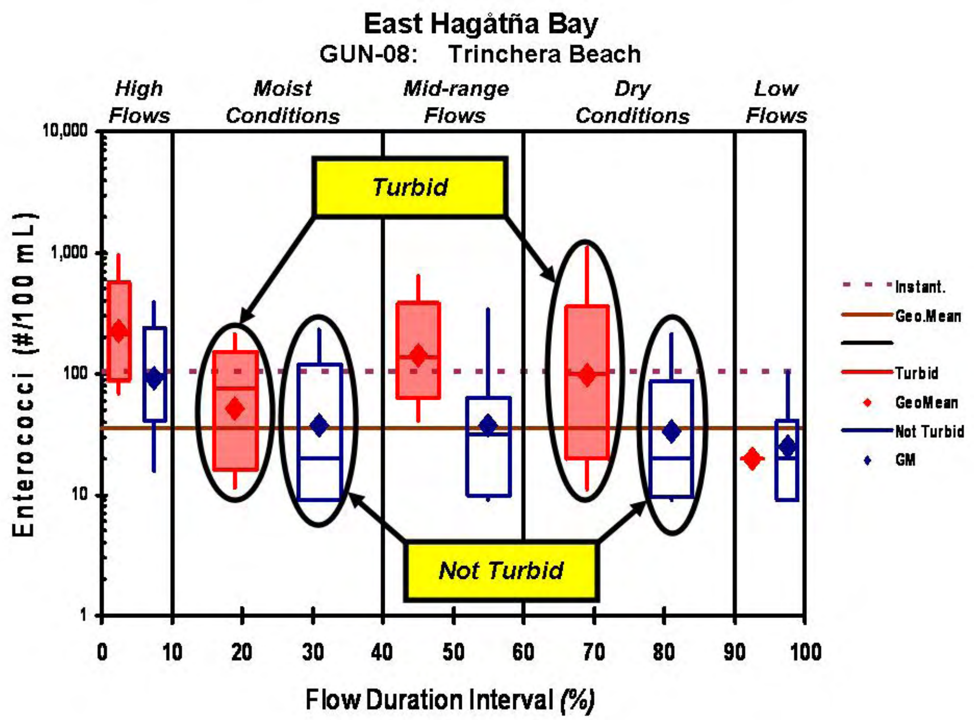

Figure 8-105. Turbid versus non-turbid sample comparison for Trinchera Beach site.

Figure 8-105 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Trinchera Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff; highway, road, & bridge runoff), and other sources (recreation & tourism activities, debris & bottom deposits). In addition, GEPA staff identified specific potential sources that could affect water quality at Trinchera Beach *(Table 8-35)*.

Figure 8-106 provides a closer look at the Trinchera Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-106 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

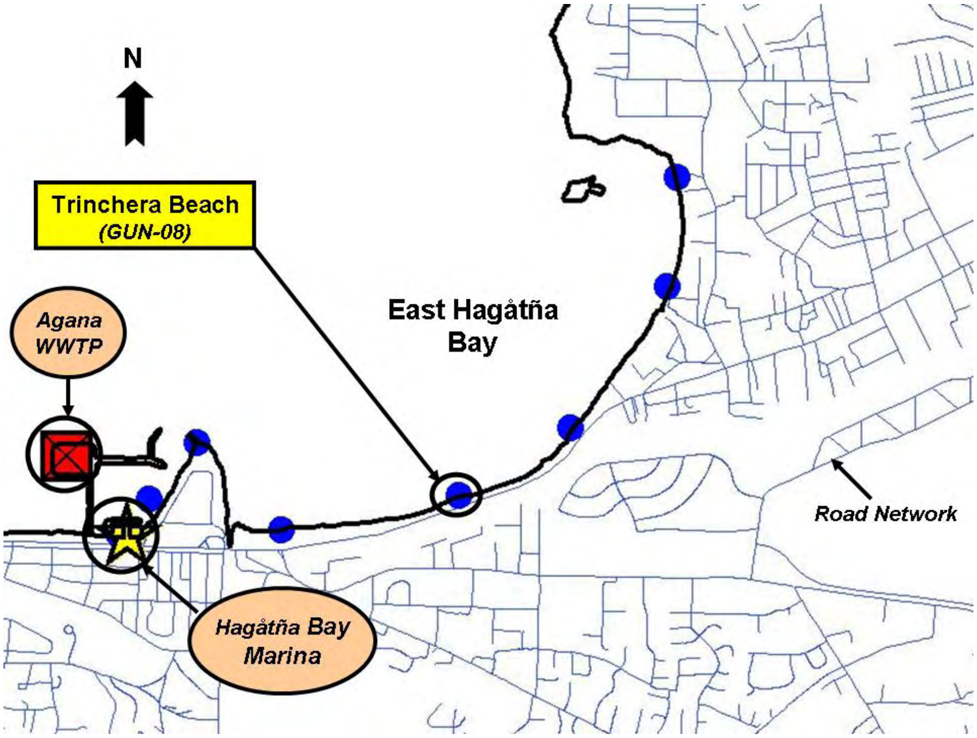

Figure 8-106. Location of Trinchera Beach relative to potential source areas.

Table 8-35. Beach specific potential source summary *(Site GUN-08: Trinchera Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-08	Storm drain runoff	DPW storm drain *Storm drain for Tiyan and airport area.*
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Wastewater	Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
	Sewage overflow	GWA sewer main lines inadequate slope *Inadequate slope of road results in grit accumulation and sewer overflows.*
		Manhole- sewer overflow *Frequent overflows to storm drain leading to East Hagåtña Bay.*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Trinchera Beach. This information is shown in Figure 8-107. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-107 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-108 shows an air photo of the area adjacent to Trinchera Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Trinchera Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Trinchera Beach. Specifically, there are a number of concerns in the vicinity of Dungca's Beach described in Section 8.10 including seepage from Harmon Sink. These potential source areas, under the right wind and tide conditions, could have an adverse effect on water quality at Trinchera Beach. Furthermore, two GPA sewer mains are situated such that, inadequate slope results in grit accumulation and sanitary sewer overflows (SSOs) that may affect this location. Finally, there is a major DPW storm drain that channels runoff from Tiyan and the airport area to a discharge point close to Trinchera Beach. Storm water from this drain may influence bacteria concentrations at this site.

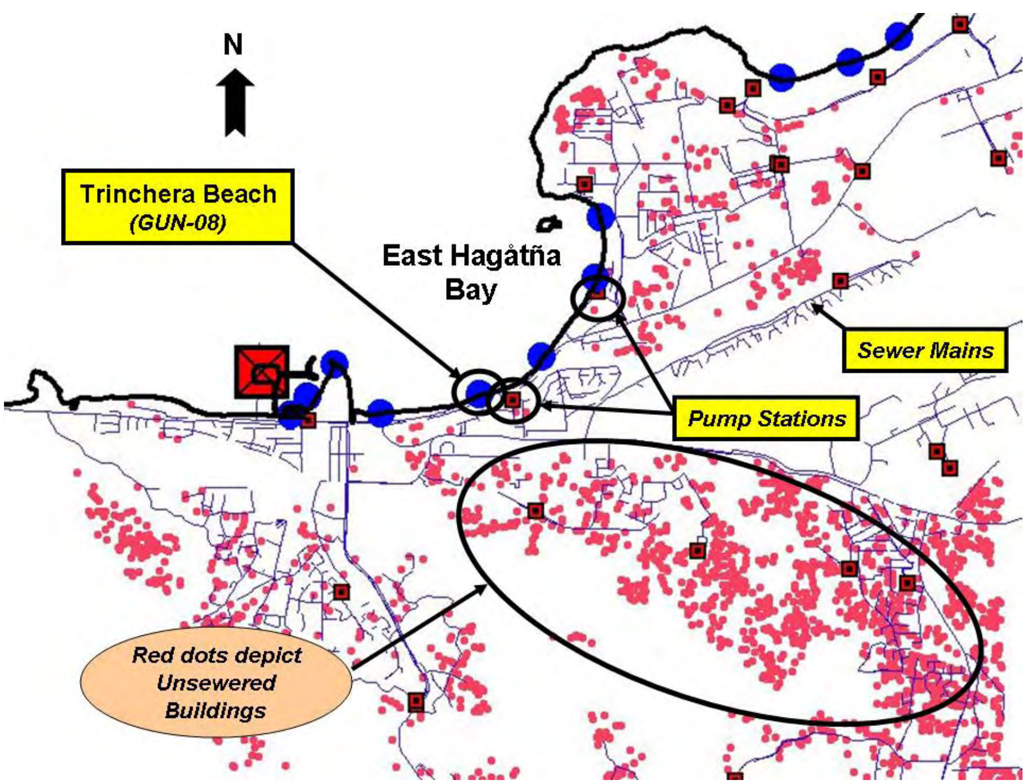

Figure 8-107. Location of Trinchera Beach relative to potential unsewered buildings.

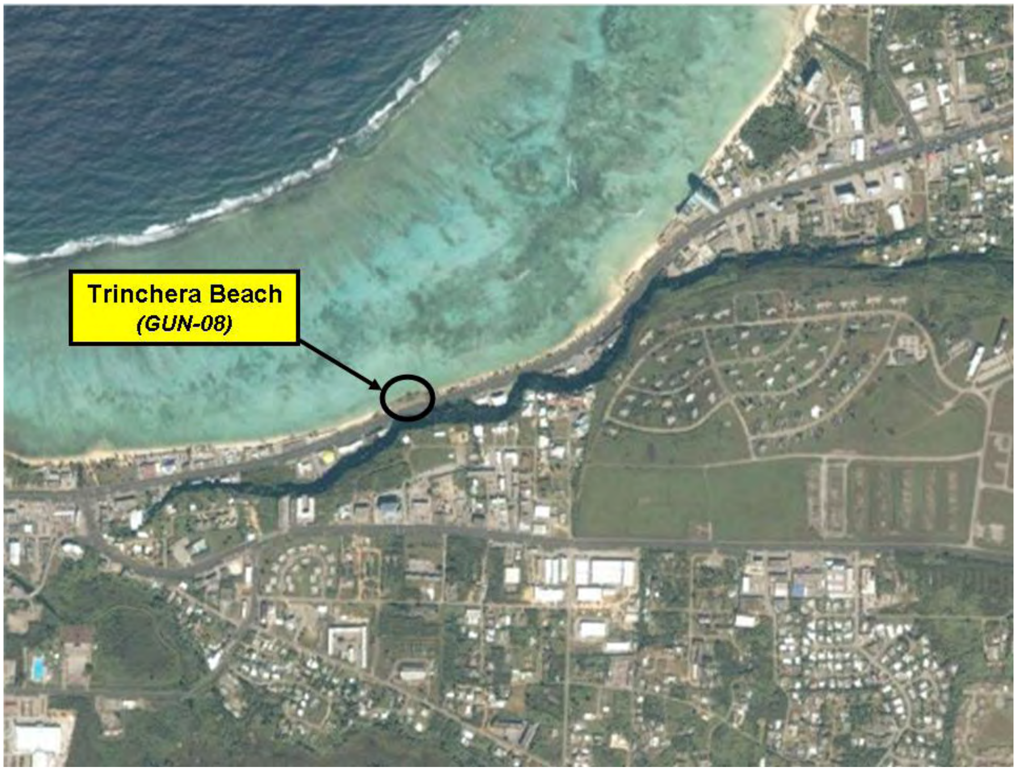

Figure 8-108. Air photo of Trinchera Beach vicinity.

Trends. Figure 8-109 presents a year-by-year summary of the enterococcus data for the Trinchera Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Trinchera Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed all year, indicating the importance of both wet and dry season sources at Trinchera Beach. This is consistent with the presence of potential storm water sources identified at this location.

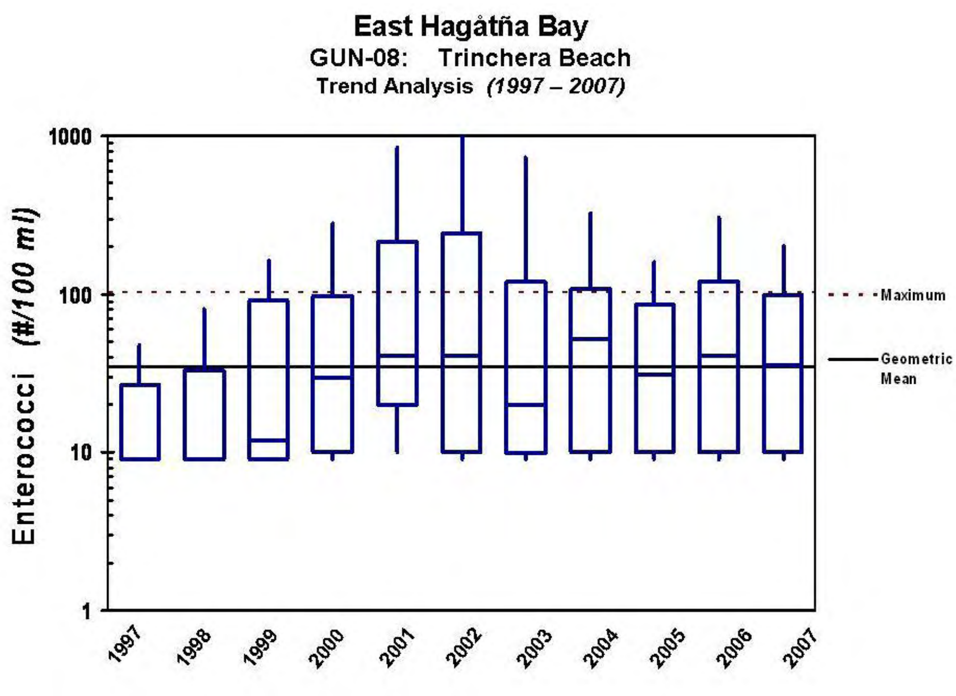

Figure 8-109. Trend analysis for Trinchera Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Trinchera Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Trinchera Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-36 presents the TMDL for Trinchera Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-36. Northern Guam Watershed TMDL summary *(Site GUN-08: Trinchera Beach)*.

TMDL Component	**Enterococcus Concentration** *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-37 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-37. Needed reductions to meet TMDL targets *(Site GUN-08: Trinchera Beach)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	75%	17%	15%	---	---
Based on instantaneous maximum	89%	61%	69%	68%	34%
Wet Season					
Based on geometric mean	65%	---	5%	---	---
Based on instantaneous maximum	88%	56%	62%	35%	---

8.13 Padre Palomo Park Beach (GUN-09)

Padre Palomo Park Beach is situated on the southern half of East Hagåtña Bay *(Figure 8-110)*. It is at the western end of the long strip of beach starting at the Alupang Towers Hotel that continues along Marine Drive. The site is located slightly east of Paseo Beach Park. The beach is a popular destination for jet skiing, parasailing, and other water vehicle type activities.

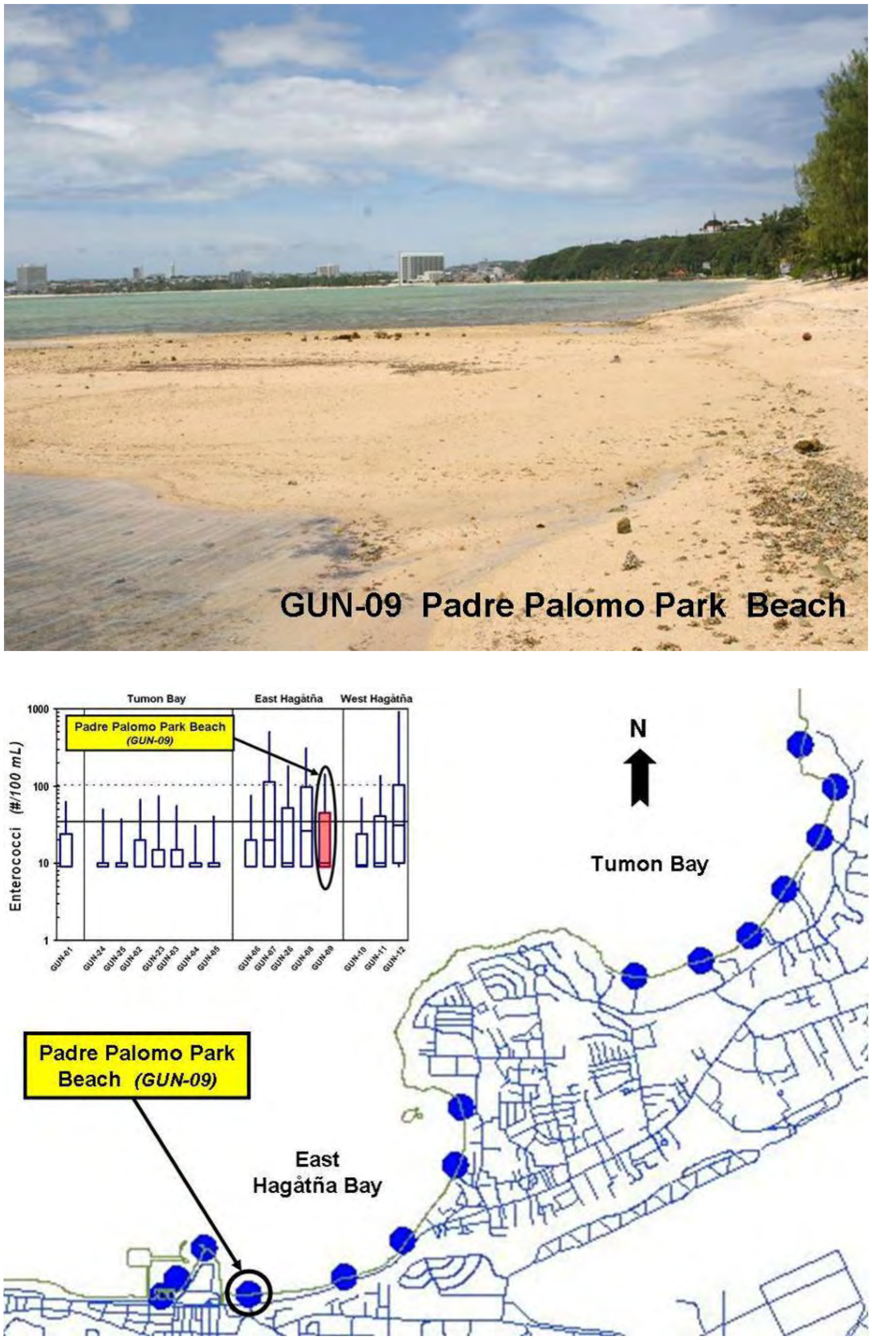

Figure 8-110. Location of Padre Palomo Park Beach relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Padre Palomo Park Beach between 1997 and 2007 was relatively high (31%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Padre Palomo Park Beach were also high compared to other project area monitoring stations *(Figure 4-2 and Figure 8-110)*. The geometric mean of all individual samples was 23 counts /100mL, while the 75th and 90th percentiles were 45 and 141 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-111 shows the seasonal variability of bacteria concentrations at Padre Palomo Park Beach. High concentrations were observed all year, indicating the importance of both wet and dry season sources at Padre Palomo Park Beach (although wet season concentrations were noticeably greater).

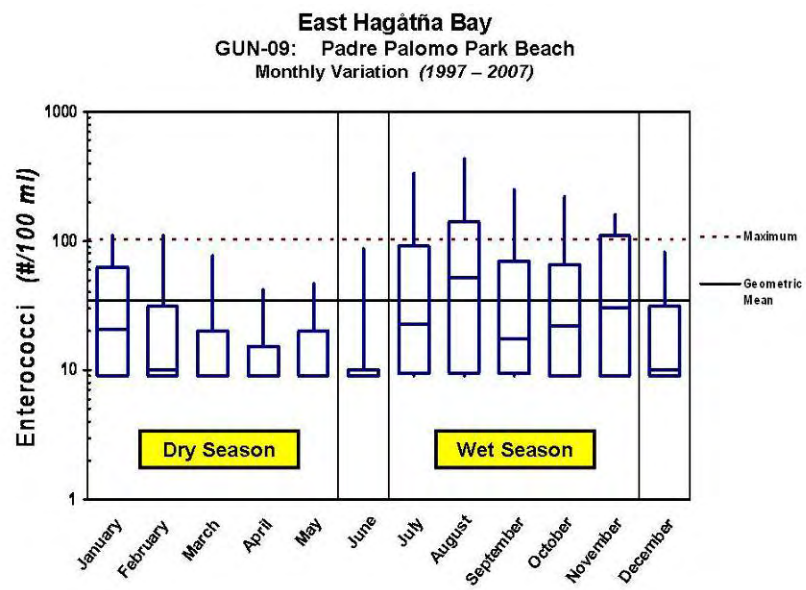

Figure 8-111. Seasonal variation at Padre Palomo Park Beach.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-112 shows enterococci monitoring data collected at Padre Palomo Park Beach using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-112, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that over 50 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. Furthermore, the 90th percentile exceeds the instantaneous maximum criterion in the moist zone. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during rain events) may be a concern under these conditions at Padre Palomo Park Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-113.

The patterns observed for both wet and dry seasons in the high, moist, mid-range and dry zones are all generally similar. Wet season values are moderately higher than those observed during the dry season. The higher wet season values, particularly in the high flow and dry zones, indicate the potential for seeps connected to storm water sources to be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

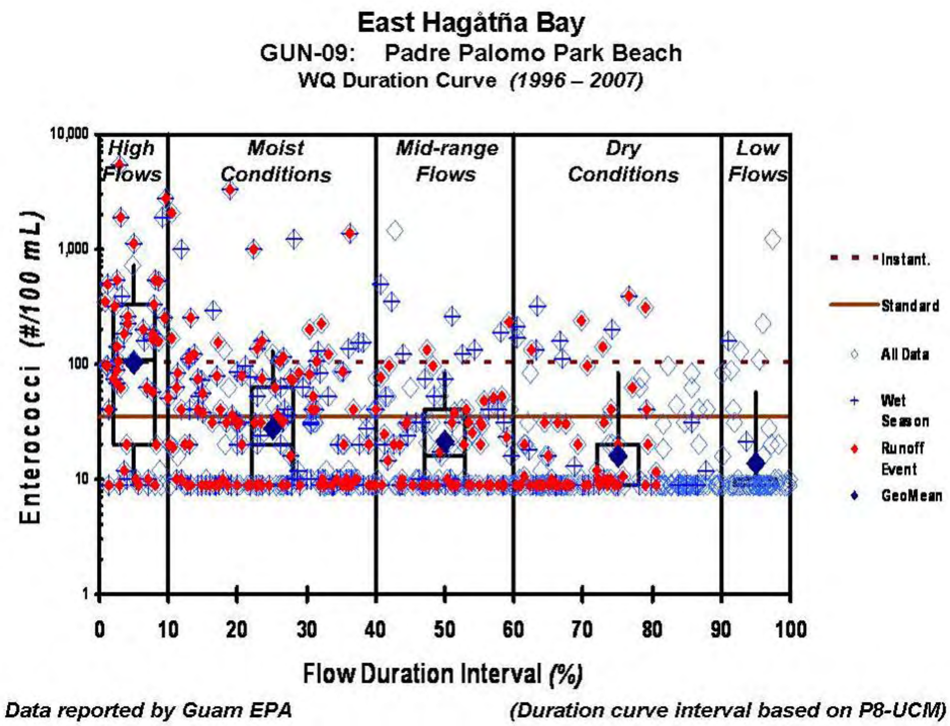

Figure 8-112. Water quality duration curve for Padre Palomo Park Beach site.

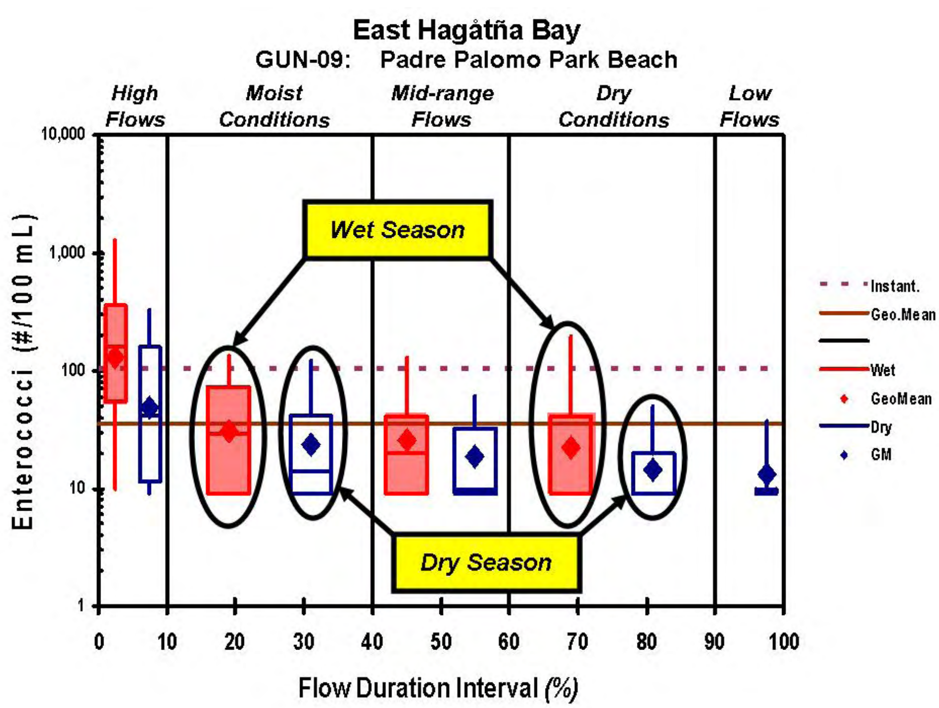

Figure 8-113. Wet versus dry season comparison for Padre Palomo Park Beach.

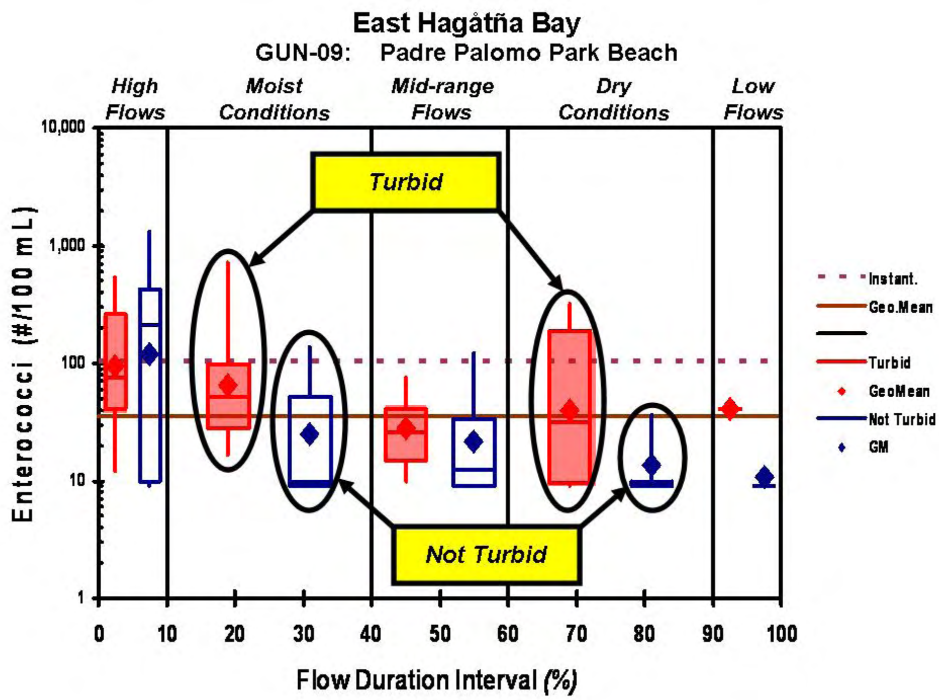

Figure 8-114. Turbid versus non-turbid sample comparison for Padre Palomo Park Beach site.

Figure 8-114 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Padre Palomo Park Beach. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO), storm water (overland runoff; highway, road, & bridge runoff), and other sources (recreation & tourism activities, debris & bottom deposits). In addition, GEPA staff identified specific potential sources that could affect water quality at Padre Palomo Park Beach *(Table 8-38)*.

Figure 8-115 provides a closer look at the Padre Palomo Park Beach monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-115 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

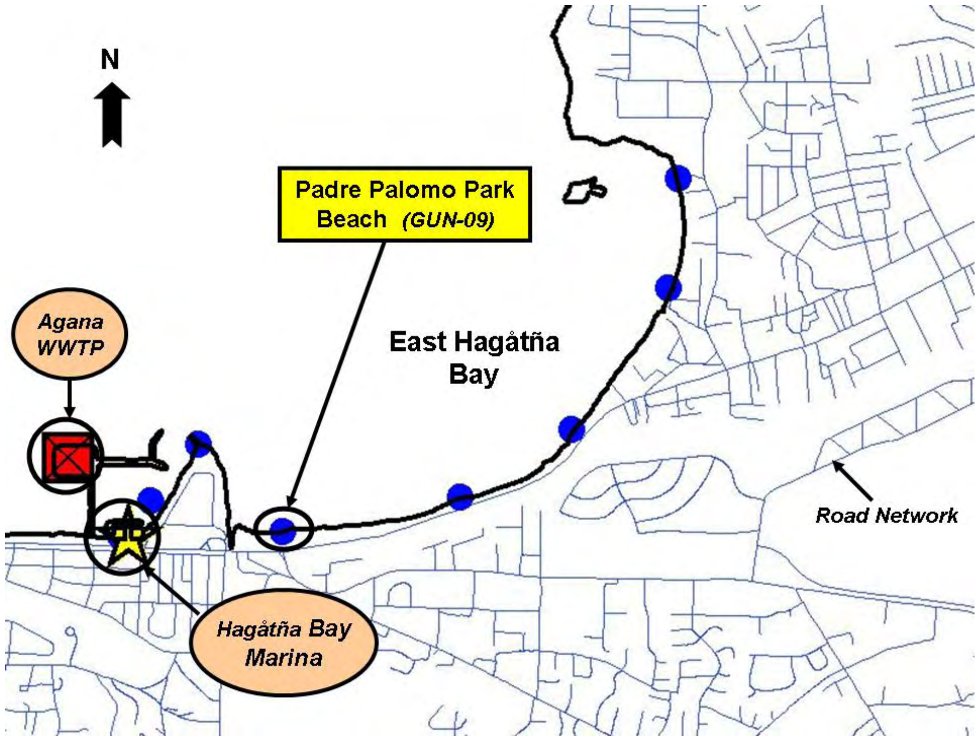

Figure 8-115. Location of Padre Palomo Park Beach relative to potential source areas.

Table 8-38. Beach specific potential source summary *(Site GUN-09: Padre Palomo Beach)*.

Site ID	Type	Source Name *(notes)*
GUN-09	Storm drain runoff	DPW storm drains • *Storm drain for Marine Drive and Route 8.* • *Runoff from Hagatna village.*
		Harmon Sinkhole *Guam International Airport Authority storm water flows to Harmon Sinkhole via concrete channel (includes failing oil / water separator).*
	Wastewater	Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
	Sewage overflow	GWA sewer main lines inadequate slope *Inadequate slope of road results in grit accumulation and sewer overflows.*
		Manhole- sewer overflows • *Near Hagåtña Mayor's office overflows into stream.* • *Frequent overflows to storm drain leading to East Hagåtña Bay.*
		Harmon Sinkhole *Receives sewage overflow from Mamajanao Pump Station.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Padre Palomo Park Beach. This information is shown in Figure 8-116. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-116 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-117 shows an air photo of the area adjacent to Padre Palomo Park Beach. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Padre Palomo Park Beach.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Padre Palomo Park Beach. Specifically, there are two major DPW storm drains that channel runoff to discharge points, which may influence bacteria concentrations at this site. Surface runoff from Hagåtña village could be exerting an effect on water quality at this location as well. There is also a manhole near Hagåtña village mayor's office that has had occasional sewage overflows, which could influence monitoring measurements at this site. Finally, two GPA sewer mains are situated such that, inadequate slope results in grit accumulation and sanitary sewer overflows (SSOs).

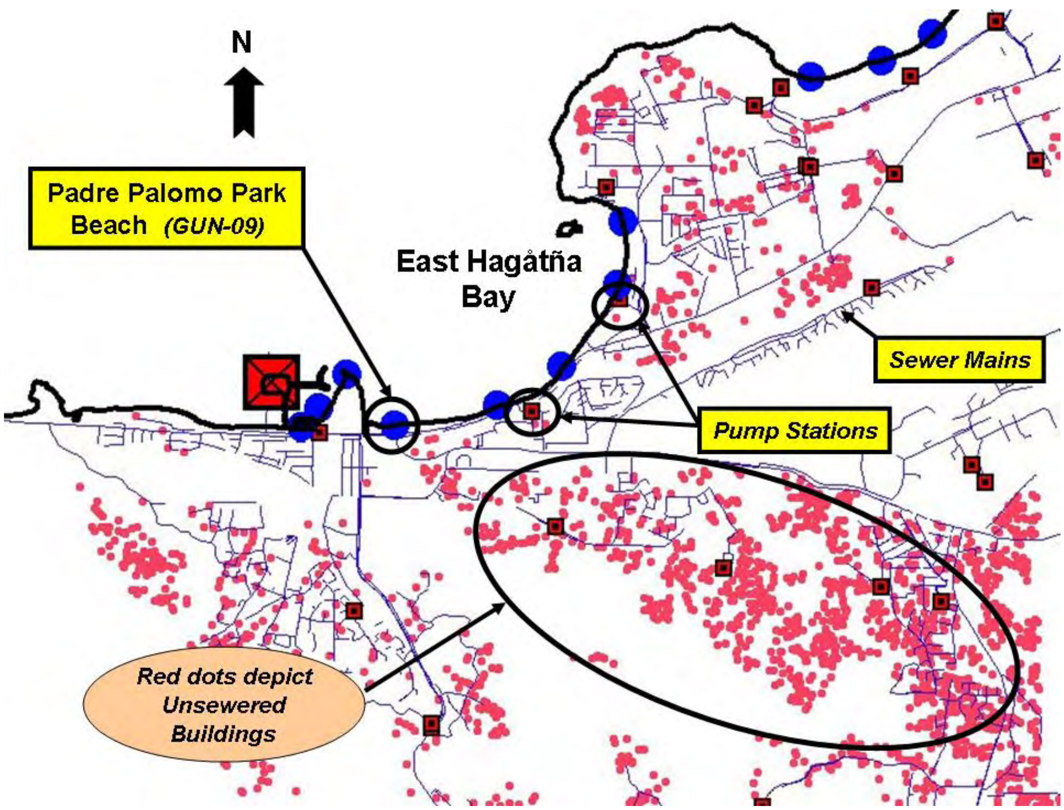

Figure 8-116. Location of Padre Palomo Park Beach relative to potential unsewered buildings.

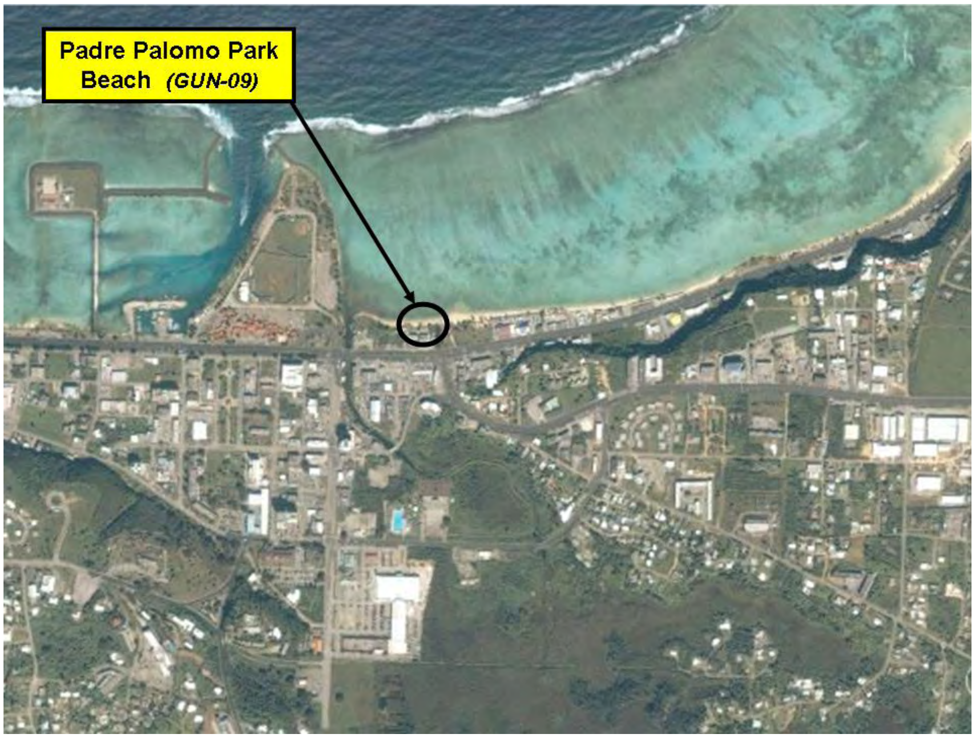

Figure 8-117. Air photo of Padre Palomo Park Beach vicinity.

Trends. Figure 8-118 presents a year-by-year summary of the enterococcus data for the Padre Palomo Park Beach site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90^{th} percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Padre Palomo Park Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed all year, indicating the importance of both wet and dry season sources at Padre Palomo Park Beach. This is consistent with the presence of potential storm water sources identified at this location.

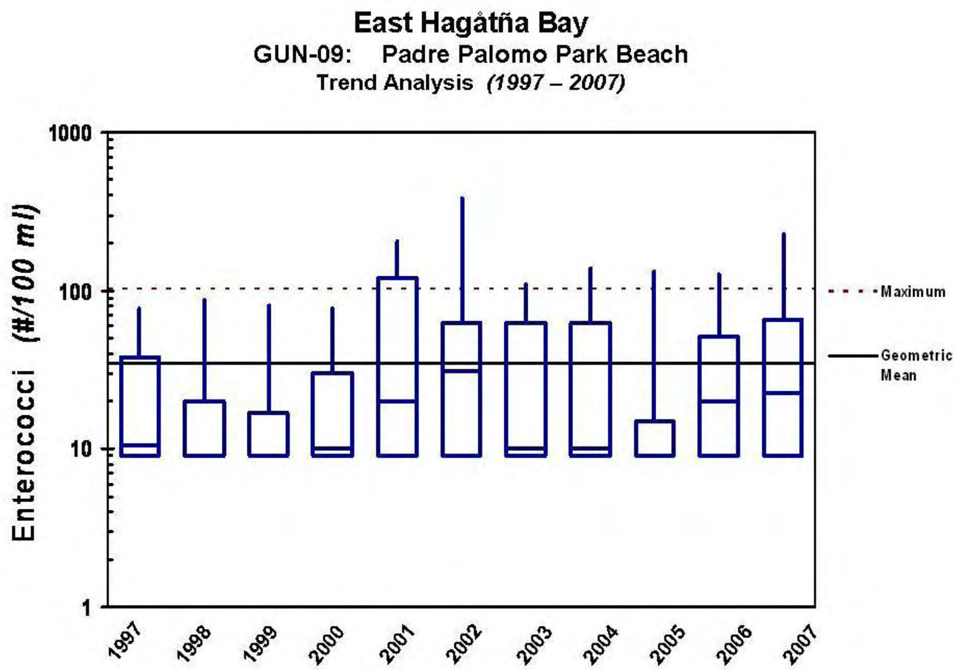

Figure 8-118. Trend analysis for Padre Palomo Park Beach site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Padre Palomo Park Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Padre Palomo Park Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-39 presents the TMDL for Padre Palomo Park Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-39. Northern Guam TMDL summary *(Site GUN-09: Padre Palomo Park Beach)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-40 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-40. Needed reductions to meet TMDL targets *(Site GUN-09: Padre Palomo Park Beach)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	27%	---	---	---	---
Based on instantaneous maximum	69%	14%	---	---	---
Wet Season					
Based on geometric mean	73%	---	---	---	---
Based on instantaneous maximum	92%	22%	20%	47%	---

8.14 Hagåtña Channel (GUN-10)

Hagåtña Channel is the waterway that connects the Hagåtña Boat Basin to East Hagåtña Bay *(Figure 8-119)*. For this reason, the channel experiences heavy boating activity by recreational users. Just beyond the rocks that mark the entrance to the channel is a popular surfing and body boarding surf break among the local residents.

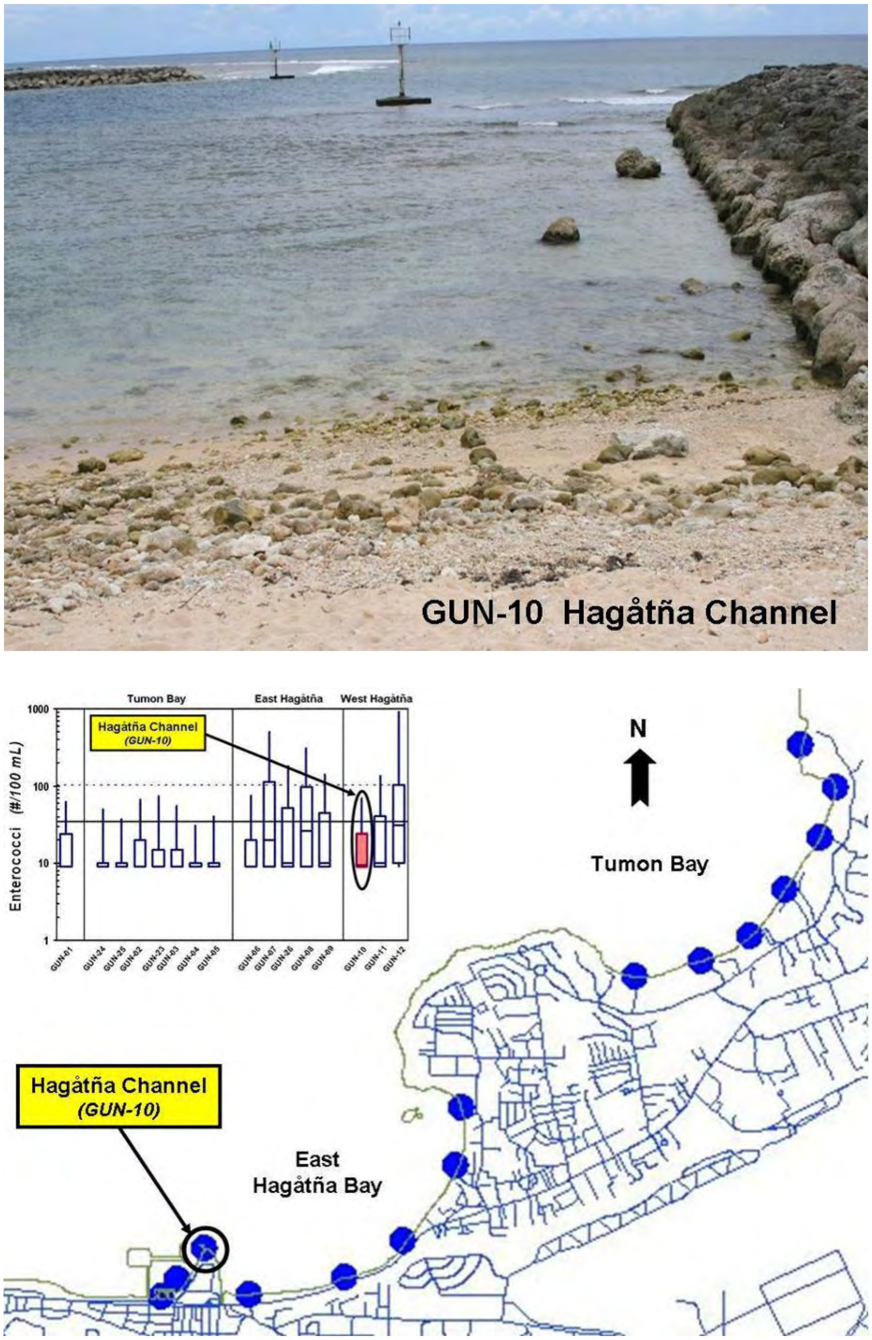

Figure 8-119. Location of Hagåtña Channel relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Hagåtña Channel between 1997 and 2007 was typical (13%) of many RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Hagåtña Channel were basically in the same range as a number of other project area monitoring stations *(Figure 4-2 and Figure 8-119)*. The geometric mean of all individual samples was 16 counts /100mL, while the 75th and 90th percentiles were 24 and 69 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-120 shows the seasonal variability of bacteria concentrations at Hagåtña Channel. The highest concentrations were observed between July and March, indicating the importance of both wet and dry season sources at the Hagåtña Channel.

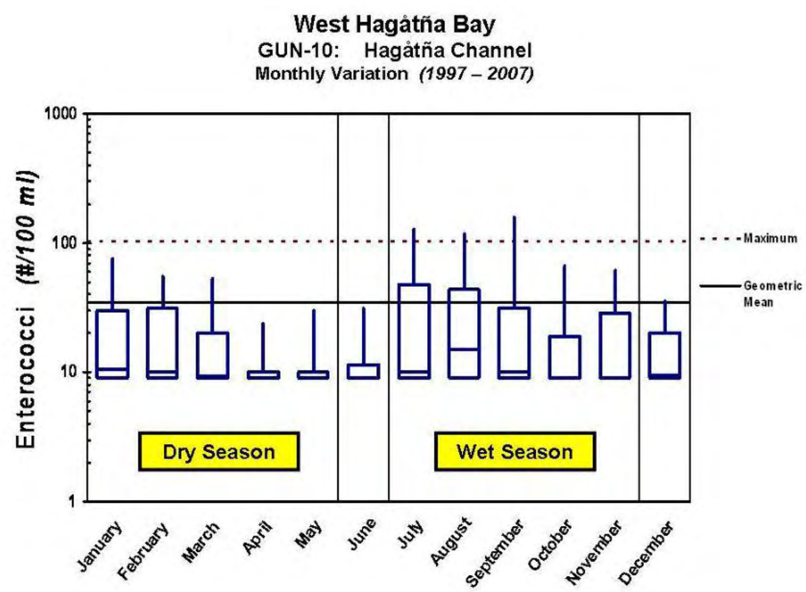

Figure 8-120. Seasonal variation at Hagåtña Channel.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-121 shows enterococci monitoring data collected at Hagåtña Channel using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-121, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean

exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that nearly 30 percent of all values in the high flow zone exceed the instantaneous maximum criterion value.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-122.

The patterns observed for both wet and dry seasons in the high, moist, mid-range and dry zones are all generally similar. Wet season values are moderately higher than those observed during the dry season in the high flow zone. This confirms the importance of storm water sources that affect Hagåtña Channel. Other sources that influence water quality in the moist, mid-range, and dry zones appear to have approximately the same effect under those conditions. Seasonal differences at this site do not appear to be a major factor.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

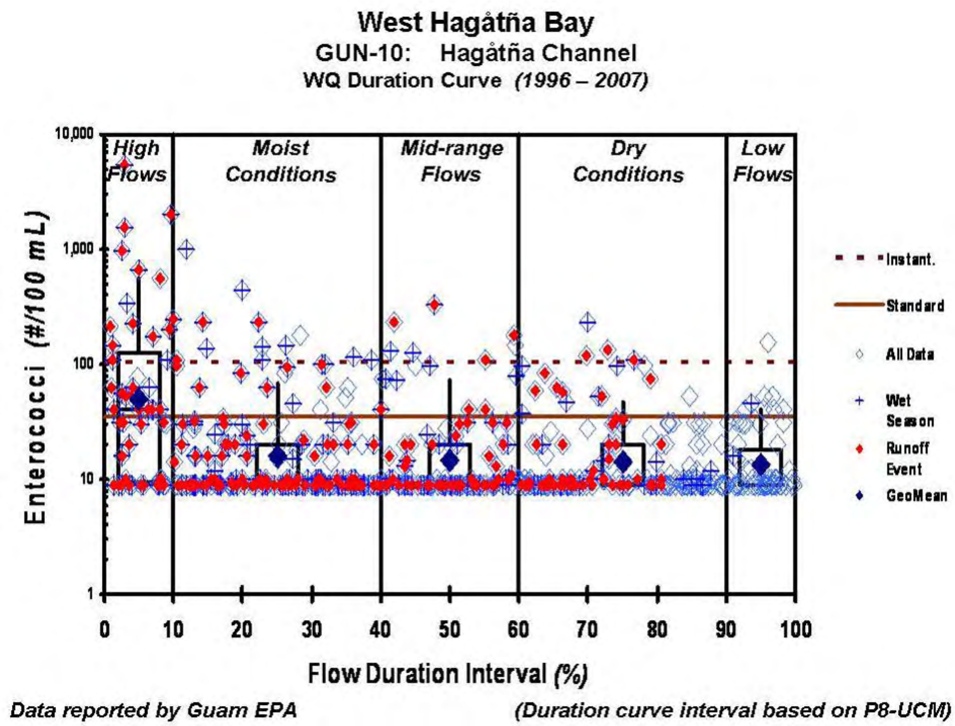

Figure 8-121. Water quality duration curve for Hagåtña Channel site.

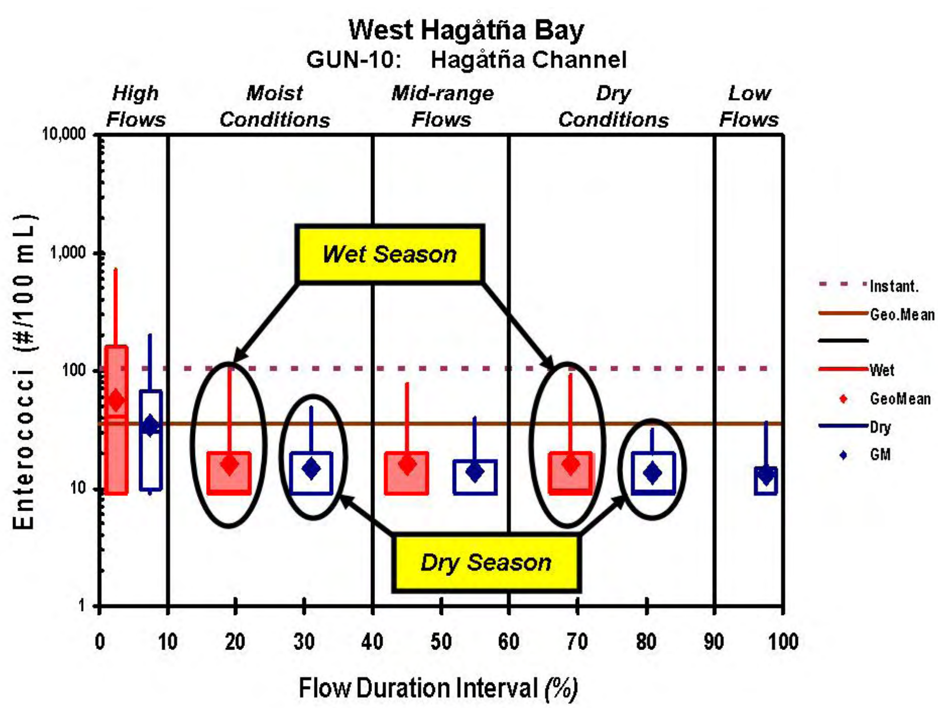

Figure 8-122. Wet versus dry season comparison for Hagåtña Channel.

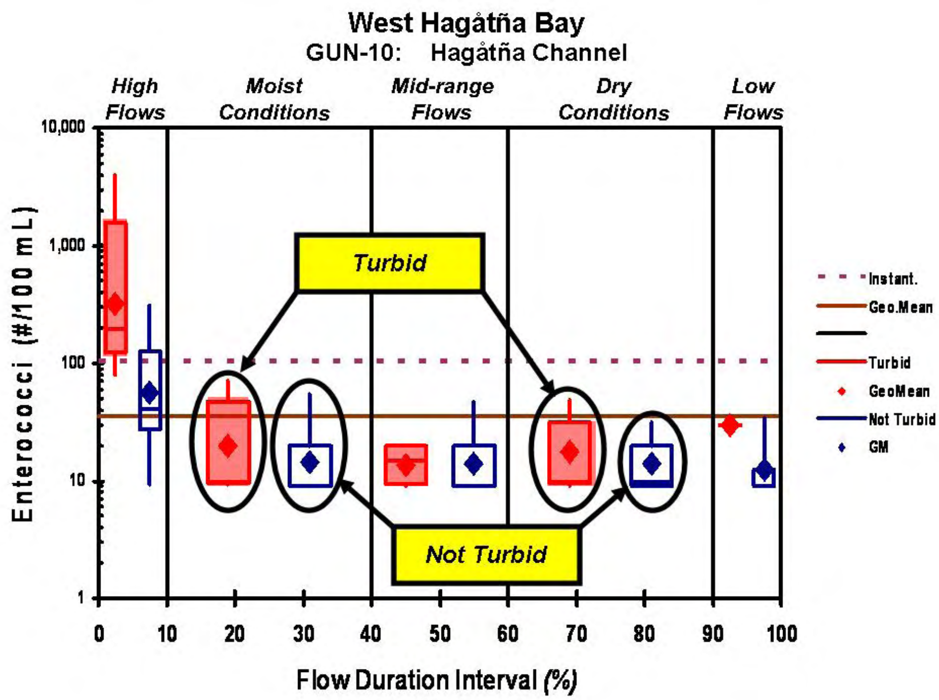

Figure 8-123. Turbid versus non-turbid sample comparison for Hagåtña Channel site.

Figure 8-123 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high and moist conditions likely reflect the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at Hagåtña Channel. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO, Agana WWTP), storm water runoff, and other sources (marina, recreational boating, boat discharges). In addition, GEPA staff identified specific potential sources that could affect water quality at Hagåtña Channel *(Table 8-41)*.

Figure 8-124 provides a closer look at the Hagåtña Channel monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-124 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

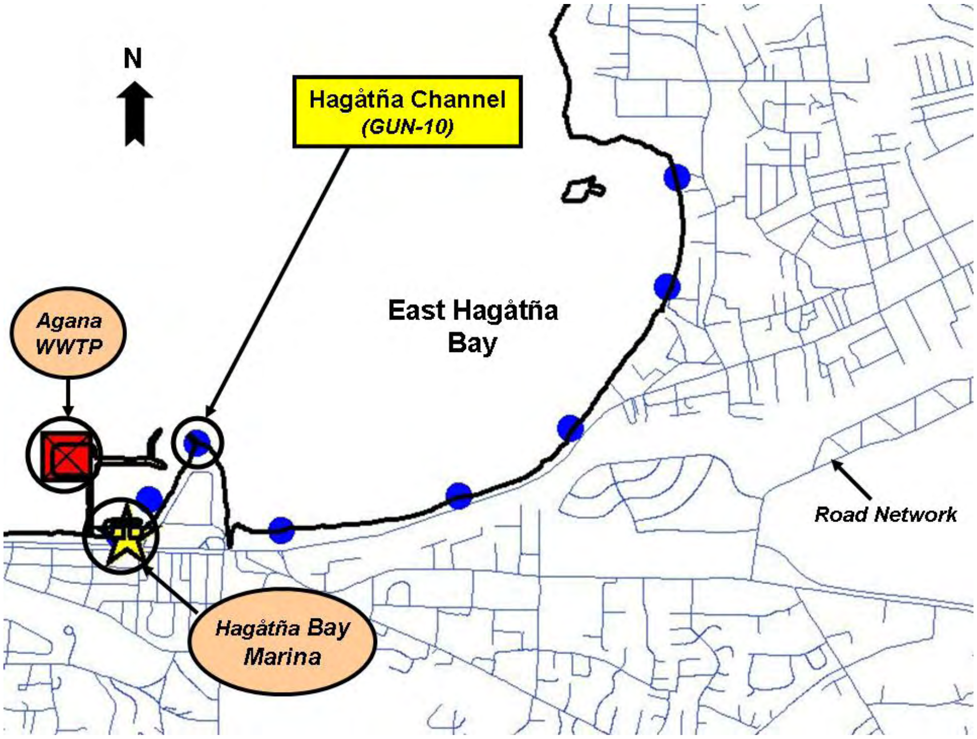

Figure 8-124. Location of Hagåtña Channel relative to potential source areas.

Table 8-41. Beach specific potential source summary *(Site GUN-10: Hagåtña Channel)*.

Site ID	Type	Source Name *(notes)*
GUN-10	Wastewater	GWA Hagåtña WWTP Sewage Outfall (old) *Old line is currently cracked on reef margin and connected to system for sporadic use.*
		GWA Hagåtña WWTP Sewage Outfall (new) *New line completed 2009.*
	Marina	Hagåtña Bay Marina (Port Authority of Guam)
	Storm water runoff	DPW Routes 7 and 7A *Runoff to Hagåtña village and storm drains to West Hagåtña Bay.*
	Storm drain runoff	DPW storm drains *Runoff from Hagåtña village and Route 1.*
	Sewage overflow	Manhole- sewer overflow *Frequent overflows to storm drain leading to West Hagåtña Bay.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Hagåtña Channel. This information is shown in Figure 8-125. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-125 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-126 shows an air photo of the area adjacent to Hagåtña Channel. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Hagåtña Channel.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Hagåtña Channel. Specifically, there is a major DPW storm drain that channels runoff to a discharge point, which may influence bacteria concentrations at this site. Also, surface runoff from Hagåtña village could be exerting an effect on water quality at this location. Finally, the old line associated with the Agana WWTP was cracked on the reef margin, which may have resulted in sporadic increases in enterococci measurements at this monitoring station.

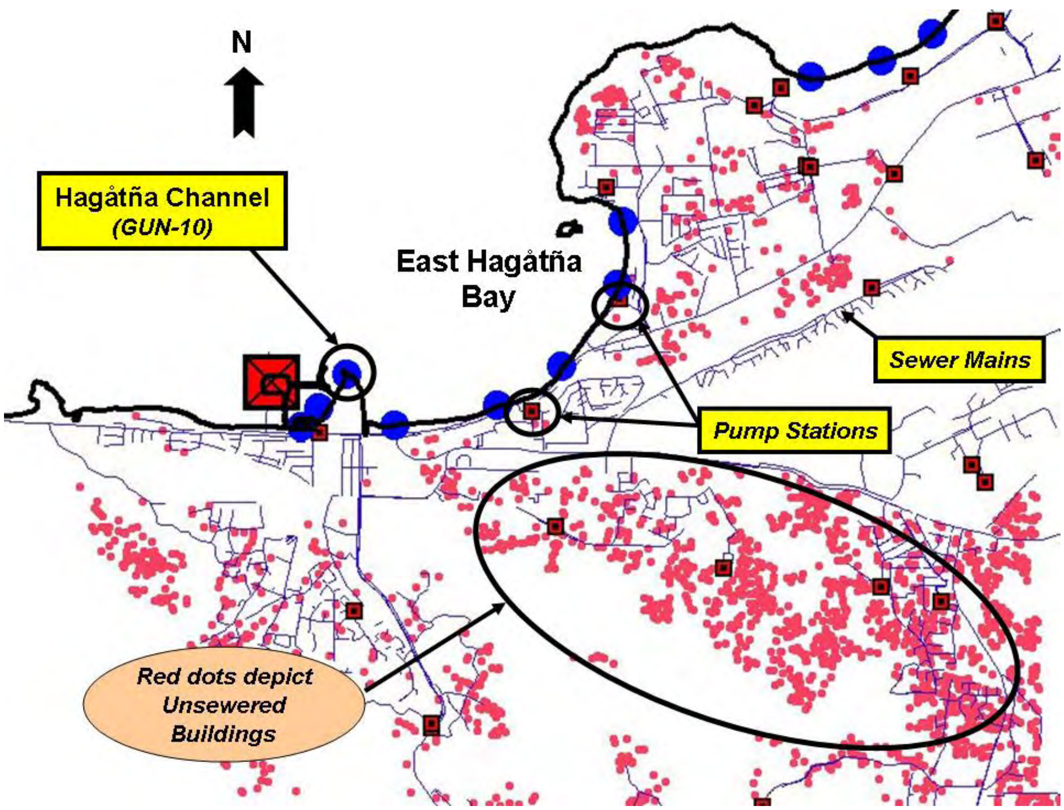

Figure 8-125. Location of Hagåtña Channel relative to potential unsewered buildings.

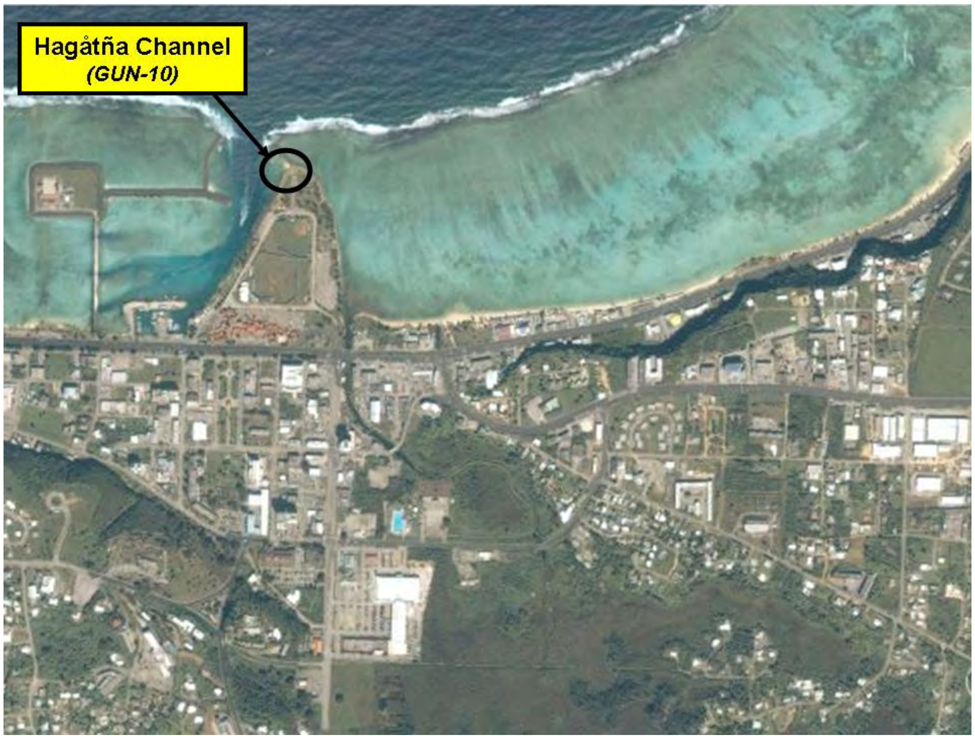

Figure 8-126. Air photo of Hagåtña Channel vicinity.

Trends. Figure 8-127 presents a year-by-year summary of the enterococcus data for the Hagåtña Channel site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Hagåtña Channel is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between July and March, indicating the importance of both wet and dry season sources at Hagåtña Channel. This is consistent with the presence of potential storm water sources identified at this location.

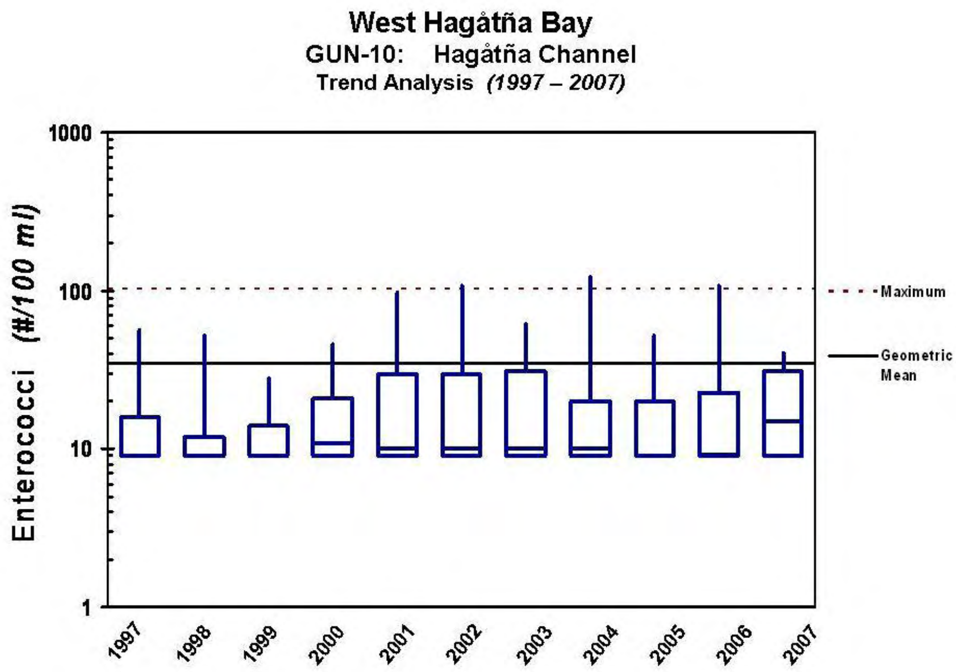

Figure 8-127. Trend analysis for Hagåtña Channel site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Hagåtña Channel, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Hagåtña Channel describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-42 presents the TMDL for Hagåtña Channel, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-42. Northern Guam Watershed TMDL summary *(Site GUN-10: Hagåtña Channel)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-43 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-43. Needed reductions to meet TMDL targets *(Site GUN-10: Hagåtña Channel)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	Moist	Mid	Dry	Low
Dry Season					
Based on geometric mean	---	---	---	---	---
Based on instantaneous maximum	48%	---	---	---	---
Wet Season					
Based on geometric mean	38%	---	---	---	---
Based on instantaneous maximum	85%	---	---	---	---

8.15 Paseo Outrigger Ramp (GUN-11)

Paseo Outrigger Ramp is situated on the Hagåtña Channel side of Paseo Beach Park *(Figure 8-128)*. It is along the waterway that connects the Hagåtña Boat Basin to East Hagåtña Bay, serving as an access point from the park. For this reason, this location experiences heavy boating activity by recreational users.

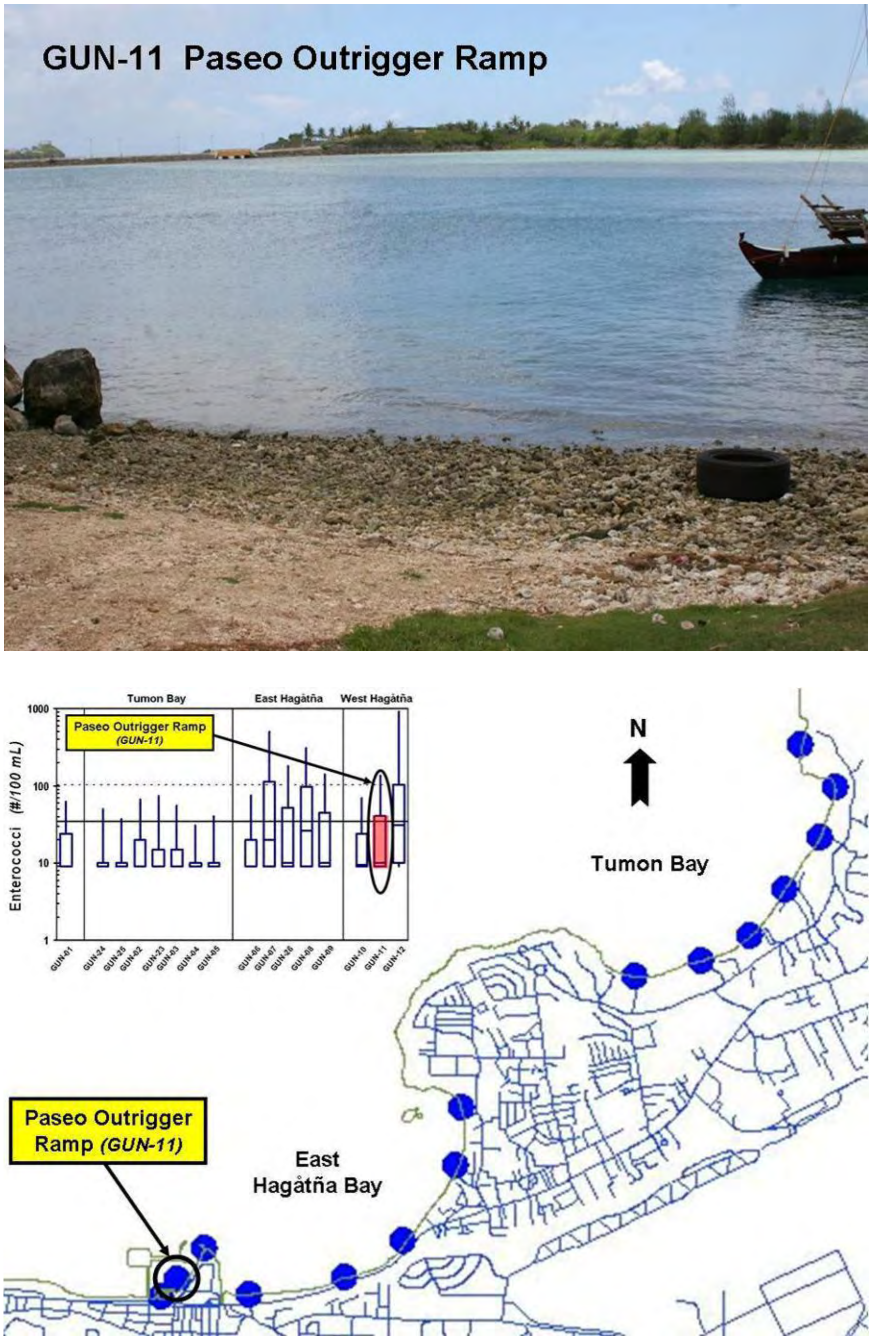

Figure 8-128. Location of Paseo Outrigger Ramp relative to other Northern Guam TMDL sites.

The frequency of beach advisories at Paseo Outrigger Ramp between 1999 and 2007 was relatively high (32%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at Paseo Outrigger Ramp were also high compared to other project area monitoring stations *(Figure 4-2 and Figure 8-128)*. The geometric mean of all individual samples was 24 counts /100mL, while the 75th and 90th percentiles were 41 and 136 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-129 shows the seasonal variability of bacteria concentrations at Paseo Outrigger Ramp. The highest concentrations were observed between June and December, indicating the importance of wet season sources at Paseo Outrigger Ramp.

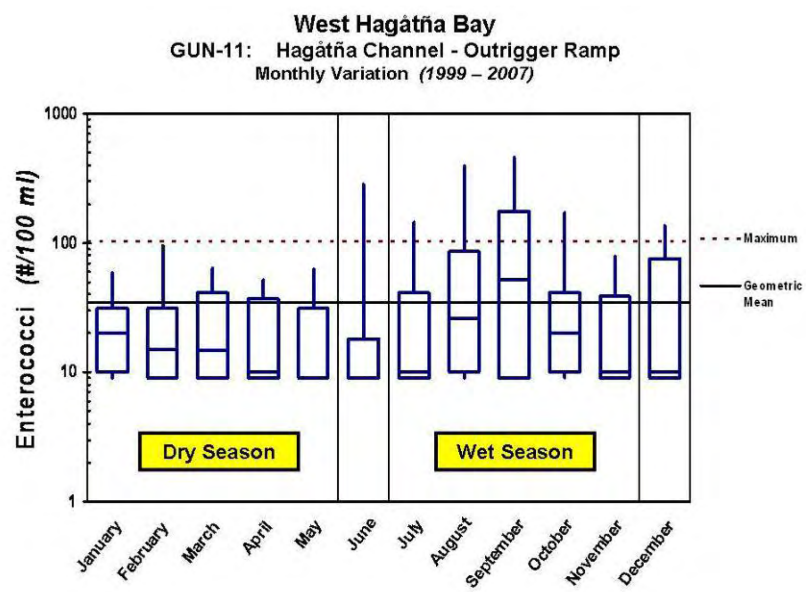

Figure 8-129. Seasonal variation at Paseo Outrigger Ramp.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-130 shows enterococci monitoring data collected at Paseo Outrigger Ramp using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-130, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean

exceeded the criterion under high flow conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that nearly 40 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. Furthermore, the 90th percentile exceeds the instantaneous maximum criterion in the moist zone. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during rain events) may be a concern under these conditions at Paseo Outrigger Ramp.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75th and 90th percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-131.

The patterns observed for both wet and dry seasons in the high, moist, mid-range and dry zones are all generally similar. Wet season values are moderately higher than those observed during the dry season, particularly in the moist, mid-range, and dry zones. These moderately higher wet season values indicate the slight possibility that seeps connected to storm water sources may be affecting water quality at this site.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

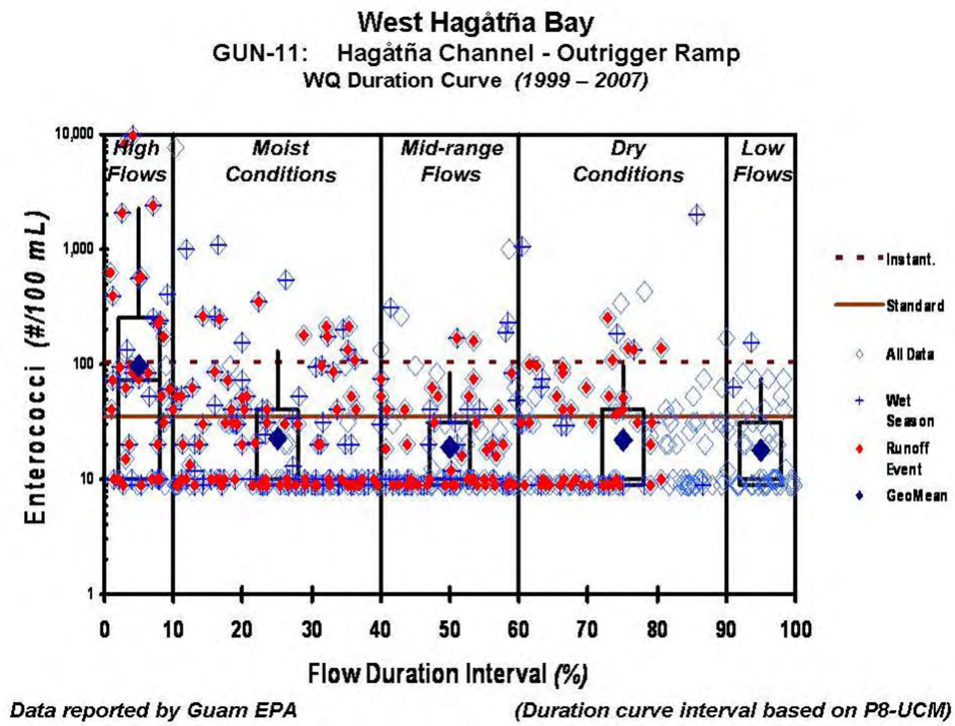

Figure 8-130. Water quality duration curve for Paseo Outrigger Ramp site.

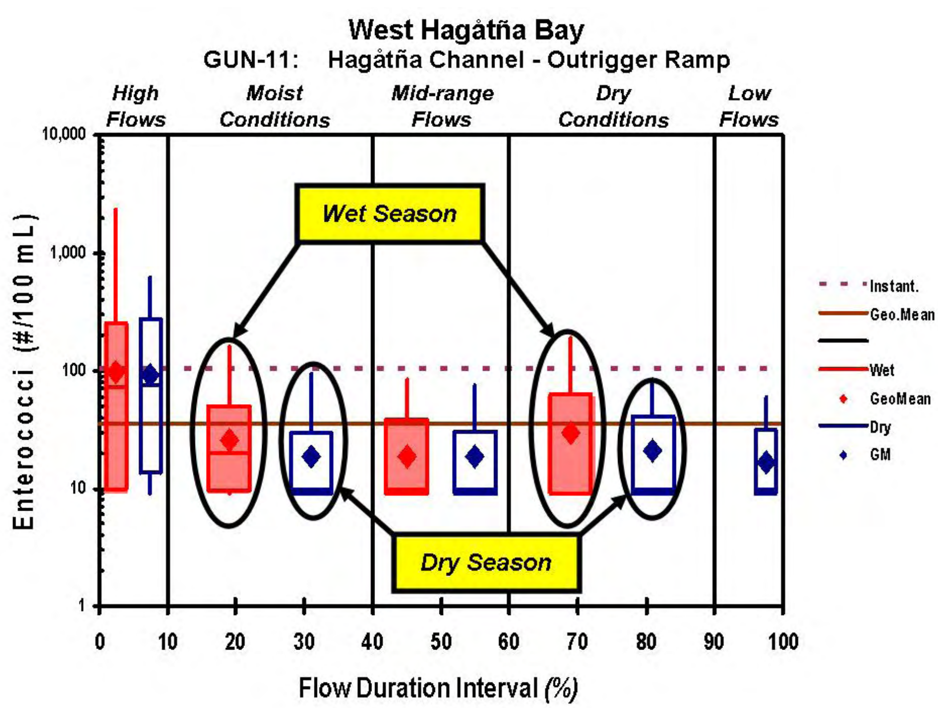

Figure 8-131. Wet versus dry season comparison for Paseo Outrigger Ramp.

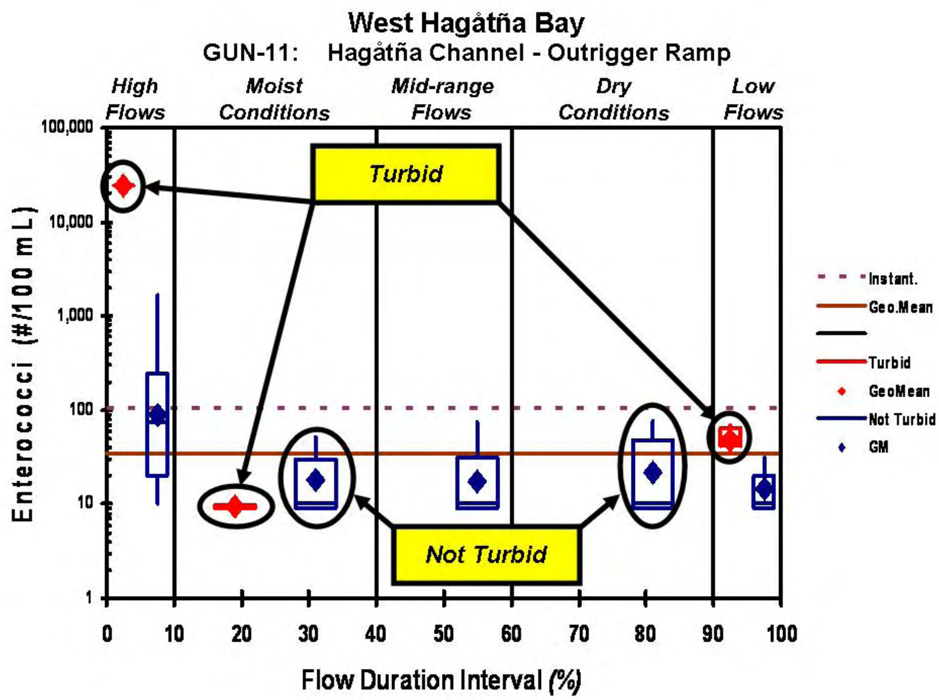

Figure 8-132. Turbid versus non-turbid sample comparison for Paseo Outrigger Ramp site.

Figure 8-132 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high flow conditions likely reflect the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at the Paseo Outrigger Ramp. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO, Agana WWTP), storm water runoff, and other sources (marina, recreational boating, boat discharges). In addition, GEPA staff identified specific potential sources that could affect water quality at the Paseo Outrigger Ramp *(Table 8-44)*.

Figure 8-133 provides a closer look at the Paseo Outrigger Ramp monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-133 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

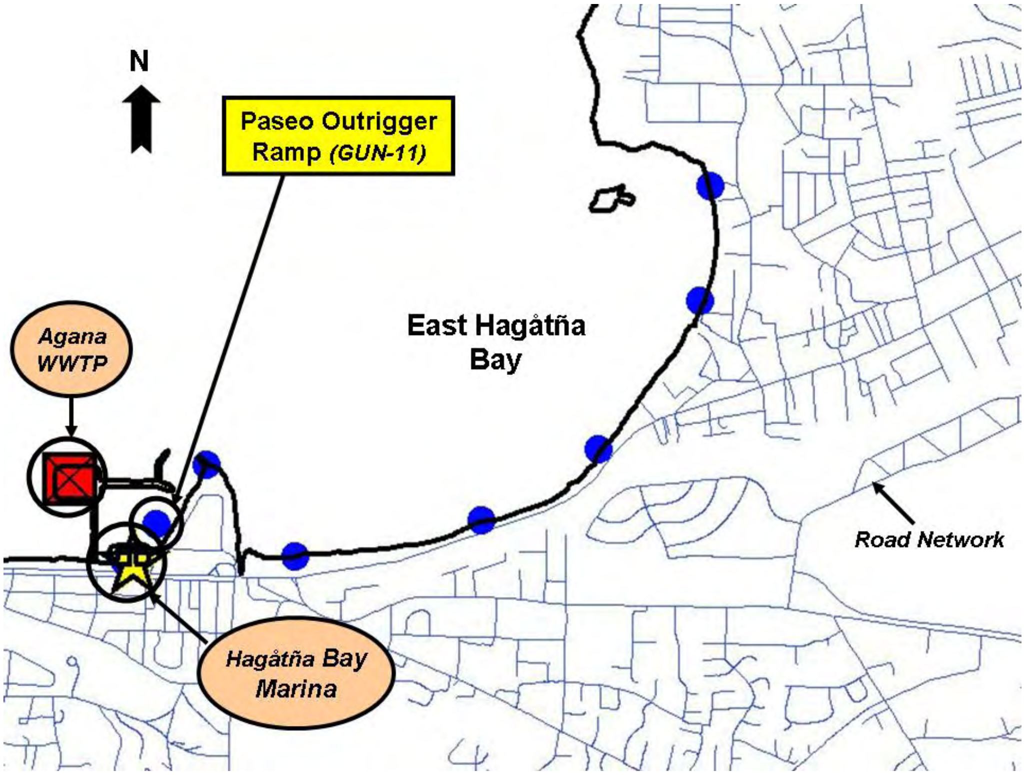

Figure 8-133. Location of Paseo Outrigger Ramp relative to potential source areas.

Table 8-44. Beach specific potential source summary *(Site GUN-11: Paseo Outrigger Ramp)*.

Site ID	Type	Source Name *(notes)*
GUN-11	Wastewater	GWA Hagåtña WWTP Sewage Outfall (old) *Old line is currently cracked on reef margin and connected to system for sporadic use.*
		GWA Hagåtña WWTP Sewage Outfall (new) *New line completed 2009.*
	Storm water runoff	DPW Routes 7 and 7A *Runoff to Hagåtña village and storm drains to West Hagåtña Bay.*
	Storm drain runoff	DPW storm drains *Runoff from Hagåtña village and Route 1.*
	Sewage overflow	Manhole- sewer overflow *Frequent overflows to storm drain leading to West Hagåtña Bay.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to Paseo Outrigger Ramp. This information is shown in Figure 8-134. In addition, sewer line blockages and breaks, as well as SSOs could contribute to elevated bacteria levels. Figure 8-134 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-135 shows an air photo of the area adjacent to Paseo Outrigger Ramp. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Paseo Outrigger Ramp.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at Paseo Outrigger Ramp. Specifically, there is a major DPW storm drain that channels runoff to a discharge point, which may influence bacteria concentrations at this site. Also, surface runoff from Hagåtña village could be exerting an effect on water quality at this location. Finally, the old line associated with the Agana WWTP was cracked on the reef margin, which may have resulted in sporadic increases in enterococci measurements at this monitoring station.

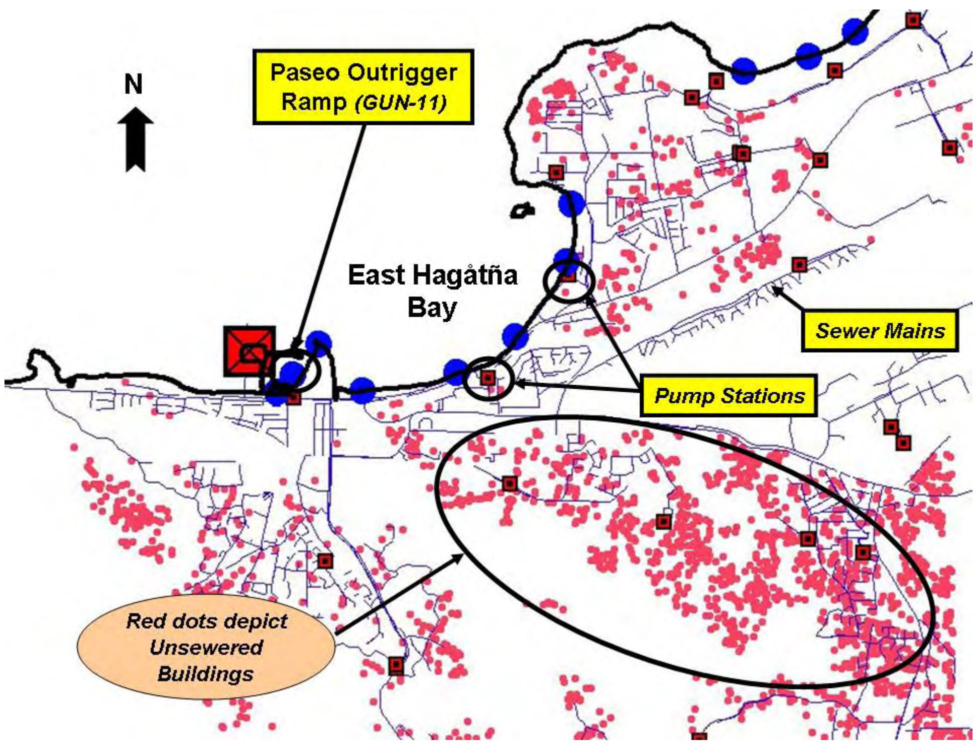

Figure 8-134. Location of Paseo Outrigger Ramp relative to potential unsewered buildings.

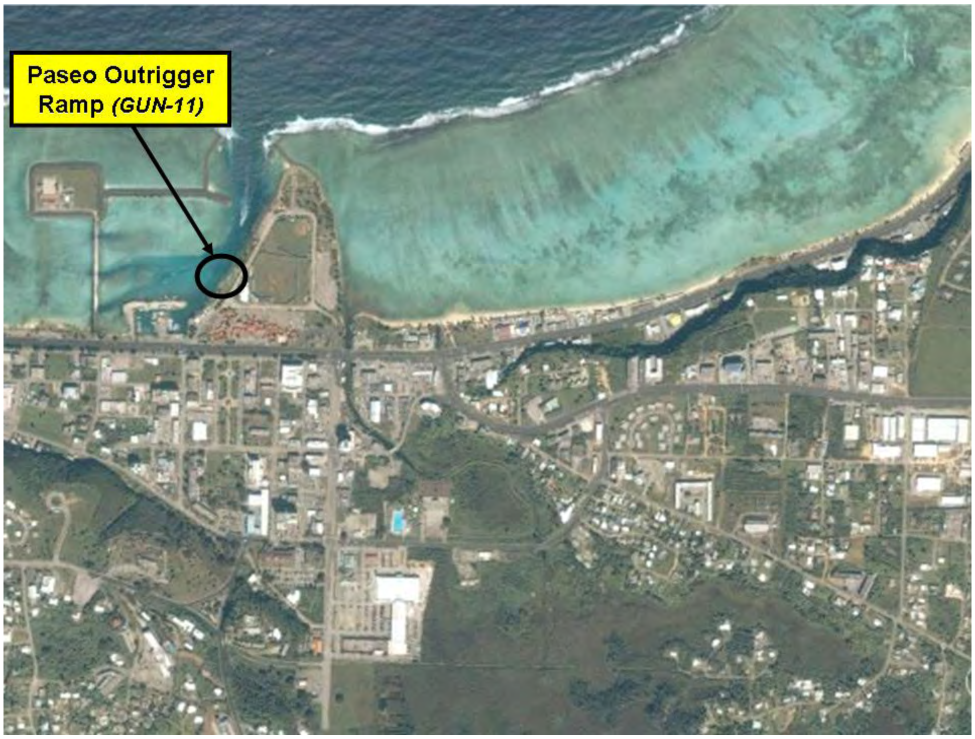

Figure 8-135. Air photo of Paseo Outrigger Ramp vicinity.

Trends. Figure 8-136 presents a year-by-year summary of the enterococcus data for the Paseo Outrigger Ramp site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Paseo Outrigger Ramp is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed between June and December, indicating the importance of wet season sources at Paseo Outrigger Ramp. This is consistent with the presence of potential storm water sources identified at this location.

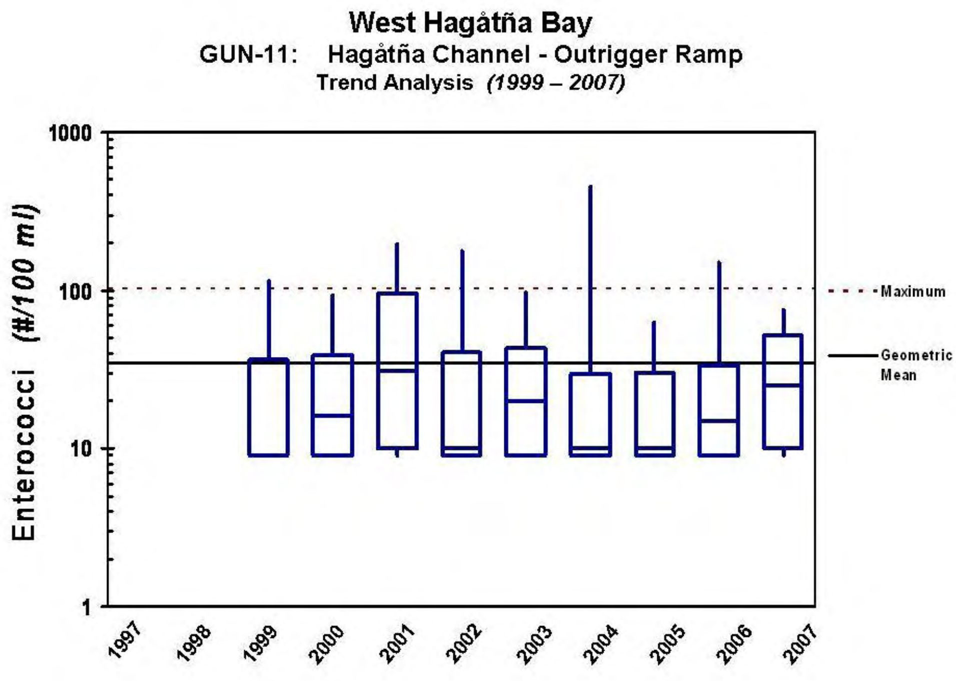

Figure 8-136. Trend analysis for Paseo Outrigger Ramp site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Paseo Outrigger Ramp, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Paseo Outrigger Ramp describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-45 presents the TMDL for Paseo Outrigger Ramp, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-45. Northern Guam Watershed TMDL summary *(Site GUN-11: Paseo Outrigger Ramp)*.

TMDL Component	Enterococcus Concentration (# / 100 mL)
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-46 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-46. Needed reductions to meet TMDL targets *(Site GUN-11: Paseo Outrigger Ramp)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	Moist	Mid	Dry	Low
Dry Season					
Based on geometric mean	62%	---	---	---	---
Based on instantaneous maximum	83%	---	---	---	---
Wet Season					
Based on geometric mean	64%	---	---	---	---
Based on instantaneous maximum	96%	34%	---	44%	---

8.16 Hagåtña Boat Basin (GUN-12)

Hagåtña Boat Basin is situated along the waterfront in the city of Hagåtña *(Figure 8-137)*. It is the principal location in the project area for boating activity that accesses Hagåtña Bay.

Figure 8-137. Location of Hagåtña Boat Basin relative to other Northern Guam TMDL sites.

The frequency of beach advisories at the Hagåtña Boat Basin between 1997 and 2007 was very high (58%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at the Hagåtña Boat Basin were also quite high compared to other project area monitoring stations *(Figure 4-2 and Figure 8-137)*. The geometric mean of all individual samples was 48 counts /100mL, while the 75th and 90th percentiles were 104 and 921 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-138 shows the seasonal variability of bacteria concentrations at the Hagåtña Boat Basin. High concentrations were observed all year, indicating the importance of both wet and dry season sources at Hagåtña Boat Basin.

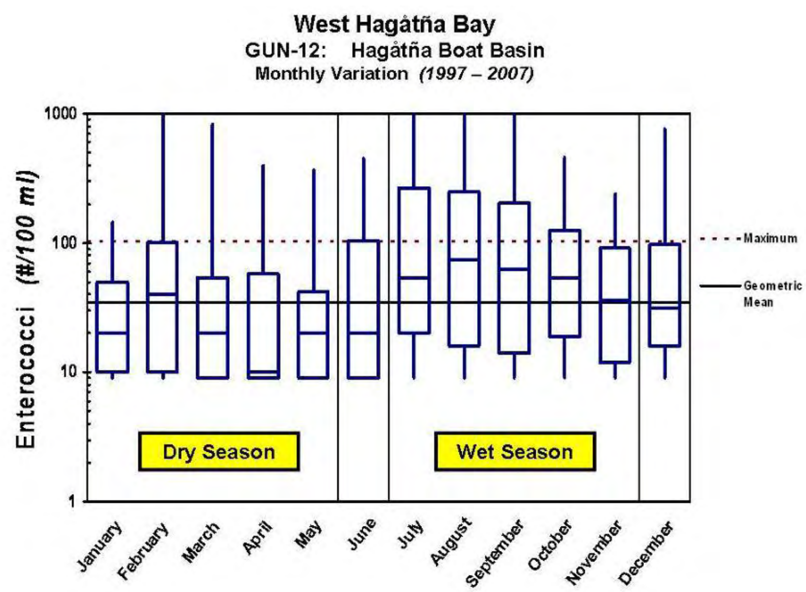

Figure 8-138. Seasonal variation at Hagåtña Boat Basin.

<u>*Effect of Flow Conditions*</u>*.* A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-139 shows enterococci monitoring data collected at the Hagåtña Boat Basin using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-139, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during heavy rainfall events. The magnitude of the increase is significantly higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean exceeded the criterion under the high, moist, and mid-range conditions. This highlights concerns at this site for storm water sources, as well as other potential sources of bacteria contamination. This concern is also confirmed by the fact that nearly 70 percent of all values in the high flow zone and over 30 percent of all values in the moist zone exceed the instantaneous maximum criterion value. Furthermore, the 90^{th} percentile exceeds the instantaneous maximum criterion value across all zones except low flows. This indicates that sources other than storm water are adversely affecting bacteria concentrations at the Hagåtña Boat Basin.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75^{th} and 90^{th} percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-140.

The patterns observed for both wet and dry seasons in the high, moist, mid-range and dry zones are all quite similar. Storm water and other sources appear to have approximately the same effect under those conditions at the Hagåtña Boat Basin. This confirms observations made regarding Figure 8-138 and Figure 8-139. Numerous sources appear to affect bacteria concentrations at this site and seasonal differences do not appear to be a factor.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

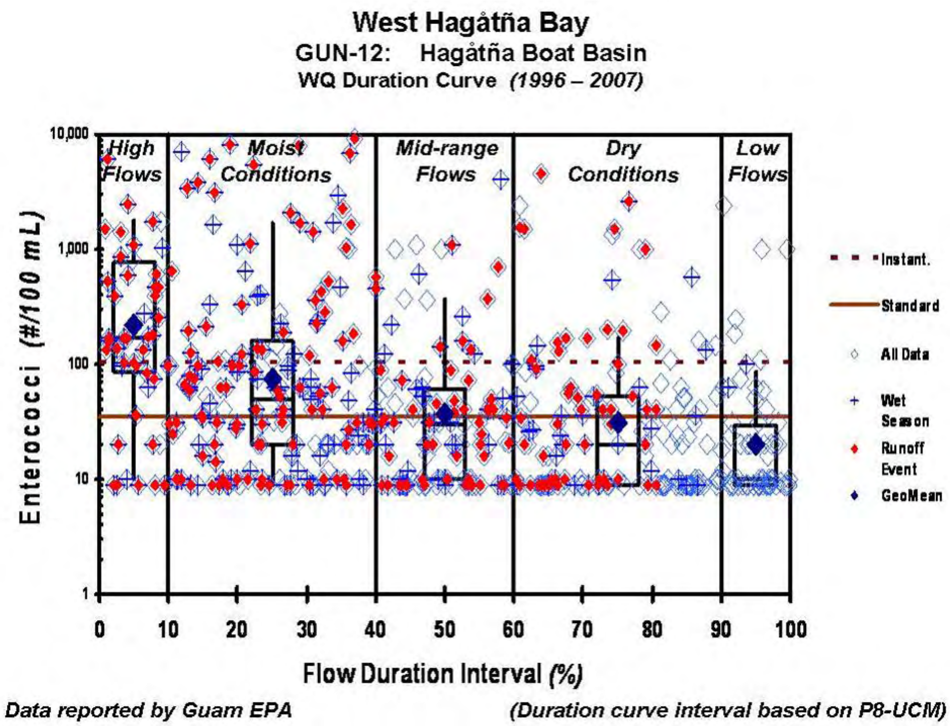

Figure 8-139. Water quality duration curve for Hagåtña Boat Basin site.

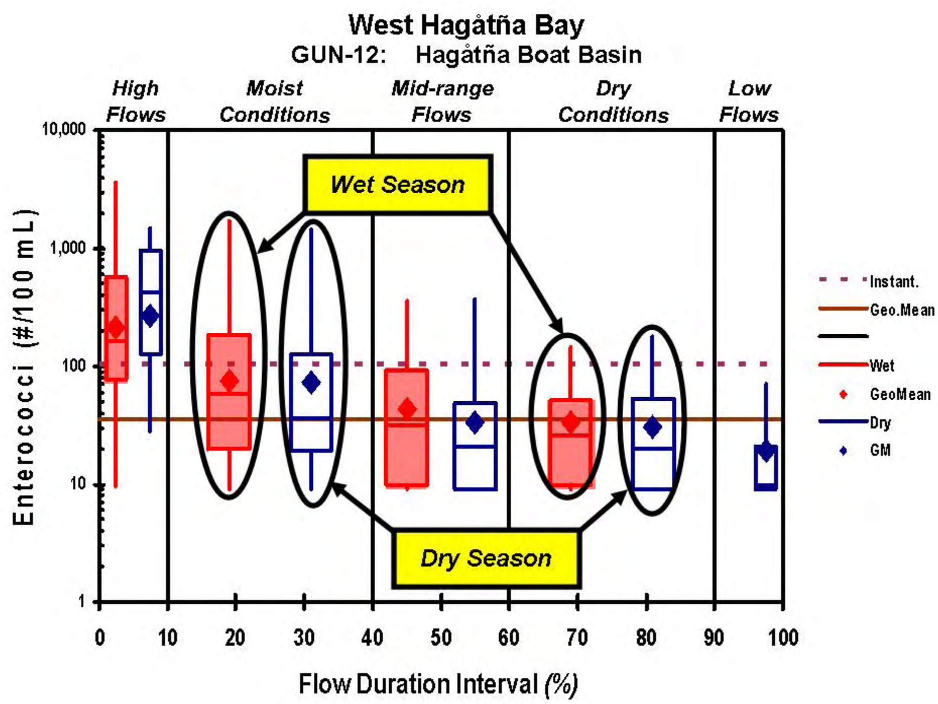

Figure 8-140. Wet versus dry season comparison for Hagåtña Boat Basin.

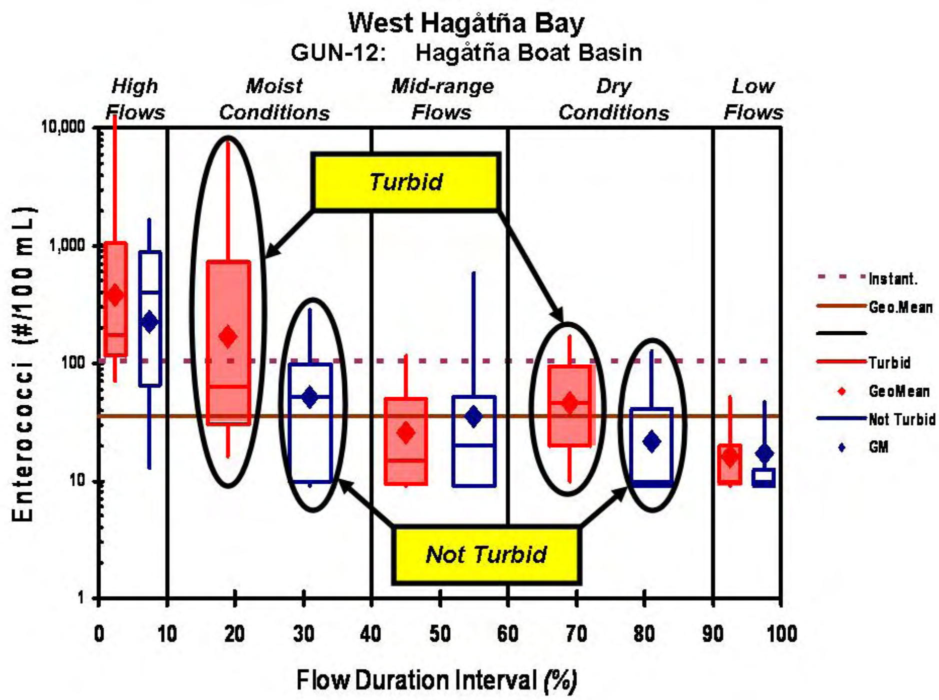

Figure 8-141. Turbid versus non-turbid sample comparison for Hagåtña Boat Basin site.

Figure 8-141 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, and mid-range flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at the Hagåtña Boat Basin. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO, Agana WWTP), storm water runoff, and other sources (marina, recreational boating, boat discharges). In addition, GEPA staff identified specific potential sources that could affect water quality at the Hagåtña Boat Basin *(Table 8-47)*.

Figure 8-142 provides a closer look at the Hagåtña Boat Basin monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-142 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

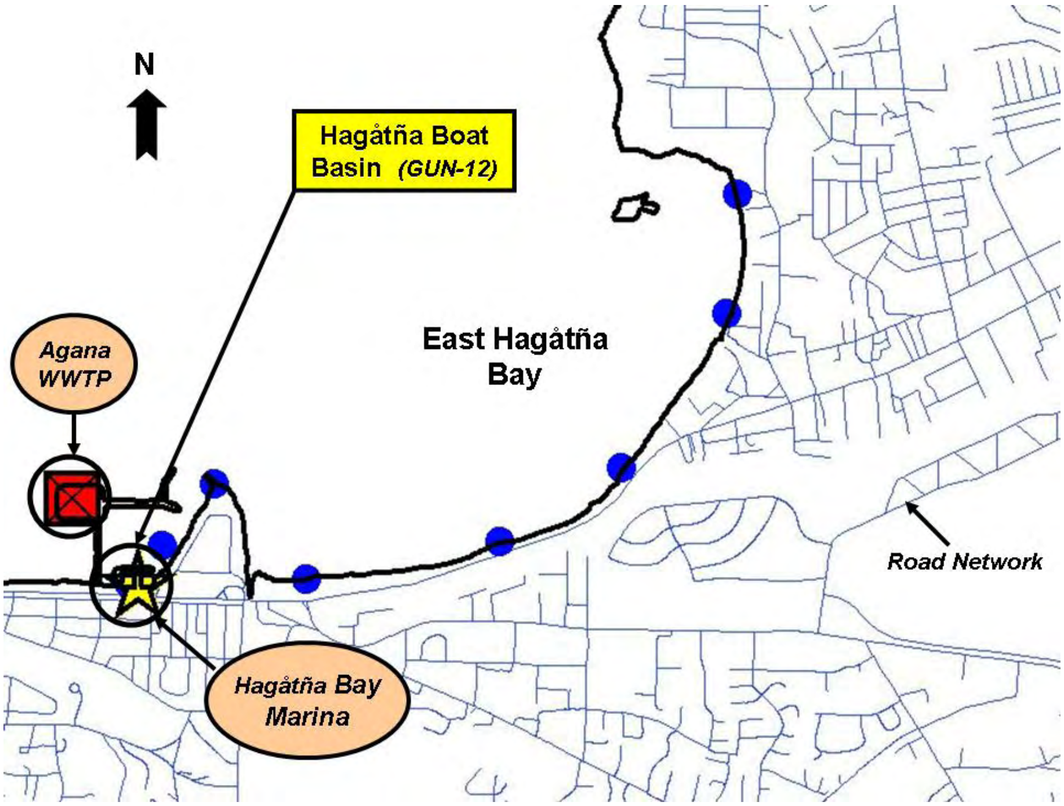

Figure 8-142. Location of Hagåtña Boat Basin relative to potential source areas.

Table 8-47. Beach specific potential source summary *(Site GUN-12: Hagåtña Boat Basin)*.

Site ID	Type	Source Name *(notes)*
GUN-12	Wastewater	GWA Hagåtña WWTP Sewage Outfall (old) *Old line is currently cracked on reef margin and connected to system for sporadic use.*
		GWA Hagåtña WWTP Sewage Outfall (new) *New line completed 2009.*
	Storm water runoff	DPW Routes 7 and 7A *Runoff to Hagåtña village and storm drains to West Hagåtña Bay.*
	Storm drain runoff	DPW storm drains *Runoff from Hagåtña village and Route 1.*
	Sewage overflow	Manhole- sewer overflow *Frequent overflows to storm drain leading to West Hagåtña Bay.*

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to the Hagåtña Boat Basin. This information is shown in Figure 8-143. In addition, sewer line blockages and breaks, as well as SSOs, could contribute to elevated bacteria levels. Figure 8-143 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-144 shows an air photo of the area adjacent to the Hagåtña Boat Basin. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Hagåtña Boat Basin.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at the Hagåtña Boat Basin. Specifically, there is a major DPW storm drain that channels runoff to a discharge point that may influence bacteria concentrations at this site. Also, surface runoff from Hagåtña village could be exerting an effect on water quality at this location. Finally, the old line associated with the Agana WWTP was cracked on the reef margin, which may have resulted in sporadic increases in enterococci measurements at this monitoring station.

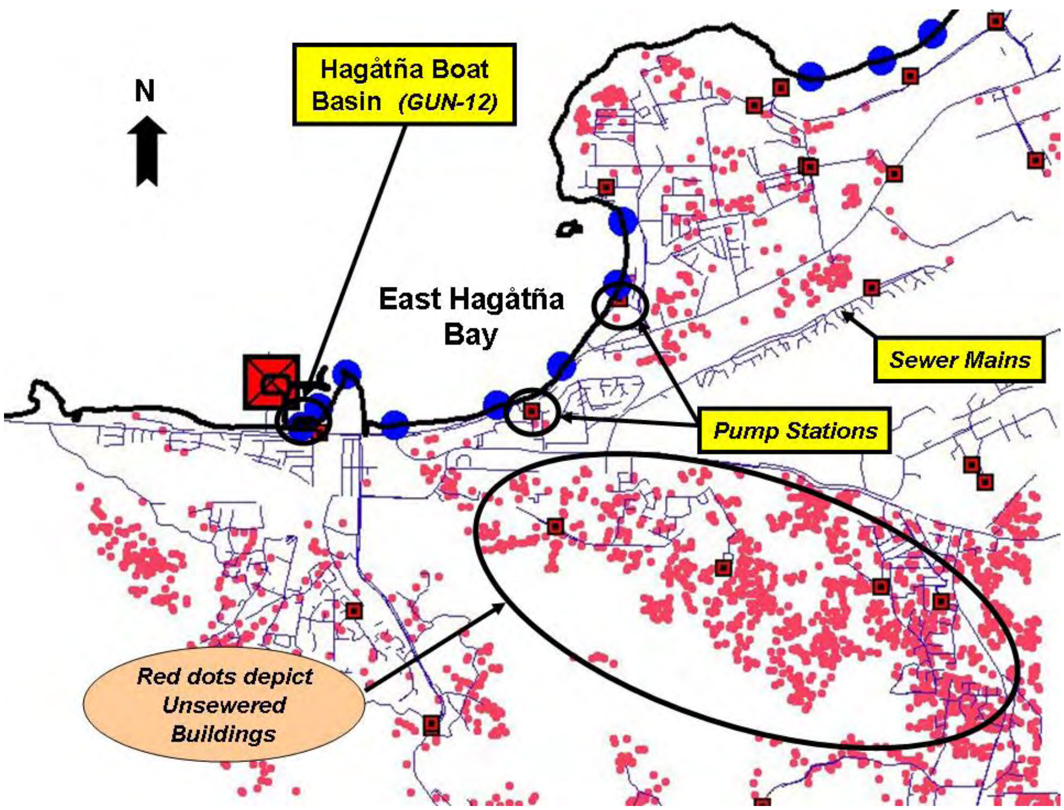

Figure 8-143. Location of Hagåtña Boat Basin relative to potential unsewered buildings.

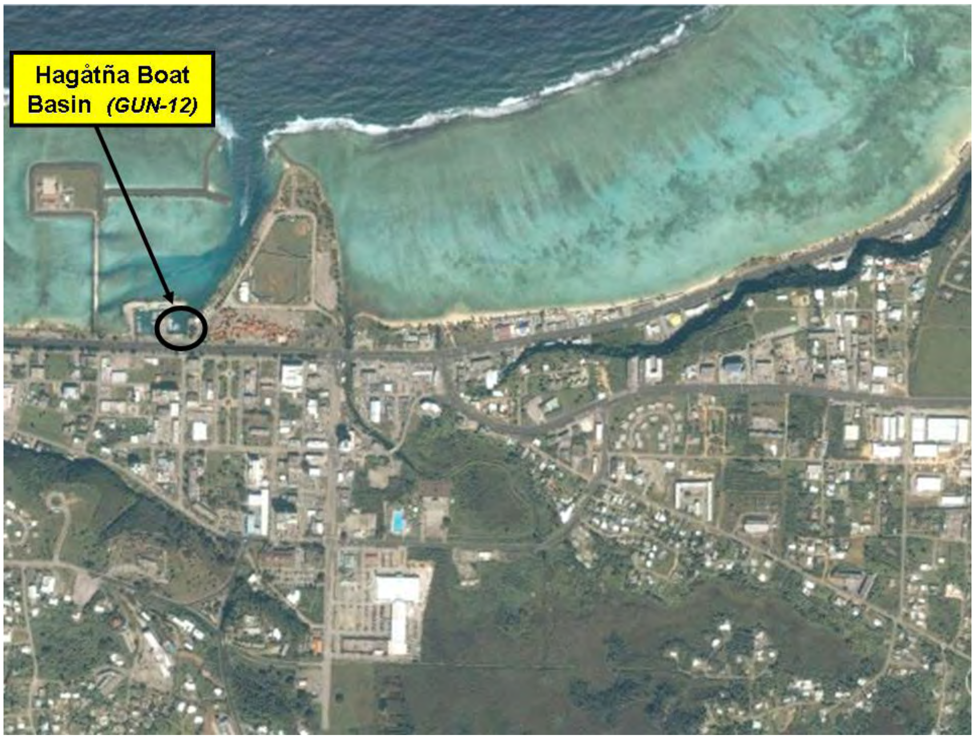

Figure 8-144. Air photo of Hagåtña Boat Basin vicinity.

Trends. Figure 8-145 presents a year-by-year summary of the enterococcus data for the Hagåtña Boat Basin site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

Linkage Analysis. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at the Hagåtña Boat Basin is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed all year, indicating the importance of wet season sources at the Hagåtña Boat Basin. This is consistent with the presence of potential storm water sources identified at this location.

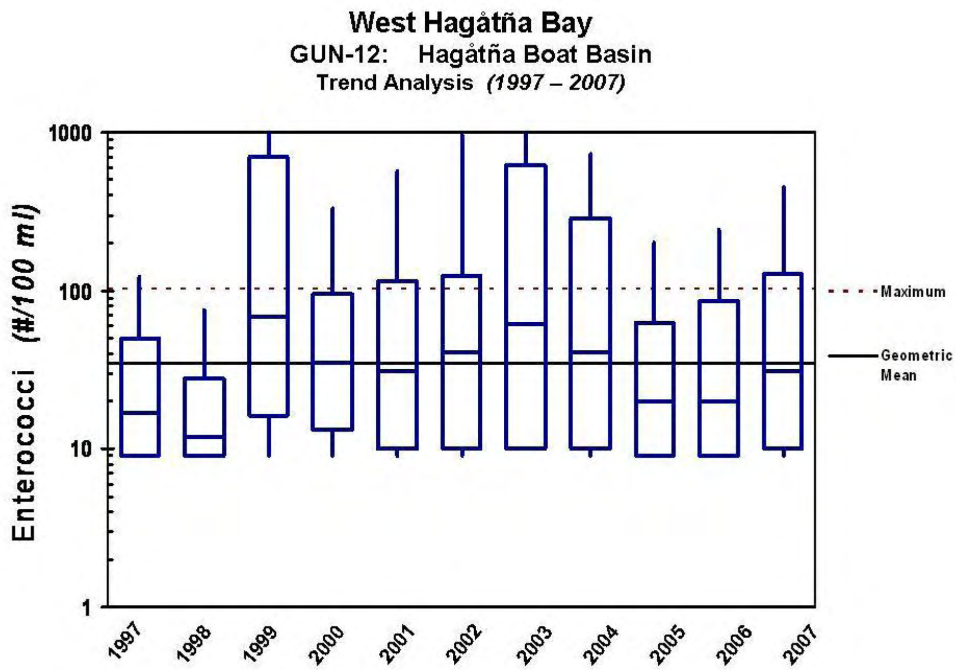

Figure 8-145. Trend analysis for Hagåtña Boat Basin site.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At the Hagåtña Boat Basin, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of the Hagåtña Boat Basin describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-48 presents the TMDL for the Hagåtña Boat Basin, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-48. Northern Guam Watershed TMDL summary *(Site GUN-12: Hagåtña Boat Basin)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-49 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-49. Needed reductions to meet TMDL targets *(Site GUN-12: Hagåtña Boat Basin)*.

Needed Reductions	Flow Conditions *(expressed as percentage)*				
	High	Moist	Mid	Dry	Low
Dry Season					
Based on geometric mean	87%	51%	---	---	---
Based on instantaneous maximum	93%	93%	72%	42%	---
Wet Season					
Based on geometric mean	83%	54%	20%	---	---
Based on instantaneous maximum	97%	94%	71%	28%	---

8.17 Hagåtña Bayside Park (GUN-13)

Hagåtña Bayside Park is situated along the waterfront in the city of Hagåtña *(Figure 8-146)*. It is located just west of the Hagåtña Boat Basin. The beach is used destination for jet skiing, parasailing, and other water vehicle type activities. The close proximity of this beach to the Hagåtña Boat Basin warrants its inclusion in the project area for these TMDLs.

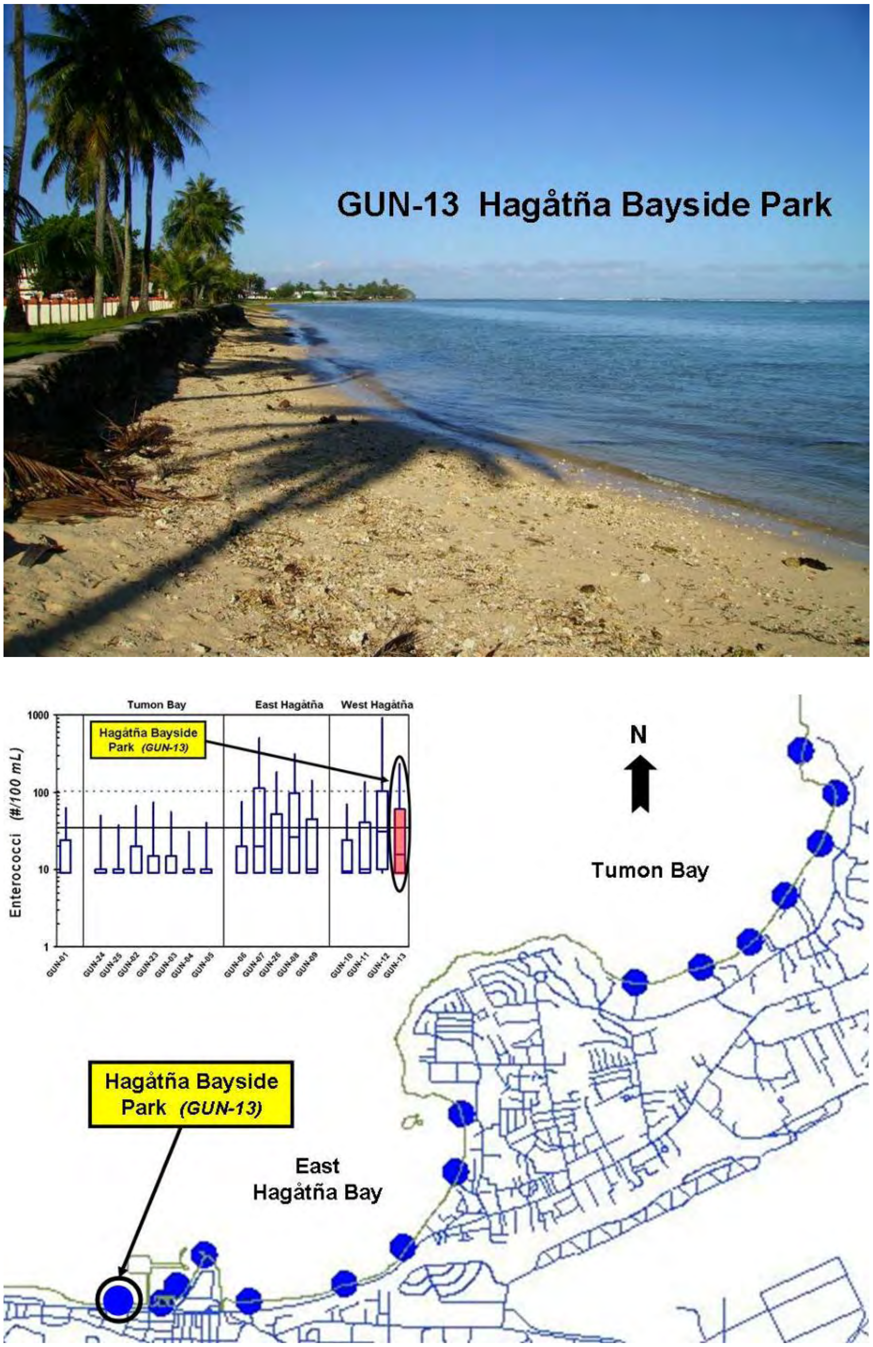

Figure 8-146. Location of Hagåtña Bayside Park relative to other Northern Guam TMDL sites.

The frequency of beach advisories at the Hagåtña Bayside Park between 1997 and 2007 was relatively high (39%) compared to other RBMP sites in the Northern Beach TMDL project area *(Figure 4-1)*. Enterococci concentrations at the Hagåtña Bayside Park were also higher compared to other project area monitoring stations *(Figure 4-2 and Figure 8-146)*. The geometric mean of all individual samples was 28 counts /100mL, while the 75th and 90th percentiles were 60 and 234 counts /100 mL respectively.

A key part of the data analysis for individual beaches is to examine water quality patterns by season and relative to flow conditions (e.g., runoff dominated versus base flows). Figure 8-147 shows the seasonal variability of bacteria concentrations at the Hagåtña Bayside Park. The highest concentrations were observed between June and October, indicating the importance of wet season sources at Hagåtña Bayside Park. The 75th and 90th percentiles were also elevated during the other months. This shows that dry season sources can occasional influence water quality at this site.

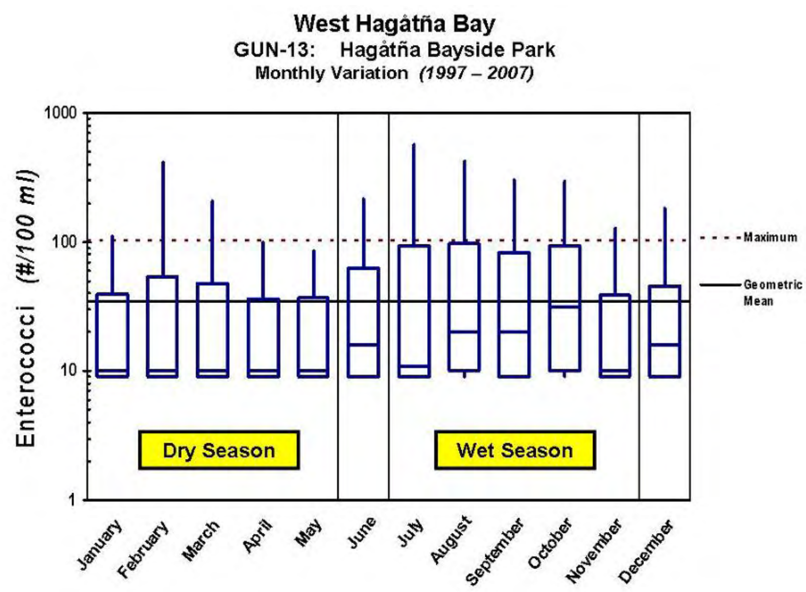

Figure 8-147. Seasonal variation at Hagåtña Bayside Park.

Effect of Flow Conditions. A useful approach for relating water quality information to potential source areas is to examine bacteria levels in terms of hydrologic conditions. Figure 8-148 shows enterococci monitoring data collected at the Hagåtña Bayside Park using a duration curve framework. Although there is significant variability in the data, which is characteristic of bacteria monitoring information, a definite pattern exists.

As indicated by the *"box and whisker"* plots in Figure 8-148, the highest bacteria concentrations occur under high flow conditions. This is not unexpected because water quality at most beaches is strongly influenced by storm water runoff during

heavy rainfall events. The magnitude of the increase is significantly higher than that observed at other Northern Guam RBMP sites. In fact, the geometric mean exceeded the criterion under high and moist conditions, which indicates the need to address storm water sources. This concern is reinforced by the fact that over 50 percent of all values in the high flow zone exceed the instantaneous maximum criterion value. Furthermore, the 90^{th} percentile exceeds the instantaneous maximum criterion in the moist and dry zones. This indicates that sources associated with periodic short term problems (e.g., spills into the storm drain system or sewer overflows during rain events) may be a concern under these conditions at Hagåtña Bayside Park Beach.

Incorporating seasonality into the analysis allows a closer look at patterns that may be associated with certain source categories. For example, bacteria delivered through seeps connected to storm water ponds are more likely to affect beach monitoring data during the wet season. In contrast, bacteria contributed from more continuous sources (e.g., leaky sewer lines or failing septics) will exert a greater effect during the dry season. Comparisons between the geometric means, the 75^{th} and 90^{th} percentiles for each duration curve zone serve as primary measures for examining seasonality. This is illustrated in Figure 8-149.

The patterns observed for both wet and dry seasons in the high and moist zones are all quite similar. Storm water and other sources appear to have approximately the same effect under those conditions at the Hagåtña Bayside Park. This confirms observations made regarding Figure 8-147 and Figure 8-148. One interesting observation is the higher bacteria concentrations during the dry season across the mid-range and dry zones. This is likely due to the effect of problems at the Agana WWTP, which would tend to be more pronounced when wet weather sources are less of a concern.

Relationship to Other Indicators. In addition to seasonal patterns, the relationship of bacteria concentrations to other parameters can be incorporated into the data analysis. Guam EPA staff noted field data for several indicators at the time of bacteria sample collection as part of the RBMP. These include observations such as tidal stage and presence or absence of turbidity.

The combination of patterns with some of these observations could be related to potential source areas and delivery mechanism that might affect bacteria concentrations at any particular beach of interest. For example, the presence or absence of turbidity may also be an indicator of either storm water runoff or suspended material associated with wind action. This approach to the analysis provides information that might prove useful in guiding implementation efforts intended to address documented problems.

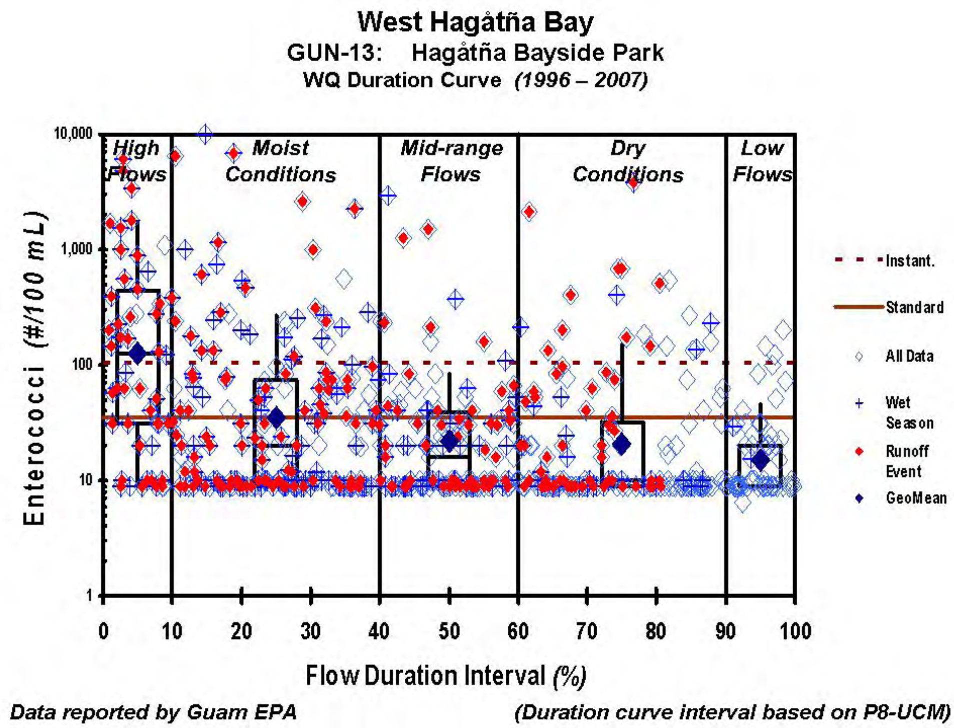

Figure 8-148. Water quality duration curve for Hagåtña Bayside Park site.

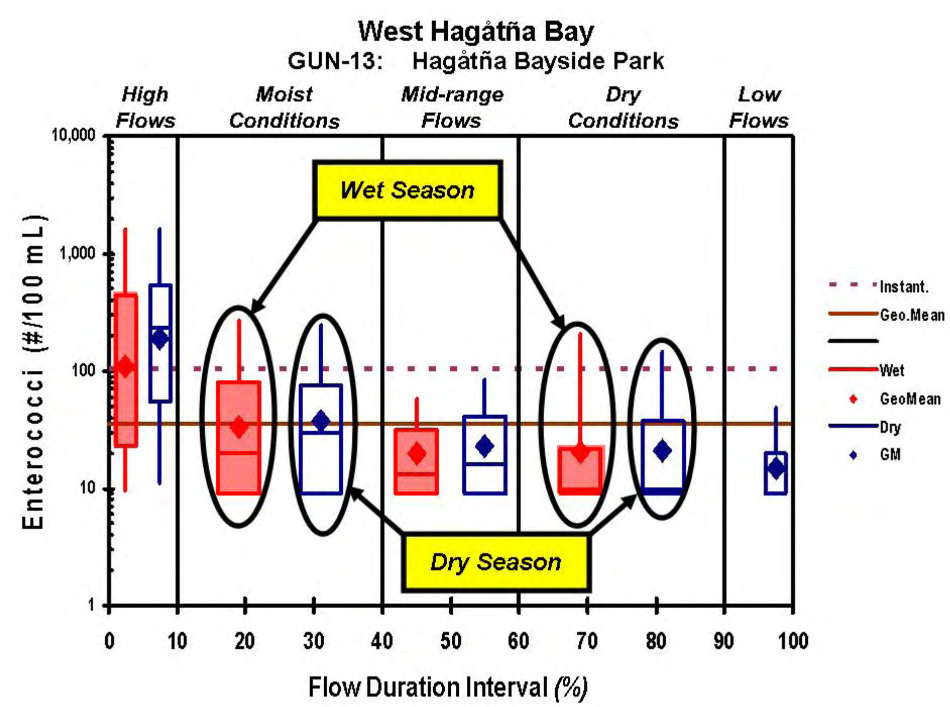

Figure 8-149. Wet versus dry season comparison for Hagåtña Bayside Park.

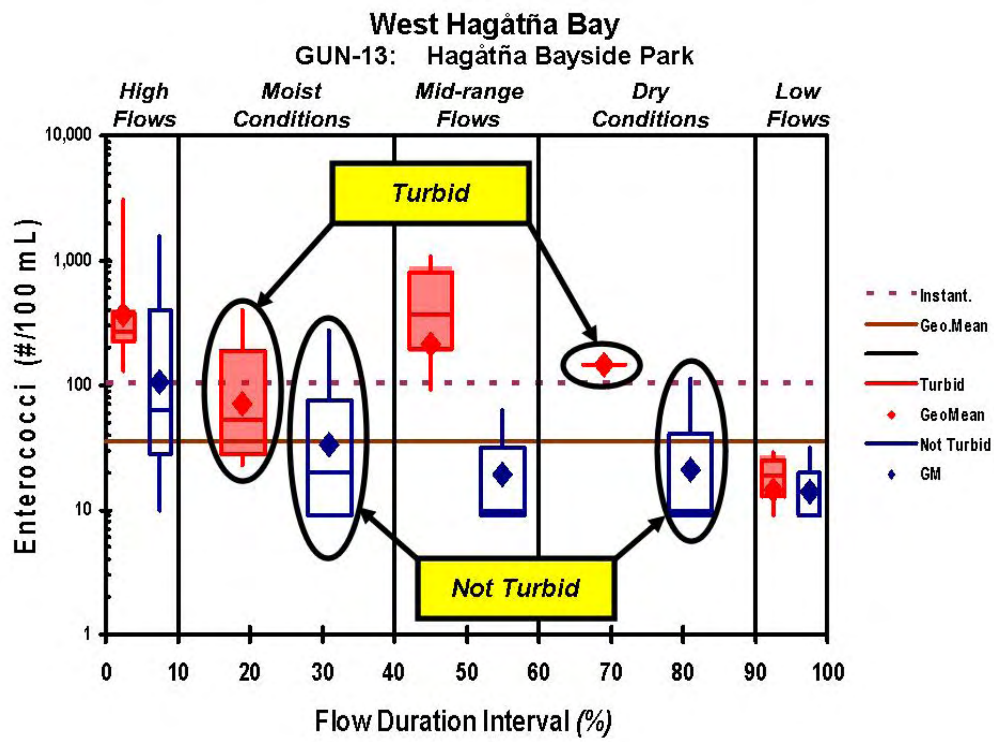

Figure 8-150. Turbid versus non-turbid sample comparison for Hagåtña Bayside Park site.

Figure 8-150 shows the difference between bacteria levels when turbidity was present or absent during sample collection under the various flow conditions. The increased levels when turbidity was present under high, moist, mid-range, and dry flow conditions likely reflects the effect of bacteria transported with fine particles during storm events. The effect of bacteria associated with resuspension of bottom sediments might also be the result of wind and wave action, which could affect beach water quality.

Potential Sources. The Source Assessment (Section 5, Table 5-2) summarized potential sources that may affect bacteria concentrations at the Hagåtña Bayside Park. Included are wastewater sources (septic systems, sewer line blockages & breaks, SSO, Agana WWTP), storm water runoff, and other sources (marina, recreational boating, boat discharges). In addition, GEPA staff identified specific potential sources that could affect water quality at Hagåtña Bayside Park *(Table 8-50)*.

Table 8-50. Beach specific potential source summary *(Site GUN-13: Hagåtña Bayside Park)*.

Site ID	Type	Source Name *(notes)*
GUN-13	Wastewater	GWA Hagåtña WWTP Sewage Outfall (new) *New line completed 2009.*
		Septic systems *Concentrated number of unsewered buildings in upland area adjacent to beach*
		Wastewater pumping activities (portable toilets).
	Storm water runoff	DPW Routes 7 and 7A *Runoff to Hagåtña village and storm drains to West Hagåtña Bay.*
	Storm drain runoff	DPW storm drains *Runoff from Hagåtña village and Route 1.*
	Sewage overflow	Manhole- sewer overflow *Frequent overflows to storm drain leading to West Hagåtña Bay.*
	UIC - SW *	US District Court *(3 locations)*
		Oil collection activities *(facility)*

Notes: * UIC - SW: Underground Injection Control – Storm Water

Figure 8-151 provides a closer look at the Hagåtña Bayside Park monitoring site relative to upland areas that potentially contribute bacteria during storm events. Figure 8-151 includes roads, which can provide a general indication of the urban drainage network and accompanying storm drains. The map also highlights the location of the Agana WWTP and the Hagåtña Bay Marina.

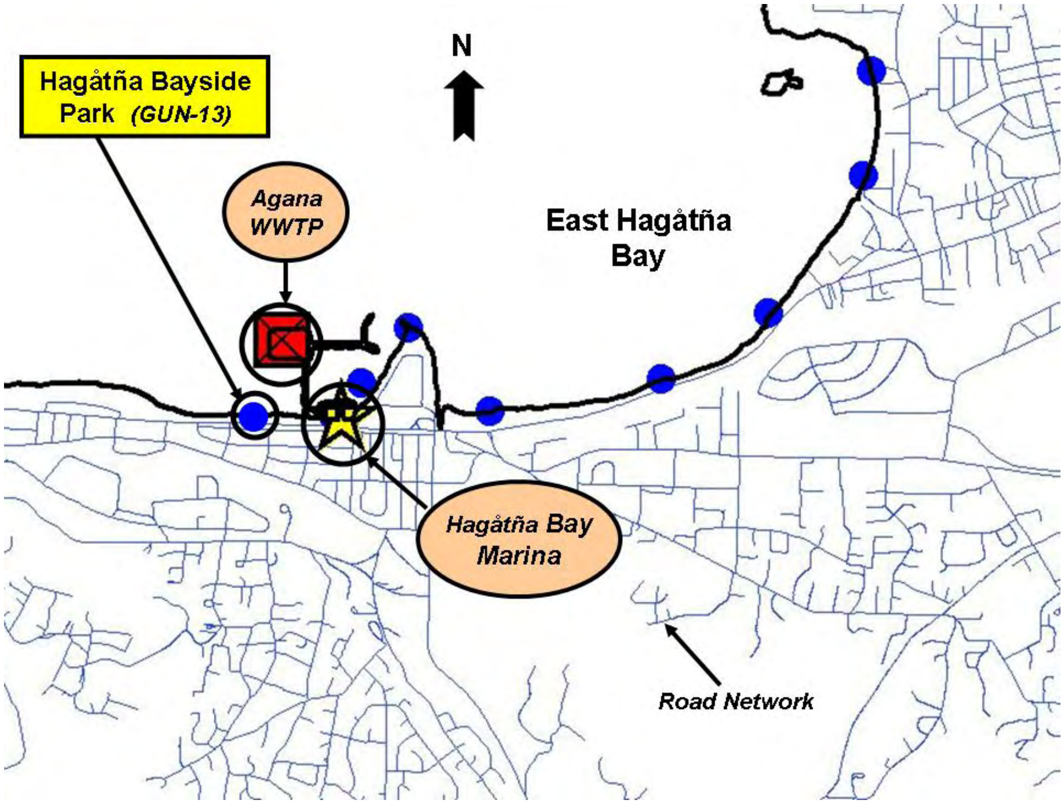

Figure 8-151. Location of Hagåtña Bayside Park relative to potential source areas.

A review of GIS information shows a number of unsewered buildings in the upland area adjacent to the Hagåtña Bayside Park. This information is shown in Figure 8-152. In addition, sewer line blockages and breaks, as well as SSOs, could contribute to elevated bacteria levels. Figure 8-152 shows the location of both sewer mains and pump stations, as indicators of potential water quality problems associated with wastewater conveyance systems.

Figure 8-153 shows an air photo of the area adjacent to the Hagåtña Bayside Park. This provides a different perspective, which highlights the high density of roads and buildings in the area adjacent to Hagåtña Bayside Park.

In addition to previous assessments and GIS information, Guam EPA staff identified other potential sources that could affect water quality at the Hagåtña Bayside Park. Specifically, there is a major DPW storm drain that channels runoff to a discharge point that may influence bacteria concentrations at this site. Also, surface runoff from Hagåtña village could be exerting an effect on water quality at this location. Finally, the old line associated with the Agana WWTP was cracked on the reef margin, which may have resulted in sporadic increases in enterococci measurements at this monitoring station.

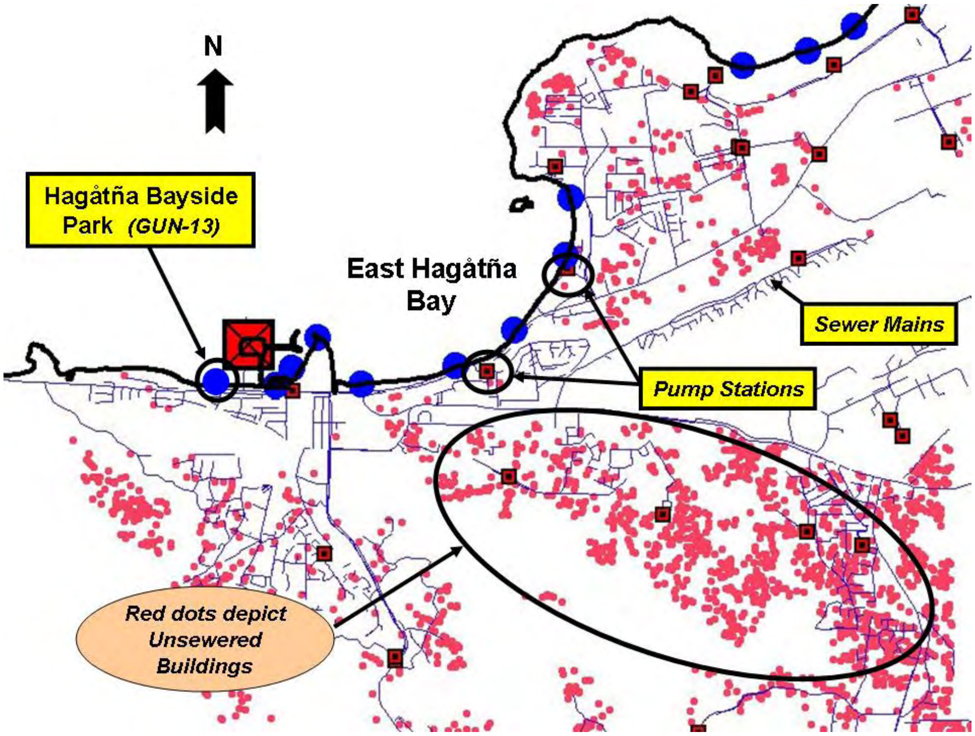

Figure 8-152. Location of Hagåtña Bayside Park relative to potential unsewered buildings.

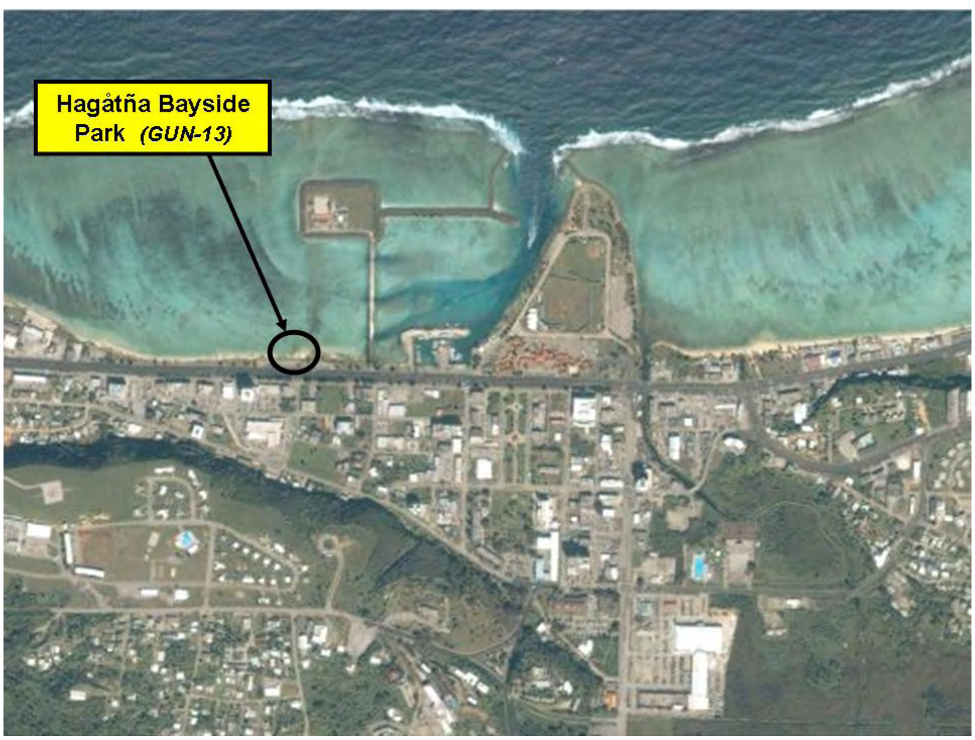

Figure 8-153. Air photo of Hagåtña Bayside Park vicinity.

<u>Trends</u>. Figure 8-154 presents a year-by-year summary of the enterococcus data for the Hagåtña Bayside Park site. This provides a useful way to examine trends relative to both central tendency and annual variation. This type of analysis is useful in looking at specific sites where efforts to address beach advisories have been implemented. For example, a focus on patterns such as trends in geometric means or 90th percentiles provides a visual analysis that can be used to evaluate program effectiveness. With respect to trends, it should be noted that a laboratory analytical method change occurred in September 2000. The IDEXX test was used to determine enterococcus concentrations on all samples collected after September 2000.

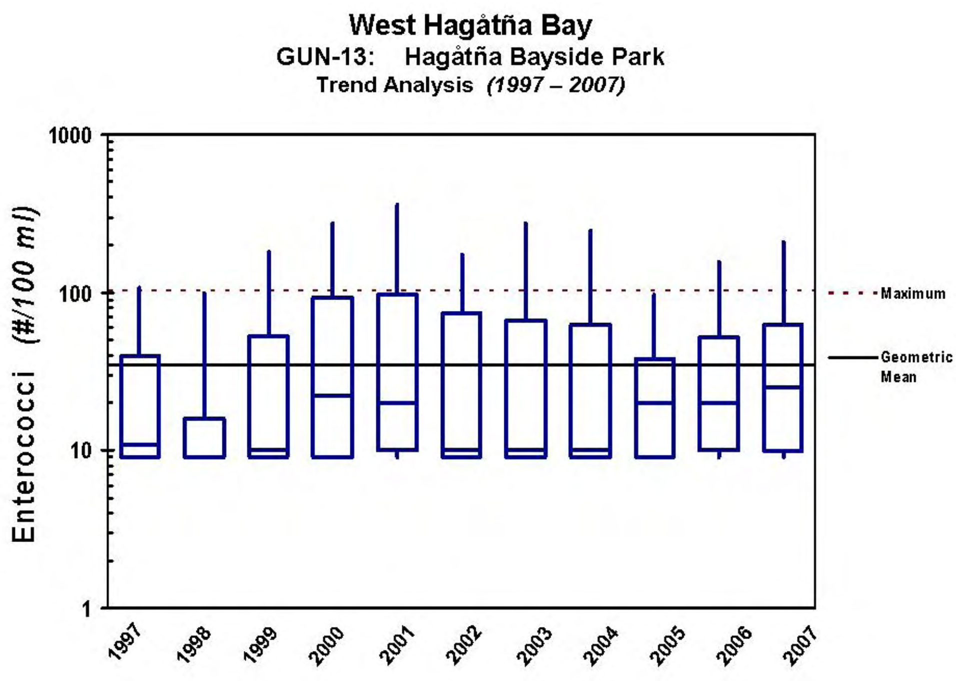

Figure 8-154. Trend analysis for Hagåtña Bayside Park site.

<u>Linkage Analysis</u>. The numeric target for this TMDL is Guam's concentration-based criteria for enterococci bacteria (i.e., a geometric mean of 35 counts / 100 mL and an instantaneous maximum of 104 counts / 100 mL). The relationship between this target and potential sources at Hagåtña Bayside Park Beach is demonstrated through an analysis of water quality monitoring data at this site. Seasonal patterns, for example, show that the highest concentrations are observed all year, indicating the importance of both wet and dry season sources at Hagåtña Bayside Park Beach. This is consistent with the presence of potential storm water sources identified at this location.

The connection between storm water sources and exceedances of numeric targets is further confirmed by examining the effect of flow conditions. At Hagåtña Bayside Park Beach, the highest bacteria concentrations occur under high flows. Water quality conditions that reflect this pattern are strongly influenced by storm water runoff during heavy rainfall events. In short, the technical analyses presented in this assessment of Hagåtña Bayside Park Beach describe the relationship between water quality patterns and potential sources at this location. The loading capacity and allocations are all concentrations set at the criteria values for enterococci bacteria. This TMDL will clearly meet water quality standards and protect recreational uses at this beach.

TMDL Components. Table 8-51 presents the TMDL for Hagåtña Bayside Park Beach, identifying the loading capacity and allocations expressed as concentration-based values for enterococcus. These concentration-based values apply across all flow zones. This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 8-51. Northern Guam Watershed TMDL summary *(Site GUN-13: Hagåtña Bayside Park)*.

TMDL Component	Enterococcus Concentration *(# / 100 mL)*
Geometric Mean	
TMDL	**35**
Future Growth	35
Waste Load Allocation	35
Load Allocation	35
Instantaneous Maximum	
TMDL	**104**
Future Growth	104
Waste Load Allocation	104
Load Allocation	104

A hydrology-based framework using duration curve zones allows the TMDL to evaluate monitoring data in a way that reflects major watershed processes indicative of different flows. This approach enables numeric targets in the TMDL to consider watershed processes, such as hydrology and source assessment information including land use.

Table 8-52 identifies reductions for each duration curve zone by season using the TMDL targets. These estimates can serve to guide problem solving discussions on appropriate management strategies (based on knowledge associated with likely source areas, delivery mechanisms, and appropriate control measures that correspond to particular hydrologic conditions).

Table 8-52. Needed reductions to meet TMDL targets *(Site GUN-13: Hagåtña Bayside Park)*.

Needed Reductions	**Flow Conditions** *(expressed as percentage)*				
	High	**Moist**	**Mid**	**Dry**	**Low**
Dry Season					
Based on geometric mean	82%	5%	---	---	---
Based on instantaneous maximum	94%	57%	---	28%	---
Wet Season					
Based on geometric mean	68%	---	---	---	---
Based on instantaneous maximum	94%	61%	---	49%	---

9. Potential TMDL Follow-up Activities

A strength of the TMDL program is its ability to support development of information-based, water quality management strategies. An important key to success is engaging the public and utilizing linkages to other programs. Basic components of the TMDL, namely the loading capacity and allocations, provide numeric targets that consider watershed processes, such as hydrology, as well as source assessment information including land use. These targets play a major role in building a problem solving framework that guides development of an effective implementation program.

Implementation planning typically identifies feasible and cost effective management measures capable of reducing pollutant loads to required levels. It is a key part of the water quality management process. TMDLs and implementation planning work together in that TMDLs provide the ability to support development of information-based, water quality management strategies.

The intent of implementation planning is to provide information to local stakeholders regarding the selection of cost-effective best management practices (BMPs). Monitoring is an important element of implementation planning because it produces data needed to refine management strategies. Monitoring data often enables the overall water quality management process to incorporate adaptive management concepts.

9.1 Activities

A number of programs and activities exist that address documented water quality problems on Guam's Northern Beaches. Several programs are implemented by GEPA, which are specifically designed to address known sources of pollution including pipes, ditches, and sanitary or storm sewers. Others rely on efforts of partner agencies. If fully implemented, measurable reductions in bacteria levels should lead to achievement of the TMDLs. Key programs include:

- NPDES Permits and Section 401 Water Quality Certification
- Individual Wastewater System Permits
- Storm Water Management
- Underground Injection Control (UIC)

A brief description of each program is provided in the following sections. Key aspects of these efforts that will lead to reductions in bacteria concentrations are discussed.

9.1.1 NPDES Permits and Section 401 Water Quality Certification

National Pollutant Discharge Elimination System (NPDES) permits in Guam are issued by USEPA Region 9. Permitted facilities that potentially affect Northern Guam beaches in the TMDL project area were listed Table 5-1. GEPA's Water Pollution Control (WPC) Program in coordination with the Environmental Planning and Review Division are responsible for certifying all permit applications. During certification, conditions and abatement schedules for each permit are recommended. The guidelines for effluent limitations in each permit are based on the revised 2001 Guam Water Quality Standards.

The WPC Program oversees implementation and compliance of conditions imposed by GEPA §401 Water Quality Certification for NPDES permits issued to industrial and non-industrial facilities. All permittees are monitored by both WPC Program and USEPA staff to ensure compliance with applicable permit requirements and schedules. The Water Pollution Control Act and Guam Water Quality Standards authorize Guam EPA to take legal action against those who pollute island waters. Enforcement is carried out through scheduled site and sampling inspections. NPDES permittees submit quarterly Discharge Monitoring Reports (DMRs) to USEPA Region 9 for review and evaluation. Appropriate enforcement action is applied for non-compliance to approved permit conditions.

One major action resulting from NPDES compliance efforts is the Guam Waterworks Authority (GWA) Stipulated Order for Preliminary Relief. This Order is one key part towards solving water quality problems in the TMDL project area. The Order outlines a list of mandated actions for GWA, including the development and implementation of a comprehensive Water Master Plan. The Order also addresses the financing of wastewater capital improvement projects.

Continued compliance with the GWA Stipulated Order will improve water quality as a result of infrastructure improvements to sewage treatment plants, pump stations, and ground water facilities. Completion of the Water Master Plan provides a strategic roadmap for the utility to meet the wastewater treatment needs in the TMDL project area. This includes bacteria contamination of the TMDL beaches that are associated with compliance issues at the two wastewater treatment facilities. The Order will also address water quality problems adversely affecting beaches on the §303(d) list that are associated with pump station failures and Sanitary System Overflows (SSOs).

9.1.2 Individual Wastewater System Permits

A number of problems discussed in the individual beach assessments are the result of inadequate on-site wastewater treatment. The concerns arise both in unsewered areas, as well as in areas where residences have not yet connected to available sewer systems. GEPA's Integrated Report indicates that domestic wastewater associated with population increase is the largest potential source of pollution to all waters of Guam. Due to economic difficulties, development associated with the population increase can occur without adequate sewage infrastructure. As a result, occupants depend on septic tank and leaching field systems for waste disposal.

The island's most extensive population development is occurring in the northern watershed above Guam's federally designated sole source aquifer. The problem is further exacerbated where development has resulted in a high density of septic systems over the high permeability substrate typical of northern Guam coupled with insufficient and poorly maintained sewage treatment systems. The combination of these factors can also affect beaches in the TMDL project area.

A key implementation tool to control this source of pollution is set forth in Section 48102, Chapter 48 of 10 Guam Code Annotated (GCA). This rule requires that no building shall be occupied or used as a dwelling, school, public building, commercial building, industrial building or place of assembly without toilet or sewage facilities of a type inspected and approved for the disposition of human excreta and other domestic wastes. Permits are required for new and remodeled buildings.

In order to ensure the installation of proper sewage disposal systems, the permitting process includes mandatory on-site inspection and building plan review, permit issuance and final inspection of the completed disposal system. Building occupancy permits are only issued upon approval of the structure's sewage disposal system. Furthermore, in the northern area of Guam, permitted housing density has been decreased to one residential dwelling unit per half acre of property in unsewered areas to protect the groundwater from contamination.

Another part of this program is sanitary surveys conducted by GEPA staff. For example, approximately 125 buildings were connected to the public sewer system in 2006 as a result of sanitary surveys and enforcement action. In 2007 GEPA staff concentrated on identifying strategic northern locations with available sewer systems. Subsequently, sanitary surveys were conducted of those residences with or without connections to the nearby systems. Enforcement action is forthcoming. A focus on continued sanitary surveys in areas that contribute to bacterial pollution of beaches in the TMDL project area is another key part of addressing documented water quality problems.

9.1.3 Storm Water Management

Storm water management is another key part of efforts to reduce bacterial contamination in the northern Guam beach TMDL project area. Although the projected 2007 population of the island was over 170,000, Guam is not covered under the USEPA Municipal Separate Storm Sewer System (MS4) program. Consequently, storm water management in the TMDL project area must rely on coordination between an array of Guam agencies and other local efforts. Guam EPA has made great improvements towards implementing storm water management through requirements under its Nonpoint Source Management Program. Large and commercial developments are required to submit “Best Management Practices” for the total elimination of storm water discharges to near shore waters of Guam. In Tumon Bay, discharges have been decreased with the elimination of most existing storm drains near shore.

GEPA and the Commonwealth of the Northern Mariana Islands (CNMI) have collaborated to produce a technical guidance document that governs storm water planning and design in both Guam and the CNMI. This effort took advantage of the geographic proximity of the islands and their similar climatic regimes, as well as local studies. The purpose of *the “CNMI / Guam Storm Water Management Manual”* and accompanying regulations is to:

- to protect the waters of the CNMI and Guam from the adverse impacts of urban stormwater runoff;
- to provide design guidance on the most effective best management practices (BMPs) for new development sites and redevelopment sites both during post construction; and
- to improve the quality of BMPs that are constructed in the CNMI and Guam, specifically in regard to their performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit.

GEPA requires that all storm water disposal for new facilities be contained on-site, up to the 20-year, 24-hour storm event. Permits for and upgrades to storm water management systems are required to accommodate large expected increases to flows and decreases to quality of the storm water, whether discharged to the ground or to surface waters.

Prior to finalizing the “*Guam / CNMI Stormwater Manual*”, Executive Order 2005-35 was promulgated on October 21, 2005. This provided interim adoption of storm water management criteria for the Department of Public Works (DPW) and other government of Guam projects. GEPA is in the process of developing local storm water regulations based on criteria in the “*Guam / CNMI Stormwater Manual*”. GEPA intends to incorporate them into a revision / update of current soil erosion and sediment control regulations. Upon approval and adoption, such regulations will be applicable to and enforceable upon both public and private sector communities.

9.1.4 Underground Injection Control

Recent concern has developed over the proliferation and extensive use, in the last several years, by commercial establishments to contain storm water runoff within its boundaries. A common method of storm water disposal in Guam is through the use of ponding basins. Over 100 ponding basins associated with developments in northern Guam, collect stormwater runoff, which subsequently percolates into the Northern Guam Lens (NGL).

Because of their configuration and purpose, these storm water drainage systems are regulated as Class V injection wells and require a UIC permit. The UIC permit, issued by GEPA's Water Resources Management Program, provides a means of tracking all injection wells and ensuring, through inspection, that such wells are properly maintained. All injection wells in Guam that have been issued permits are inspected annually. At present, there are two hundred ninety-four (294) permitted wells in Guam. The majority of these storm water ponding wells that potentially affect TMDL project area beaches are owned by the Guam International Airport Authority, the Department of Public Works (DPW), and the Guam Power Authority (GPA).

9.1.5 Other Programs

The Coastal Zone Act Reauthorization Amendments (CZARA) was passed by Congress to address nonpoint source pollution in coastal waters. Section 6217 of CZARA requires states and territories (including Guam) to develop Coastal Nonpoint Pollution Control Programs. The Coastal Nonpoint Program builds upon existing state coastal zone management and water quality programs by applying a consistent set of economically achievable management measures to prevent and mitigate polluted runoff. These measures are designed to control runoff from six main sources:

- Urban areas
- Marinas
- Forestry
- Agriculture
- Hydromodification (shoreline and stream channel modification)
- Loss of wetlands and riparian areas

State coastal nonpoint programs implement the measures and provide accountability through a variety of tools, including rules, ordinances, voluntary approaches, educational campaigns and financial incentives, all backed by enforceable policies and mechanisms.

In its program, a state or territory describes how it will implement nonpoint source pollution control management measures. If the original management measures fail to produce the necessary coastal water quality improvements, a state or territory then must implement additional management measures to address remaining water quality problems.

Guam's Coastal Nonpoint Control Program (CNPCP) was approved in 2007. The approval document describes mechanisms in place that Guam can use to control runoff from nonpoint sources. Urban programs were described earlier in this section under storm water management. Designation of the urban portions of Guam to be subject to NPDES MS4 permit requirements is an option that would strengthen the storm water management program relative to TMDL implementation. In fact, the water quality benefits to be achieved under an NPDES MS4 permit were noted in the final decision document approving Guam's CNPCP.

The final decision document approving Guam's CNPCP also describes mechanisms in place to address water quality problems associated with marinas. The primary mechanisms in place to address pollution problems associated with marinas rely on Guam's Water Quality Standards and Marina Rules and Regulations of the Port Authority of Guam (Marina Rules and Regulations).

Guam's Marina Rules and Regulations address vessel, property or facility cleanliness and sanitation (Section 4.02); management, control and disposal of shipboard solid waste (Section 4.03); and disposal of any litter, sewage, or other gaseous, liquid or solid materials into the water (Section 4.06 and 4.07). Guam's Recreational Water Use Management Plan (RWUMP) establishes rules to regulate uses of recreational and commercial watercraft within the waters of Guam.

In addition to these regulatory components, Guam has laid out a process and timeline for developing a comprehensive clean marina program. The Clean Marina Advisory Group has identified and is beginning to implement priority actions to reduce nonpoint source pollution from Guam's marinas, including installing hazardous waste storage containers and wash down facilities at the two most heavily used marinas. The Advisory Group is also improving public outreach and education by installing educational signage about clean marina BMPs at the marinas and working closely with the Port Authority of Guam as it updates its marina rules and regulations to incorporate additional clean marina BMPs.

If these programs fail to address problems associated with marinas, another option is be to explore the use of a Multi-Sector General Permit under the NPDES program. Marinas are a designated SIC category under EPA's storm water management rules. A permit could be issued with appropriate conditions that would lead to achieving water quality standards and TMDL targets.

9.1.6 Military Expansion

The Guam Civilian / Military Task Force (GCMTF) was created by Executive Order 2006-10 to create an integrated comprehensive master plan that will address issues related to the military buildup. The purpose of this master plan is to maximize opportunities resulting from this expansion for the benefit of all the civilian and military community. An Environment Sub-Committee to this Task Force has been created under the lead of GEPA. This Sub-Committee must determine environmental concerns including adverse effects projected to occur off Department of Defense (DOD) properties.

Activities associated with the military buildup will have a direct effect on efforts to implement the Guam Northern Watershed Bacteria TMDLs. One of the more significant impacts is the increased pressure on the wastewater infrastructure system. GWA is already conducting activities under a Stipulated Order to address documented problems that lead to beach advisories. This includes sewage overflows, pump station failures, and wastewater treatment plant performance. Potential effects of the military expansion on efforts by local agencies to implement the TMDL need to be recognized and addressed in the planning and funding process.

Similarly, the increased population associated with the military expansion includes not only direct personnel, but also dependents, construction and support staff. The increased numbers of people will undoubtedly use the existing road system and commercial facilities in the TMDL project area. Individual beach assessments identified several locations where improved storm water management is a key to successful implementation. As local agencies work to improve storm water management, DOD can clearly help provide leadership in implementing solutions.

An example is DOD's efforts to implement the Energy Independence and Security Act. Section 438 of this legislation establishes strict storm water runoff requirements for Federal development and redevelopment. The Navy, for instance, has a policy that requires the implementation of Low Impact Development (LID). The Navy's experience and expertise in the application of LID could serve as a technical resource for local agencies in their efforts to improve stormwater management in the TMDL project area.

9.2 Connections to TMDLs

A major advantage of the duration curve framework is the ability to provide meaningful connections between TMDL allocations and implementation efforts. Because the flow duration interval serves as a general indicator of hydrologic condition (i.e., wet versus dry and to what degree), allocations and reduction targets can be linked to source areas, delivery mechanisms, and the appropriate set of management practices. The implementation programs discussed in Section 9.1 are all aimed at reducing delivery of bacteria, which cause beach advisories in the TMDL project area.

The connection between the duration curve framework and development of management strategies is illustrated in Table 9-1. Potential implementation opportunities are identified, which could be most effective under each of the different flow zones. For example, GWA’s efforts to address sewerage infrastructure problems (notably pump station failures and sewer overflows) are targeted to preventing delivery of bacteria that could occur under any flow conditions. The TMDL analysis demonstrated specific beaches where these problems are a likely source of bacteria.

The same rationale applies to implementation activities designed to address problems with individual waste water systems. Storm water management programs will reduce delivery of bacteria to beaches under high flow and moist conditions. Thus, the use of duration curves enables a framework that can help guide implementation efforts to address water quality concerns, particularly when ambient monitoring data is available for pattern analysis of existing conditions.

Table 9-1. Opportunities highlighted using a duration curve framework.

<table>
<tr><th rowspan="2"></th><th colspan="5">Duration Curve Zone</th></tr>
<tr><th>High</th><th>Moist</th><th>Mid-Range</th><th>Dry</th><th>Low</th></tr>
<tr><td rowspan="6">Opportunities</td><td colspan="3">Storm Water Management</td><td colspan="2"></td></tr>
<tr><td colspan="5">GWA Sewerage System Improvements to Address Pump System Failures and Reduce Sewer System Overflows</td></tr>
<tr><td colspan="5">Individual On-site Waste Water Permits, Sanitary Survey & Enforcement, and Sewer Connections</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">Implement Waste Water Treatment Plant Improvements through NPDES Permits</td></tr>
<tr><td colspan="3">Marina Management</td></tr>
</table>

Tables 9-2 through Table 9-5 summarize reduction targets from the individual beach assessments. These tables show conditions that correspond with water quality patterns exhibiting the greatest concern at each beach. These summaries can be combined with information in Table 9-1 to highlight key implementation activities pertinent to the location (or in several cases, a set of locations) in a way that brings everything together.

Table 9-2. Summary of needed reductions to meet TMDL *(Geometric Mean – dry season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	22%	---	---	---	---
Tumon Bay	Gun	GUN-24	---	---	---	---	---
	Gognga	GUN-25	---	---	---	---	---
	Naton	GUN-02	3%	---	---	---	---
		GUN-23	---	---	---	---	---
		GUN-03	---	---	---	---	---
		GUN-04	---	---	---	---	---
	Ypao	GUN-05	---	---	---	---	---
East Hagåtña Bay	Dungca's	GUN-06	44%	---	---	---	---
		GUN-07	90%	20%	---	---	---
	Alupang Towers	GUN-26	---	---	---	---	---
	Trinchera	GUN-08	75%	17%	15%	---	---
	Padre Palomo	GUN-09	27%	---	---	---	---
West Hagåtña Bay	Hagåtña Channel	GUN-10	---	---	---	---	---
		GUN-11	62%	---	---	---	---
		GUN-12	87%	51%	---	---	---
	Bayside Park	GUN-13	82%	5%	---	---	---

Note: Shaded cells indicate those zones where the geometric mean criterion was exceeded. This is indicative of potential long term, chronic problems under those conditions.

Table 9-3. Summary of needed reductions to meet TMDL *(Geometric Mean – wet season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	***Moist***	***Mid***	***Dry***	***Low***
Northern	Tanguisson	GUN-01	---	---	---	---	---
Tumon Bay	Gun	GUN-24	---	---	---	---	---
	Gognga	GUN-25	---	---	---	---	---
	Naton	GUN-02	30%	---	---	---	---
		GUN-23	---	---	---	---	---
		GUN-03	---	---	---	---	---
		GUN-04	---	---	---	---	---
	Ypao	GUN-05	---	---	---	---	---
East Hagåtña Bay	Dungca's	GUN-06	36%	---	---	---	---
		GUN-07	82%	20%	---	---	---
	Alupang Towers	GUN-26	64%	---	---	---	---
	Trinchera	GUN-08	65%	---	5%	---	---
	Padre Palomo	GUN-09	73%	---	---	---	---
West Hagåtña Bay	Hagåtña Channel	GUN-10	38%	---	---	---	---
		GUN-11	64%	---	---	---	---
		GUN-12	83%	54%	20%	---	---
	Bayside Park	GUN-13	68%	---	---	---	---

Note: Shaded cells indicate those zones where the geometric mean criterion was exceeded. This is indicative of potential long term, chronic problems under those conditions.

Table 9-4. Summary of needed reductions to meet TMDL *(90th percentile – dry season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	*Moist*	*Mid*	*Dry*	*Low*
Northern	Tanguisson	GUN-01	49%	---	---	---	---
Tumon Bay	Gun	GUN-24	---	---	---	---	---
	Gognga	GUN-25	---	---	---	---	---
	Naton	GUN-02	48%	---	---	---	---
		GUN-23	54%	---	---	---	---
		GUN-03	25%	---	---	---	---
		GUN-04	---	---	---	---	---
	Ypao	GUN-05	80%	---	---	---	---
East Hagåtña Bay	Dungca's	GUN-06	95%	---	---	---	---
		GUN-07	98%	71%	67%	37%	43%
	Alupang Towers	GUN-26	---	74%	34%	23%	---
	Trinchera	GUN-08	89%	61%	69%	68%	34%
	Padre Palomo	GUN-09	69%	14%	---	---	---
West Hagåtña Bay	Hagåtña Channel	GUN-10	48%	---	---	---	---
		GUN-11	83%	---	---	---	---
		GUN-12	93%	93%	72%	42%	---
	Bayside Park	GUN-13	94%	57%	---	28%	---

Note: Shaded cells indicate those zones where the 90th percentile exceeded the instantaneous maximum criterion. This is indicative of recurring short term problems under those conditions.

Table 9-5. Summary of needed reductions to meet TMDL *(90th percentile – wet season)*.

Water	Beach	Site ID	Duration Curve Zone				
			High	*Moist*	*Mid*	*Dry*	*Low*
Northern	Tanguisson	GUN-01	15%	---	---	---	---
Tumon Bay	Gun	GUN-24	---	---	12%	---	---
	Gognga	GUN-25	---	---	---	76%	---
	Naton	GUN-02	74%	---	---	26%	---
		GUN-23	35%	---	---	62%	---
		GUN-03	49%	---	---	---	---
		GUN-04	---	---	---	---	---
	Ypao	GUN-05	---	---	---	41%	---
East Hagåtña Bay	Dungca's	GUN-06	81%	---	---	10%	---
		GUN-07	93%	82%	71%	51%	---
	Alupang Towers	GUN-26	98%	23%	21%	52%	---
	Trinchera	GUN-08	88%	56%	62%	35%	---
	Padre Palomo	GUN-09	92%	22%	20%	47%	---
West Hagåtña Bay	Hagåtña Channel	GUN-10	85%	---	---	---	---
		GUN-11	96%	34%	---	44%	---
		GUN-12	97%	94%	71%	28%	---
	Bayside Park	GUN-13	94%	61%	---	49%	---

Note: Shaded cells indicate those zones where the 90th percentile exceeded the instantaneous maximum criterion. This is indicative of recurring short term problems under those conditions.

9.3 Monitoring and TMDL Re-Assessment

The application of the duration curve framework allows water quality monitoring information to be used in a way, which characterizes concerns and describes patterns associated with impairments. Continued data collection at these seventeen beaches under the RBMP will provide information that enables these TMDLs to be evaluated in terms of progress towards achieving Guam's Water Quality Standards.

NPDES permits are re-issued every 5 years and the §303(d) impaired waters list is re-assessed every 2 years. Because a number of critical implementation actions are connected to compliance with the permits, these TMDLs will be re-evaluated in seven years. If sufficient progress has not been made during the seven year timeframe, the TMDLs will be re-opened. Sufficient progress is defined as removal of at least 50% (or nine of the seventeen beaches) from the impaired waters list. Any adjustments to wasteload and load allocations needed to meet water quality standards will be incorporated into revised TMDLs.

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