UNIVERSITY OF KWAZULU-NATAL

BEACH WATER QUALITY: A COMPREHENSIVE ANALYSIS OF THE PATHOGENIC POLLUTION OF THE DURBAN COASTLINE

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2015

DECLARATION

I, Katelyn Ann Johnson declare that:

1. The research reported in this dissertation, except where otherwise indicated, is my original research.

2. This dissertation has not been submitted for any degree or examination at any other university.

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K.A. Johnson Date

As the candidate"s supervisor, I agree/do not agree to the submission of this dissertation.

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Prof. D.D. Stretch Date

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ABSTRACT

South Africa"s beaches have many local and international visitors. Various recreational activities occur along the Durban coastline, especially during the holiday seasons. Beach water quality is negatively affected by pathogenic pollution which enters coastal water via stormwater and river discharges. Poor water quality jeopardises public health and has an adverse effect on tourism and the economy. The focus of this research is pathogenic pollution of Durban"s coastal waters.

In an attempt to understand the changes and establish any trends in pathogenic water quality conditions over the past decade, a critical assessment and statistical review of the historical water quality conditions of the Durban beaches has been done. This involves a general statistical analysis and water quality classification according to the new South African Water Quality Guidelines. Statistical parameters considered include arithmetic mean, standard deviation, geometric mean, and percentiles. A total of 42 beaches were analysed. Beaches were grouped into 4 sections: Northern, City, Bluff, and Southern.

Water quality data for E.coli and Enterococcus were analysed from 2003 to 2013. The highest concentrations of both bacteria occurred in summer and autumn most often. Generally the average levels of both bacteria have either remained consistent or increased. Large standard deviations noted indicate variability in pollution as they represent a large spread of data from the average pollution values. Geometric mean comparisons show that Enterococcus levels were generally higher than E.coli, but both bacteria follow same patterns.

Classification of water quality conditions shows that water quality has deteriorated as the frequency of poor water quality has increased. Water quality is classified as poor more frequently based on Enterococcus when compared to E.coli. However, higher levels of E.coli are allowed than Enterococcus as per the guidelines. Beaches located near rivers and stormwater outfalls are adversely affected and are shown to exhibit poorer water quality conditions.

A case study was completed involving the analysis of the beach water quality data for 2009 to 2013 to determine the possible eligibility of Durban"s beaches to receive the Blue Flag Award. Based on the microbiological water quality, it is unlikely that Durban will be a “Blue Flag coastline” in the immediate future. Most beaches have not managed to consistently meet the criteria for both E.coli and Enterococcus. As of October 2014, 7 beaches had pilot status.

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LIST OF ABBREVIATIONS

BEACH – Beaches Environmental Assessment and Coastal Health
CFU – Colony forming units
CSIR – Council for Scientific and Industrial Research
CWA – Clean Water Act
CWQM – Coastal Water Quality Model
DA – Democratic Alliance
DWAF – Department of Water Affairs and Forestry
DEA – Department of Environmental Affairs
E.coli – Escherichia Coli
EMWSS – eThekwini Municipality Water and Sanitation Services
EU – European Union
FEE – Foundation for Environmental Education
FF – First flush
GM – Geometric mean
KZN – Kwa-Zulu Natal
NGO – Non-Governmental Organisation
RWQC – Recreational Water Quality Criteria
SA – South Africa
SANS – South African National Standards
SAWQ – South African Water Quality
STV – Statistical Threshold Value
US EPA – United States Environmental Protection Agency
WESSA – Wildlife and Environmental Society of South Africa
WHO – World Health Organisation
WWTW – Waste Water Treatment Works

CHAPTER 1:
INTRODUCTION

1.1. Introduction

South Africa‟s beaches attract numerous tourists each year and are popular amongst local communities. Various recreational activities occur at many beaches along the Durban coastline throughout the year, with increased popularity during the holiday seasons. Coastal waters can also be used for maricultural and disposal purposes. Poor water quality jeopardises public health and has an adverse effect on tourism and consequently, the economy. An adequate knowledge and understanding of the criteria that affect the quality of beach water is important in order to manage beach water quality effectively and efficiently. The Durban coastline has been chosen for the purposes of this study focusing on the pathogenic pollution of coastal waters.

1.2. Motivation

Coastal waters are negatively affected by disease-causing agents, known as pathogens, which enter the waters by means of river discharges and stormwater outlets along the beaches. These discharges often contain large quantities of mammalian faecal matter and as such, are significant sources of pathogenic pollution. Consumption of waters contaminated by these pathogens often results in illness.

The Department of Environmental Affairs (DEA) has published a new set of guidelines with revised requirements for microbiological water quality. These requirements as stipulated in the South African Water Quality (SAWQ) Guidelines (2012) are significantly different to those first published in 1995 in the previous set of guidelines.

The City of Durban has re-applied for Blue Flag status for its beaches to increase domestic visitors and international tourists. It is important to understand the microbiological water quality conditions for the years which precede the year of application.

The eThekwini Municipality Water and Sanitation Services (EMWSS) department tests the quality of beach waters weekly and displays this information at the beaches, making the public aware of the water quality of the beaches. However, the information displayed is often not up to date as testing is not done every day and test results cannot be obtained instantly after sampling due to the nature of the testing methods required to quantify pathogenic pollution. In order to better monitor water quality, a coastal water quality model (CWQM) can be developed to predict the level of pathogenic pollution, and hence beach water quality, without the actual testing of the waters.

A comprehensive understanding of the changes and trends in pathogenic pollution can assist in the effective and efficient management of the quality of Durban‟s coastal waters. A thorough analysis of past water quality conditions can aid the development of accurate predictive models. The outcomes of this research may be used to underpin the development such models.

1.3. Research Questions

- How has the pathogenic water quality of the Durban coastline changed over the past decade, are there any evident trends in these changes and what are the possible causes?
- How have the microbiological water quality conditions compared to the new SAWQ guidelines and what are the implications?
- How have the microbiological water quality conditions compared to the Blue Flag requirements and what are the implications?

1.4. Aims & objectives

Aims:

- To develop a comprehensive understanding of the changes and trends in coastal water quality of the Durban beaches.
- To classify the quality of Durban"s beach waters according to the new South African Water Quality Guidelines
- To determine if beaches are potentially eligible to receive the Blue Flag award based on microbiological water quality requirements.

Objectives:

- Obtain water quality data for each beach in the study area
- Develop an understanding for:
  - Historical water quality conditions by completing a comprehensive statistical analysis
  - SAWQ Guidelines
  - Blue Flag requirements

1.5. Methodology

1.5.1. Critical Review – Literature Review

A literature review was done to develop a knowledge and understanding for various beach water quality criteria and pathogenic pollution of coastal waters.

1.5.2. Statistical Analysis

A critical assessment and statistical review of the historical water quality conditions of the beaches in the study area has been done. The assessment also involves the comparison of the statistical results with the requirements of the new South African Water Quality Guidelines. The complete analysis can be found in Chapter 3.

1.5.3. Case Study – Blue Flag Award

A case study was completed and involves the analysis of the microbiological beach water quality data for 2009 to 2013 in order to determine the possible eligibility of Durban"s beaches to receive the Blue Flag Award, based on microbiological water quality requirements. The complete case study can be found in Chapter 4.

CHAPTER 2:
LITERATURE REVIEW

2.1. Introduction

The management of water quality is of crucial importance in South Africa. The principal purpose of water quality management in this country is to ensure that water resources are kept in a state such that they remain suitable for designated uses. South African beaches are primarily used for recreational purposes and many beaches are popular with both tourists and locals. Pollution of these beaches poses a threat to public health as well as tourism. This also has an adverse effect on the economy. Pathogenic pollution jeopardises the quality of beach waters. The dominant source of this type of pollution is human faecal discharges that enter coastal waters by means of stormwater and river discharges.

2.1.1. Water quality

The term water quality refers to the physical, chemical and biological characteristics of a water body. According to Lee (1999), the quality of water is based on the characteristics of the water relative to the intended purpose of the water, and cannot simply be classified as "good" or "bad". The presence of waterborne pathogens in beach waters affects the quality of these waters.

2.1.2. Waterborne pathogens and health implications

Waterborne pathogens are disease-causing agents which include micro-organisms, bacteria, viruses and protozoa. These pathogens are linked to marine associated diseases and are transferred to humans via intentional or unintentional consumption of contaminated waters (Cloete *et al*, 2004). Pathogens can also enter the body through skin contact. An extensive variety of pathogens are carried easily by water.

The quantity of organisms that may result in infection is dependent on the specific pathogen. Health risks are directly proportional to the quantity of faecal pollution determined by the use of indicator organisms (Barrell *et al,* 2000).

Since water-borne pathogens are disease-causing agents, if these pathogens are consumed by beach users they can become seriously ill. Some micro-organisms can even cause death. When these pathogens are ingested by humans through contaminated waters they may result in various infectious diseases. These include: typhoid fever, dysentery, cholera and gastrointestinal diseases. Diseases associated with the ingestion of bacterial coliforms, pathogens include gastroenteritis, diarrhoea, hepatitis A, nausea and vomiting, fever, and infection of the ears, eyes, nose and skin (WHO, 2003).

2.1.3. Water quality indicators

2.1.3.1. Development of water quality indicators

The use of bacterial organisms as indicators of water quality can be dated back to the late 1800"s. In 1981, the Franklands developed the concept that organisms characteristic of sewage should be identified and used to provide evidence of potentially dangerous pathogenic pollution. By the year 1983, the "Wurtz Method" was used by sanitary bacteriologists to enumerate *Escherichia coli* (E.coli, formerly known as *Bacillus coli* prior to 1919). The method involved directly plating water samples on litmus lactose agar and used the concept of acid from lactose as an indicative feature. (Ashbolt *et al,* 2001). The enumeration of faecal streptococci (Enterococcus) became popular in 1957 when an appropriate selective medium agar became available. Moreover, epidemiological studies have shown that levels of Enterococcus are more closely related to enteric diseases than faecal coliforms. This resulted in the revision of recreational water quality indicators. Faecal coliforms which were previously favoured as indicators were replaced with E.coli and Enterococcus (US EPA, 1985).

2.1.3.2. The use of indicator bacteria in modern times

According to DWAF (1995), for recreationally used waters the following sets of indicators can be used for the scientific analysis of water samples: physicochemical properties of the water, nutrient content, inorganic and organic constituents, and microbiological indicators. Microbiological indicators are preferred when assessing beach water quality. Their presence indicates the presence of waterborne pathogens in coastal water. Moreover, the enumeration of pathogens is challenging and expensive. As such, in order to establish the presence of pathogens in water, indicator organisms are used (Mardon & Stretch, 2004). Indicator organisms are more practical and affordable to monitor regularly.

Presently, E.coli and Enterococcus are considered to be the two most favourable bacterial indicators and are recommended to quantify faecal pollution. According to SANS (2011) and WHO (2004), these bacteria do not ordinarily have the ability to multiply in marine waters and they are found in the intestines of mammals. Consequently, the presence of these bacteria is clearly indicative of recent faecal contamination of water bodies. In this way, the presence of bacterial pathogens is identified and quantified. However, the World Health Organisation (WHO) conducted studies that determined that intestinal Enterococcus was the only microbiological indicator that clearly linked the levels of the bacterium with illness levels. Moreover, this specific bacterium can survive longer than E.coli and, as such, is a preferred indicator of pathogenic pollution of coastal recreational waters. Results from experiments conducted by Johnson (2012) also support the idea that Enterococcus is a more reliable indicator of pathogenic pollution. Furthermore, studies have shown E.coli and Enterococcus may grow in warmer tropical waters. This in turn affects their suitability as indicators for such conditions. Ashbolt *et al* (2001) explains that *Clostridium perfringens* (*C. perfringens*), a species of clostridia, can be used as an indicator as it is associated with the faeces of mammals.

2.2. Water quality standards

2.2.1. South African water quality guidelines

In 1995, the then *Department of Water Affairs and Forestry* (DWAF) first published The *South African Water Quality* (SAWQ) *Guidelines*. In 2012 a revised set of guidelines was released by the *Department of Environmental Affairs* (DEA). The revised guidelines, *South African Water Quality Guidelines for Coastal Marine Waters: Guidelines for Recreational Use,* addresses some of the shortfalls of the previous version. These new guidelines are based on the World Health Organisation values (TNA, 2012).

The ultimate goal in the management of coastal waters is to ensure that they remain suitable for their selected uses. According to DEA (2012), typical water quality problems associated with recreational use of coastal waters include: aesthetics, human health and safety, and mechanical interference. The most concerning of these is human health and safety.

Previously, there had been no clear rationale for the selection of South African target values for E.coli. Furthermore, E.coli is no longer considered to be the only suitable indicator bacterium for coastal waters as their presence does not correlate with health risk. According to DEA (2012), most countries have found the Enterococcus bacterium to be the most suitable ad preferred indicator as it indicates the presence of pathogens and correlates to health risks. Despite this, E.coli is still used as an indicator bacterium in addition to Enterococcus, as Enterococcus levels alone may be misleading.

It has also been noted that there is potential for survival and regrowth of E.coli and Enterococcus in tropical areas. As such, in tropical waters, the levels of the indicator bacteria can become elevated beyond that from faecal impacts alone. Internationally this concern is still being addressed with no clear outcome. In the interim, a spore-forming anaerobe known as *C.perfringens* (as explained in Chapter 2, Section 2.1.3.2.), can be used as a supplement. *C.perfringens* cannot regrow in aerobic conditions but they are able to survive for extended periods. The detection of its presence in coastal waters is definite proof of sewage contamination, although the pollution may not be recent. Together with high counts of E.coli and Enterococcus it represents a source of concern (DEA, 2012).

Recommended target values are scientific yardsticks for various water quality indicators that are considered to be appropriate for assessing the fitness of coastal marine waters for recreational use. Microbiological indicators are used to identify the risk to public health from possible disease-causing agents in marine waters. DEA has identified the Enterococcus bacterium as well as E.coli as the most suitable indicators for the assessment of water quality. The recommended target values for intestinal enterococci (also known as faecal streptococci) and E.coli are depicted in Table 2-1. The „Sufficient or Fair‟ category is considered to be the minimum acceptable risk for South Africa, according to the new guidelines.

Table 2-1: Risk-based Ranges for Intestinal Enterococci and E.coli (Microbiological Indicator Organisms) (DEA, 2012)

CATEGORY	ESTIMATED RISK PER EXPOSURE	ENTEROCOCCI (Counts per 100ml)	E.coli (Counts per 100ml)
Excellent	2.9% gastrointestinal (GI) illness risk	≤ 100 (95 percentile)	≤ 250 (95 percentile)
Good	5% GI illness risk	≤ 200 (95 percentile)	≤ 500 (95 percentile)
Sufficient or Fair (minimum requirement)	8.5% GI illness risk	≤ 185 (90 percentile)	≤ 500 (90 percentile)
Poor (unacceptable)	>8.5% GI illness risk	>185 (90 percentile)	>500 (90 percentile)

In tropical areas an additional microbiological indicator, C.perfringens, may be used. The recommended target for this indicator is as follows: The geometric mean should be at most 5 counts per 100ml.

Monitoring protocols have been introduced in the revised guidelines. These protocols aid local authorities with the monitoring of coastal waters and mainly focus on microbiological data as part of long term monitoring of recreational coastal water quality. DEA (2012) recommends that a systematic random-sampling regime be followed. Samples should be collected at least fortnightly, irrespective of the weather. However, there may be exceptions if conditions present a health or safety. All related information should be captured on sampling log sheet at each sampling point and on every sampling occasion. The sampling locations should be representative of the water quality throughout the whole contact recreation area. Samples should be taken at a depth 15 to 30cm below the surface of the water, where the depth of water is roughly 0.5m. In addition, samples should be collected on the seaward side of a recently broken wave. Samples for the analyses of both E.coli and Enterococcus, and possibly C. perfringens, must be collected. Finally, samples must be tested using analytical methods prescribed by the South African National Standards (SANS).

The implementation framework is based on international best practice and should ideally consist of: a classification system for recreational waters, and an operational management plan. The classification system for recreational waters is primarily based on a combination of: a sanitary inspection, and a microbiological quality assessment. The sanitary inspection rating system is depicted in Figure 2-1.

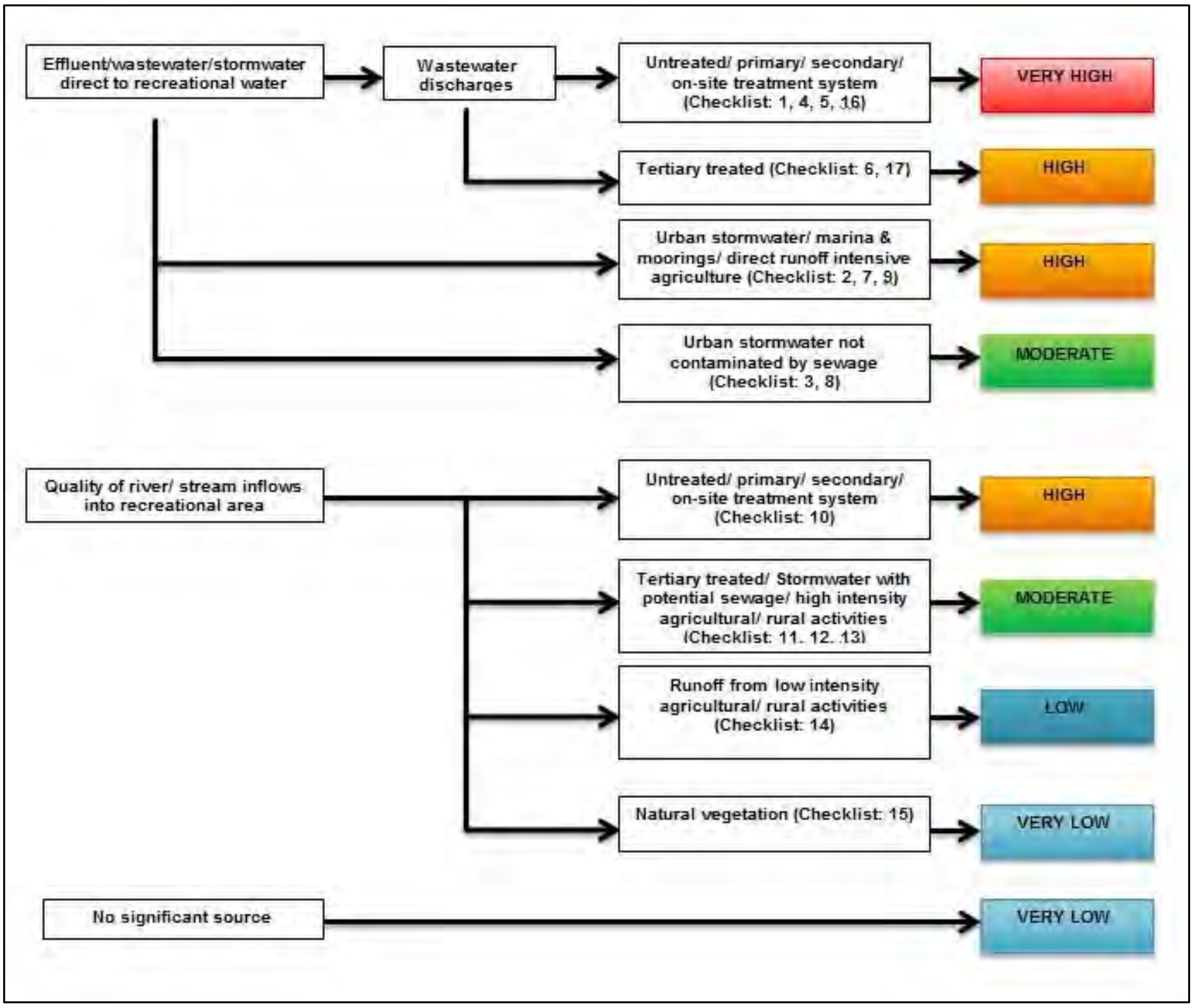

Figure 2-1: Sanitary Inspection Rating System (DEA, 2012)

The microbiological inspection is based on an evaluation of indicator data which has been collected over a fixed period. Microbiological quality is graded into four possible groups. The grading system as per Table 2.1 is used.

The classification of recreational waters is based on a combination of the Sanitary Inspection Category and the Microbiological Quality Assessment Category. This is illustrated in Table 2-2.

Table 2-2: Classification of Recreational Waters (DEA, 2012)

		MICROBIOLOGICAL QUALITY ASSESSMENT CATEGORY				
SANITARY INSPECTION CATEGORY		Excellent	Good	Sufficient	Poor	Exceptional circumstances
	Very Low	Very Good	Very Good	Follow up	Follow up	
	Low	Very Good	Good	Fair	Follow up	
	Moderate	Good	Good	Fair	Poor	
	High	Good	Fair	Poor	Very Poor	
	Very High	Follow up	Fair	Poor	Very Poor	
	Exceptional					Action Required

Sanitary inspections should be conducted at least annually. Microbiological quality assessment should be based on data running over a 12 month period. This approach allows for a more real-time classification. As such, a proposed operational management process for South Africa is depicted in in Figure 2-2.

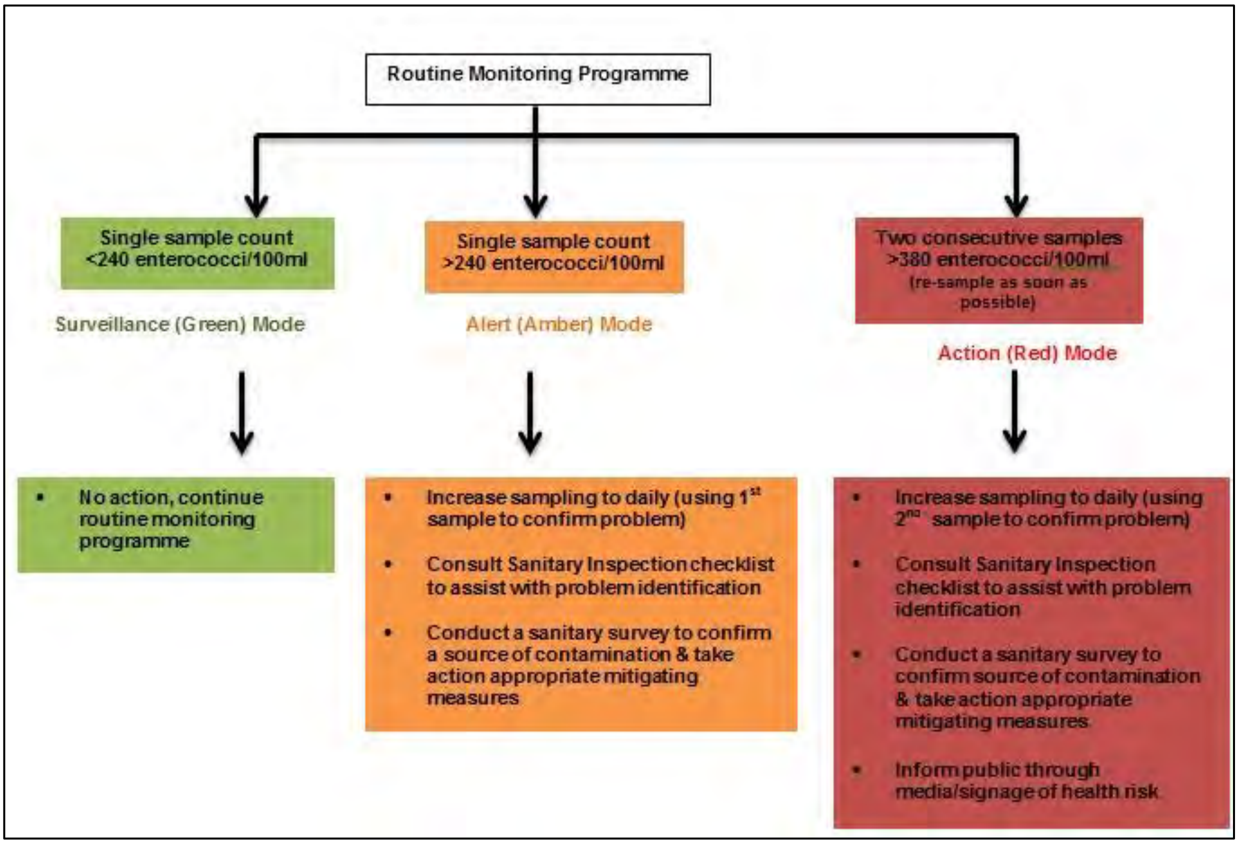

Figure 2-2: Proposed Operational Management System (DEA, 2012)

2.2.2. US EPA

The United States Environmental Protection Agency (US EPA) governs the water quality standards in the United States of America. This agency is responsible for the provision of the water quality criteria. Moreover, it ensures that the standards are enforced and adhered to. In 2012 EPA released a new set of guidelines: *Recreational Water Quality Criteria* (RWQC). Subsequent to these guidelines, EPA last issued *Ambient Water Quality Criteria for Bacteria* in 1986. The 2012 RWQC meet the requirements of the BEACH Act (2000) to conduct studies associated with pathogens and human health. The two bacterial indicators of faecal contamination that are used are E.coli and Enterococcus as they have consistently performed well as indicators of illness (US EPA, 2012). Enterococcus is preferred over E.coli for marine waters (WHO, 2003).

The RWQC consists of 3 components: magnitude, duration and frequency. The magnitude of the bacterial indicators are described by both the geometric mean (GM) as well as the statistical threshold value (STV) for the samples. The STV approximates the 90th percentile of the water quality distribution. This value should not be exceeded by more than 10% of the samples taken. In addition, the new set of guidelines offers 2 sets of numeric thresholds. Both of these thresholds would protect the designated use of primary contact recreation and, therefore, would protect the public from exposure to harmful levels of exposure. Table 2-3 summarizes the magnitude component of the recommendations.

Table 2-3: Water Quality Criteria (US EPA, 2012)

CRITERIA ELEMENTS	**Recommendation 1 Estimated Illness Rate 36/1000**		**Recommendation 2 Estimated Illness Rate 32/1000**	
Indicator	**GM** (cfu/100mL)	**STV** (cfu/100mL)	**GM** (cfu/100mL)	**STV** (cfu/100mL)
Enterococci (marine & fresh)	35	130	30	110
E.coli (fresh)	126	410	100	320

For both the recommendations the duration and frequency components are as follows:
"*The waterbody GM should not be greater than the selected GM magnitude in any 30-day interval. There should not be greater than a 10% excursion frequency of the selected STV magnitude in the same 30-day interval. The duration should not exceed 90 days.*"

2.2.3. European Union Directive

In Europe the Bathing Water Directive (2006/7/EC) is the guideline document that is used to manage beach water quality. The purpose of this Directive is to preserve, protect, and improve the quality of the environment and to protect human health. The Directive lays down provisions for:

- The monitoring and classification of bathing water quality;
- The management of bathing water quality; and
- The provision of information to the public on bathing water quality.

The Directive has strict guidelines regarding sampling and testing of beach waters. It requires that one sample be taken shortly before the start of a new bathing season, and no fewer than 4 samples are to be taken and analysed for each bathing season. The interval between sampling dates must never exceed one month. According to the Directive, when assessing bathing water, the quality of the water can be classified as: "poor", "sufficient", "good", and "excellent". Table 2-4 shows the criteria used when classifying the quality of bathing waters in Europe. Bathing waters must be classified as "poor" if the percentile values for microbiological enumerations are worse than the "sufficient" values.

Table 2-4: Coastal Water Quality Criteria (CEC, 2006)

Parameter	Excellent	Good	Satisfactory
Intestinal enterococci (cfu/100ml)	≤ 100 (95th percentile)	≤ 200 (95th percentile)	≤ 185 (90th percentile)
E.coli (cfu/100ml)	≤ 250 (95th percentile)	≤ 500 (95th percentile)	≤ 500 (90th percentile)

The European Union (EU) is constantly monitoring recreational waters and researching ways to improve monitoring techniques, guidelines and public notification processes. In 2008 the EU generated the first list of bathing waters under the revised Bathing Water Directive and in 2011 bathing water profiles were published for all bathing waters. In May 2012 a four year monitoring plan of recreational water quality conditions began. This will result in a revised Bathing Water Directive, which is anticipated to be published in 2015.

2.3. Sources of pollution

Coastal waters can become polluted in a variety of ways. Rainfall and urban run-off can contaminate waters. Coastal waters can also be directly physically contaminated. Water bodies are used as convenient disposal basins for various wastewaters. The quality of these waters is degraded in this way (UNESCO, 2005).

2.3.1. Stormwater reticulation systems and urban runoff

According to Zoppou (2000), urban runoff is usually highly polluted with pathogenic constituents that are a threat to public health. In an urban area, precipitation occurs on pervious and impervious surfaces. Some precipitation will infiltrate a pervious surface; the remaining precipitation will run off the surface. This runoff will move into stormwater drains and will thereafter be discharged into a receiving body of water. In contrast, impervious surfaces offer minimal opportunity for infiltration of precipitation. Most of the precipitation becomes runoff, resulting in higher volumes of urban runoff.

Pathogenic pollution may be present on the surfaces within a catchment and hence carried by the runoff. The level of pathogenic pollution is affected by the duration and intensity of a particular rainfall event. In addition; the period of time since the previous rain event, and the type of activities that occur in the catchment also affect pollution quantities (Convery, 2011).

In addition to the pollution found on the catchment surface, there are also indirect sources of pathogenic pollution. High rainfall events may cause failure of urban infrastructure, such as burst pipes, which could result in sewer infiltration. Untreated water or inadequately treated water may enter coastal waters via direct connections of sewer pipes to stormwater drains. Haile *et al* (1999) found that the levels of total and faecal coliforms and enterococci are sometimes higher in the waters neighbouring stormwater outlets. Stormwater pollution is erratic and multifarious due to the variability of the sources of pollution.

2.3.2. First flush

The "First Flush" (FF) phenomenon plays a pivotal role in the pathogenic pollution of coastal waters. Stenstrom and Kayhanian (2005) define FF to be the initial surface runoff that occurs at the start of a rain event. During a dry period, concentrations of pollutants accumulate on surfaces. When a rain event commences, these pollutants are carried in the runoff waters during the FF phase. As the rain event continues, the pollution carried by the runoff decreases. Generally an impervious surface is expected to have a higher concentration of pollutants, and greater surface runoff, than a pervious surface. This causes the water that enters stormwater drains during this phase to have a higher concentration of pollutants when compared to the remainder of the rain event. Furthermore, these highly polluted waters are discharged from stormwater drains to coastal waters. This ideal is related to the belief that most of the pollutants are carried in the first runoff at the beginning of a storm event.

The term "seasonal first flush" refers to the idea that, in a particular rain season, pollutants in the runoff of the first series of storm events are more concentrated than that of succeeding storms. The occurrence of the seasonal first flush is dependent on an extended dry period prior to the rainy season (Stenstrom and Kayhanian*,* 2005).

Rapid changes occur in water quality after rain conditions; this is known as the "first flush effect". According to Li-qing *et al*, (2006) polluted urban stormwater runoff has a significant impact on water quality degradation. The occurrence of rainfall is erratic, and the sources of pollutants vary unpredictably. Consequently, pollution of this type is challenging when compared to steady-state point discharges. First flush is influenced by: the intensity of the rainfall, the area of the impervious surface, the area of the watershed, as well as the antecedent dry weather period.

2.3.3. Rivers

Rivers, being the major routes from land to sea, are also noteworthy sources of pollution to the shoreline region. They play a significant role as pathways of materials from inland to the coast. The pollution potential of a river can be affected by the characteristics of individual river basins such as: the size of the river, vegetation along the river banks, geomorphology, climate, as well as the types and sizes of developments along the river (Pommepuy *et al*, 2006). Any substance added to a river upstream will ultimately enter coastal waters. Rivers that are just moderately polluted can have substantial effects on the quality of receiving water bodies. Contaminants are added to rivers through various means, such as industrial and agricultural activities. Waters that are disposed of in rivers should be treated before disposal. However, there may be times when this is not the case and untreated or poorly treated waters are disposed of in rivers. Sources of pollution in this case include: combined sewer overflows, leaky wastewater infrastructure, illegal connections, and dumping into stormwater drains. This can prove to be detrimental to river water quality (US EPA, 2010).

Untreated wastewaters also pose a threat to the quality of rivers. In many locations there are many informal settlements located along the course of many rivers (Pommepuy *et al*, 2006). Dwellers of these informal settlements often do not have access to proper waterborne sewerage systems. As a result, they conveniently use the rivers to dispose of their waste. In this way raw sewage enters rivers. This waste will inevitably flow into coastal waters. In addition, industrial wastewaters containing toxic waste and pathogens are disposed of in rivers. Often, pollution levels of rivers are complex cannot be predicted without the use of intricate models (US EPA, 2010).

2.4. Pollution mixing and dispersion

Factors such as: the shape of the coastline, nearshore bathymetry, and the presence of man-made structures such as piers affect physical processes in the nearshore region of the coastline. These physical processes include mixing and currents, which induce physical dilution in waters.

2.4.1. Freshwater plumes

A freshwater plume often forms when a river or an estuary discharges water onto the continental shelf. Stormwater outflows also produce freshwater plumes. The outflows from rivers and stormwater drains tend to be lighter than the ambient coastal waters because they are less saline. Due to this, plumes are produced as the buoyant water spreads away from the mouth of the river outfall. Surface freshwater plumes are typically thin, and as such, they can be sensitive to wind stresses (Fong, 1998). Freshwater plumes remain within the nearshore region. Instead of mixing out to sea, they promulgate along the nearshore zone. Stratification due to the differences in salinity and temperature inhibits the mixing between nearshore and deeper waters. In addition, freshwater plumes are also affected by wind stresses. During upwelling favourable conditions mixing with ambient ocean water is boosted, and during downwelling favourable wind conditions mixing is inhibited. According to Fong (1998), the pollution levels of the freshwater that enters the nearshore region from rivers as well as stormwater drains varies. Furthermore, the advection the fresh water can be affected by external forcing mechanisms such as winds, hydrography, atmospheric pressure and tides. These mechanisms determine the mixing of freshwaters and seawaters, and thus the associated pollutants (Pommepuy *et al*, 2006). Plumes can be spread significant distances offshore due to upwelling winds, while downwelling winds tend to restrain a plume alongside the coast.

2.4.2. Wind driven surface currents

According to Tsanis (1978), a drift current results when waves are generated by wind which propagates across the surface of water due to shear stress induced at the air-water interface. When wind velocities are low, and the wind is affected by the surface friction as well as the form drag of the capillary waves, the wind drives the surface current. This occurs either directly or through the micro-breaking and viscous dissipation of the capillary waves. In this way, energy is lost in turbulence and is eventually dissipated, and the associated wave momentum boosts the surface current. When wind speeds are greater, the energy dissipation becomes greater due to the breaking of gravity waves. This contributes to surface water mixing.

2.4.3. Rip currents

Rip currents are powerful, narrow surface currents of swiftly flowing water moving out to sea. Complex wave interactions may generate circulation patterns as waves break near the shore. This results in the formation of rip currents which send water back out to the sea (Carey *et al*, 2004). They are usually confined to deeper channels between shallow sand bars. Larger waves generate stronger currents. The most common type of rip currents is low energy rips. These rips occur when waves are smaller or haven‟t changed for a significant period. They are typically fixed in place and they sit in channels between sand bars. Low energy rips do not move considerably. High energy rips are commonly referred to as flash rips. These rips occur when waves increase suddenly or during a storm event. Flash rips have a tendency to flow faster. Headland and fixed rips are often permanent. They are present next to headlands and structures such as jetties and groynes. In addition, rip currents can develop when currents running parallel to the shore are deflected by coastal structures (Brander, 2007).

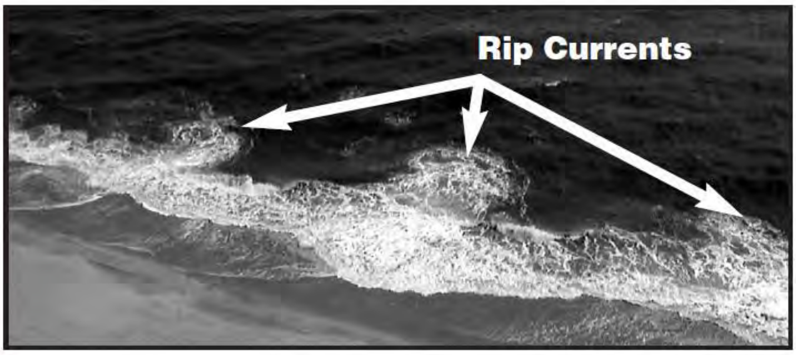

Figure 2-3: Typical Rip Currents (Carey *et al*, 2004)

2.4.4. Longshore currents

Longshore currents are produced when breaking waves interact with the coastline. A mean flux of longshore momentum occurs as waves approach the coastline obliquely. These waves direct a portion of momentum flux alongshore, generating longshore currents which can travel at speeds which range from 0.2 to 1.0 m/s. The slopes are a driving force for these currents. It has been found that longshore currents are often unstable. Moreover, there are low frequency shear waves associated with unstable currents (Feddersen, 1996).

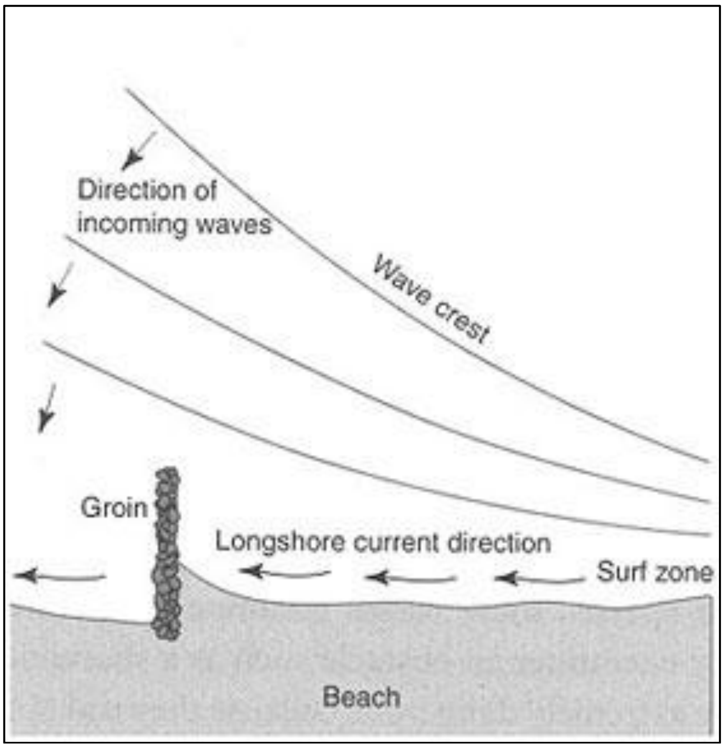

Figure 2-4: Diagrammatic Representation of Longshore Currents (Feddersen, 1996)

Feddersen (1996) explains littoral drift of sand along the coastline occurs mainly due to the longshore current. This is also dependent on the direction of the incident waves, frequency of the waves as well as wave heights.

2.5. Water quality management

2.5.1. Blue Flag Campaign

The Blue Flag Campaign is a voluntary initiative which aims to encourage local authorities to provide clean and safe beaches for the local community as well as tourists.

The Blue Flag Award is an annual certification given by The Foundation for Environmental Education (FEE). This Foundation is a non-governmental, non-profit organisation. A beach or marina is required to meet the Foundation‟s strict standards in order to receive the Blue Flag certification. As such, the Blue Flag Award is pursued to indicate the high environmental and quality standards of beaches and marinas. The four main criteria include safety and services, environmental management, environmental education, and beach water quality (FEE, 2003).

The programme was first started in 1985 in France and has been operating throughout Europe since 1987. As of 2012, more than 40 countries are participating in the program and a total of 3489 in the world beaches and marina have been awarded the Blue Flag (Pullan, 2012). South Africa is the first non-European country to obtain the Blue Flag Award.

If a beach has a Blue Flag flying, beach goers will know that the beach is safe, the water quality is good, and there is environmental information displayed at the beach. The Blue Flag Award can also be used to attract tourists. If the flag is absent from a beach then none of the previous mentioned is guaranteed.

According to DA eThekwini Spokesman on Beaches, Cllr Geoff D A Pullan, for a tourist friendly municipality it makes sense to use the Blue Flag scheme. Despite this technological age, not very many people actually check the beach water quality on the internet before going to the beach.

The Blue Flag Programme has based the bathing water quality standards on the relevant international and national standards and legislation. Details of the environmental quality targets vary for each region. Table 2-5 shows the microbiological water quality criteria required for a beach to receive Blue Flag status in South Africa.

Table 2-5: Microbiological Water Quality Criteria for Blue Flag Beaches in SA (Source: DEA, 2012)

PARAMETER	ENVIRONMENTAL QUALITY TARGETS
Microbiological Indicators	Faecal coliform (E.coli) per 100ml: <100 in 80% of samples (guideline)
	Faecal coliform (E.coli) per 100 ml: <2000 in 95% of samples (imperative)
	Faecal streptococci (Enterococcus) < 100/100ml in 80% of samples (imperative)
	Faecal streptococci (Enterococcus) < 50/100ml at 75% compliance (guide)

2.5.2. eThekwini Metro

The eThekwini Metro samples the Durban beaches on a weekly basis and tests the samples for the two indicator bacteria: Enterococcus and E.coli. This water quality information is displayed at the beaches and is put up on the eThekwini Metro website. This enables users to make decisions and gives details of the facilities at each beach along the coastline. In addition, information regarding general beach cleanliness and litter information is displayed at the beaches and on the website (eThekwini Municipality, 2013).

2.5.3. BEACH Act

In October 2000, the Beaches Environmental Assessment and Coastal Health (BEACH) Act was signed into federal law in the United States of America. Prior to this, the Clean Water Act (CWA) was in place. The BEACH Act stipulates that it is a requirement for all coastal states to submit monitoring, notification, and all other information regarding their beaches to the US EPA. This Act also addressed pathogenic indicators in recreational beaches and requires that all beaches must be sampled frequently. Implementation of the BEACH Act has resulted in vast improvements in beach monitoring across America and created uniformity that did not exist throughout the country (BEACH Act, 2000).

CHAPTER 3:
STATISTICAL ANALYSIS OF STUDY SITE

3.1. Introduction to the study area

Durban boasts a series of beaches along its coastline of more than 100km. The eThekwini Municipality Water and Sanitation Services (EMWSS) regularly samples beaches from the north to the south of the Durban coastline. A total of 42 beaches are included in the study area. For the purpose of this study the coastline has been divided into four sections as indicated in Figure 3-1 and described in Table 3-1.

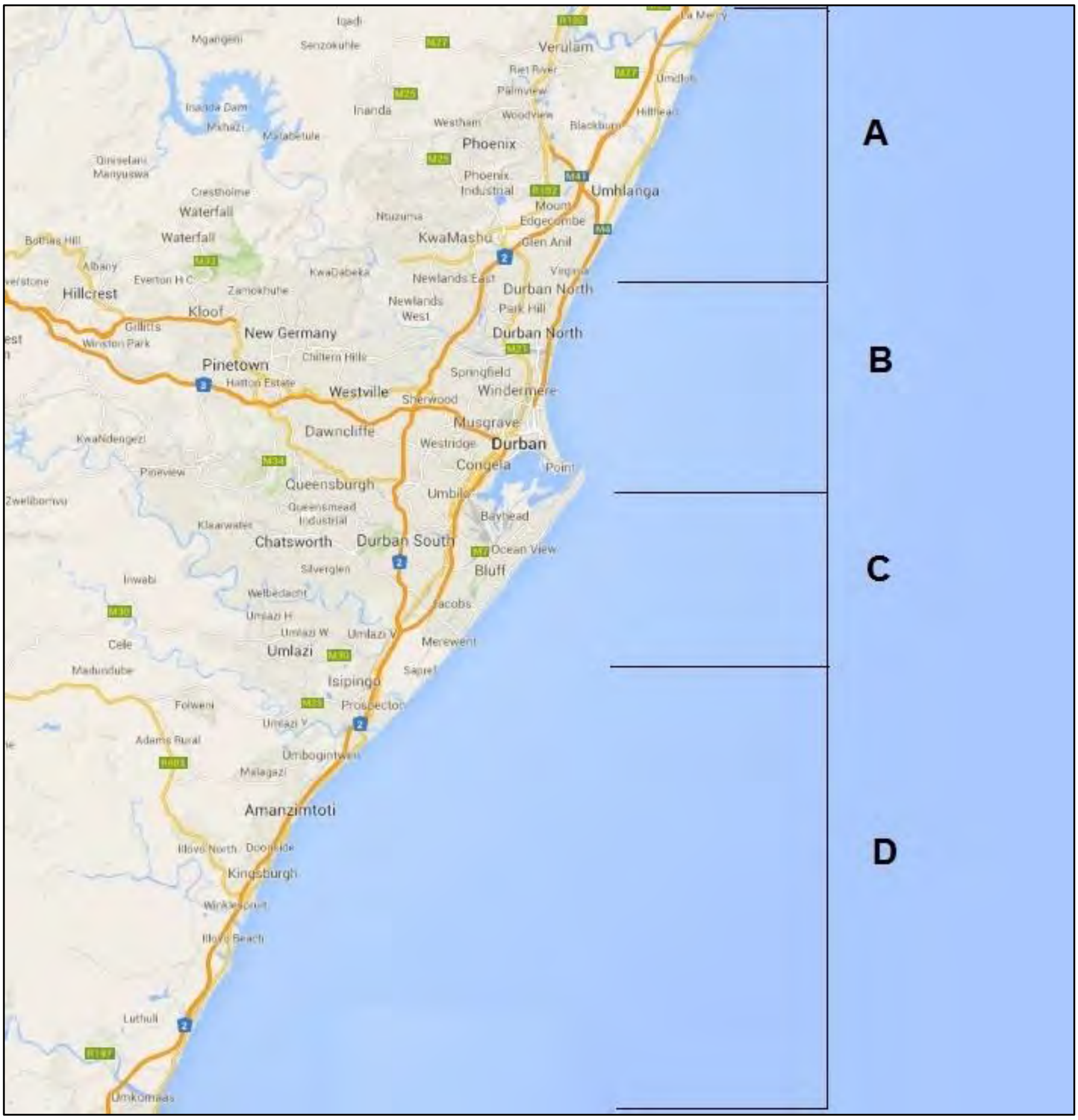

Figure 3-1: Durban Coastline (Google Maps, 2014)

Table 3-1: Beaches by Section

SECTION A NORTHERN	SECTION B CITY	SECTION C BLUFF	SECTION D SOUTHERN
1. Westbrook	1. Blue Lagoon (Umgeni South)	1. Garvies	1. Reunion
2. Casuarina (Tongaat)	2. Laguna	2. Anstey‟s	2. Isipingo
3. La Mercy	3. Thekwini	3. Brighton	3. Dakota (Umbogintwini)
4. Umdloti Tidal	4. Country Club	4. Treasure	4. Amanzimtoti Pipeline
5. Umdloti Main	5. Dunes (Suncoast)	5. Umlaas	5. Amanzimtoti Main
6. Umdloti South	6. Battery		6. Warner
7. Bronze (Umhlanga)	7. Bay of Plenty		7. Warner Baggies
8. Umhlanga Rocks Main	8. North		8. Winkelspruit
9. Umhlanga Rocks Granny‟s Pool	9. Wedge		9. Karridene
10. Umhlanga Rocks Lighthouse	10. South		10. Umgababa
11. Glenashley	11. Addington		11. Umkomaas
12. Virginia	12. uShaka		
13. Beachwood	13. Vetch‟s		

Section A encompasses the Northern beaches. This section consists of a total of 13 beaches, with the northern-most beach being Westbrook beach. Figure 3-2 shows the Northern beaches as indicated by number in Table 3-1.

Figure 3-2: Section A – Northern Beaches (Durban.gov.za, 2014)

Section B encompasses the City beaches. A total of 13 beaches are sampled in this section, starting at Blue Lagoon and ending at Vetch‟s. Figure 3-3 shows the City beaches as indicated by number in Table 3-1.

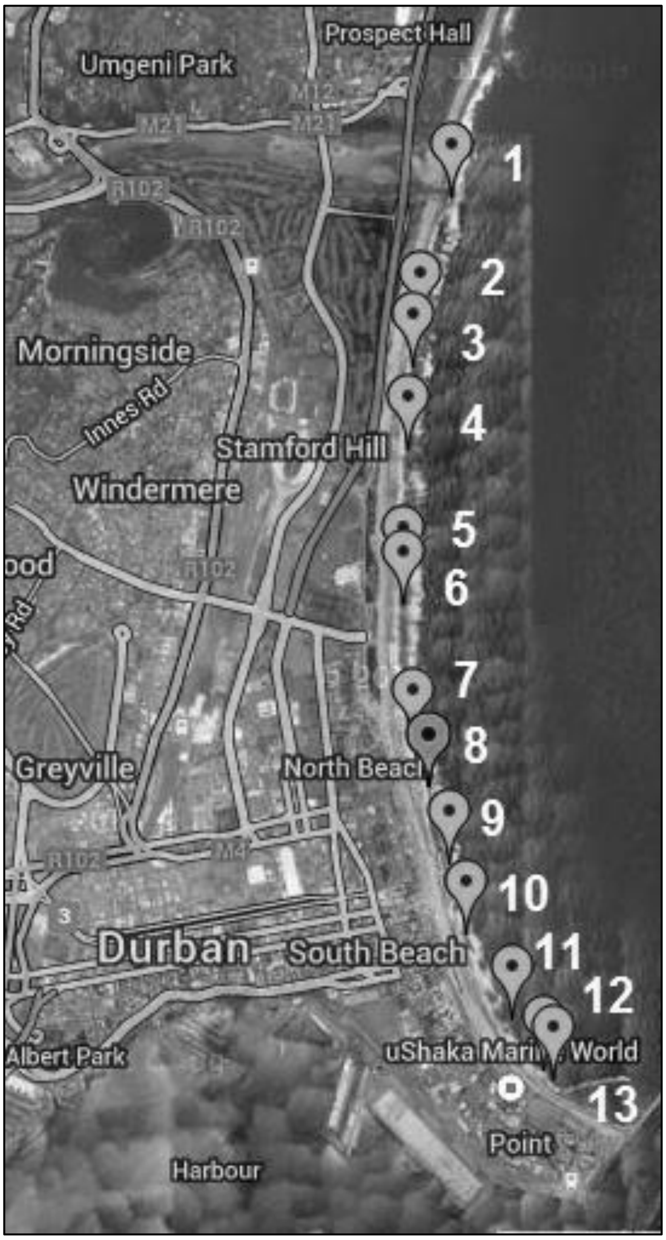

Figure 3-3: Section B – City Beaches (Durban.gov.za, 2014)

The Bluff beaches are grouped together as Section C. This section consists of 5 beaches. Figure 3-4 shows the Bluff beaches as indicated by number in Table 3-1.

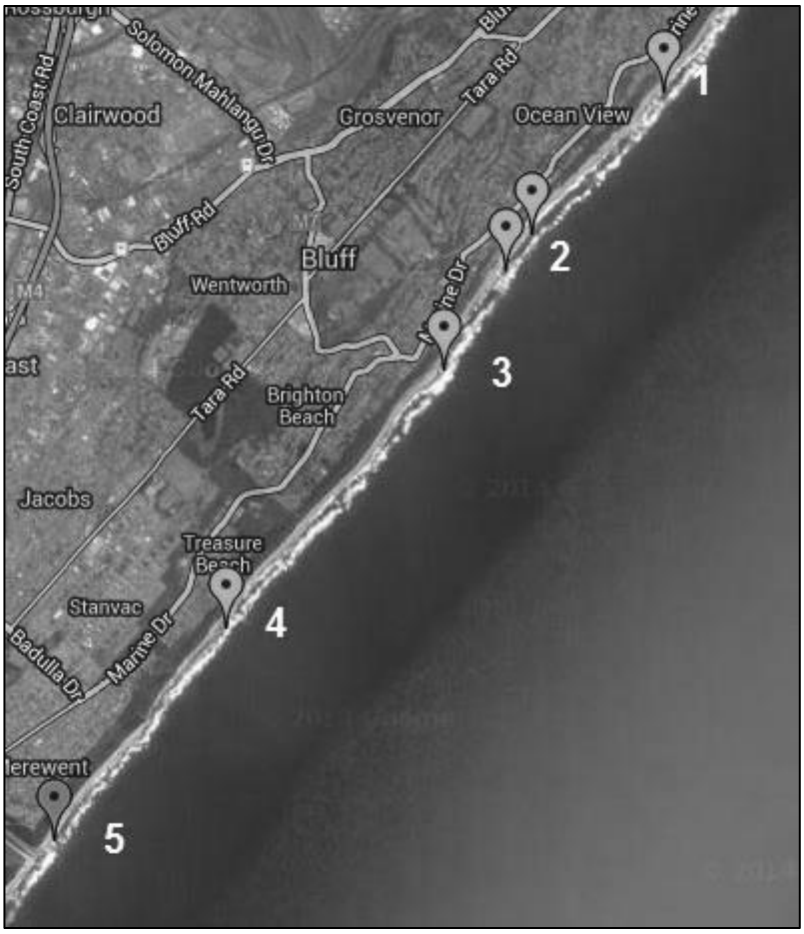

Figure 3-4: Section C – Bluff Beaches (Durban.gov.za, 2014)

A total of 11 beaches make up Section D, the Southern beaches. This section starts at Reunion beach up to the southern-most beach, Umkomaas. Figure 3-5 shows this set of beaches as indicated by number in Table 3-1.

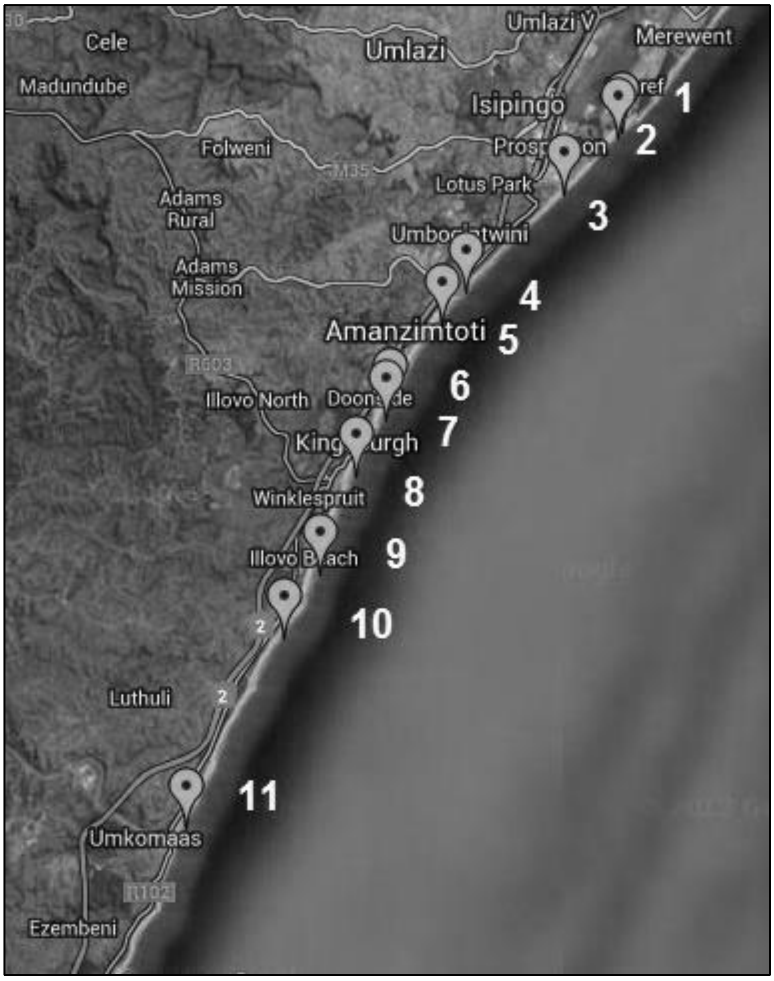

Figure 3-5: Section D – Southern Beaches (Durban.gov.za, 2014)

3.2. Water quality data

On a fortnightly basis the EMWSS samples beach water at each beach to test the quality of the beach water by establishing the levels of pathogenic pollution. On occasion sampling may be done more frequently. The samples are tested for the two indicator bacteria: E.coli and Enterococcus. EMWSS provided data for this research. All data was given in CFU/100ml (colony forming units/ 100ml), also referred to as counts/100ml. The raw data are attached as Appendix A. The sampling periods for which the data was provided and analysed were:

- January 2003 to December 2013 for E.coli
- January 2003 to June 2013 for Enterococcus

Unless otherwise stated.

3.3. Data analysis

To develop a comprehensive understanding of the changes in beach water quality along the Durban coastline, a critical assessment of water quality data has been undertaken. The assessment was done in two parts: a general statistical analysis and a comparison with the new SAWQ Guidelines. The data was analysed in 3 parts: monthly, seasonally, and annually. For the seasonal analysis the seasons are described as follows:

1. Spring – September to November
2. Summer – December to February
3. Autumn – March to May
4. Winter – June to August

3.3.1. Selection of statistical parameters

3.3.1.1. General statistical analysis

A general statistical analysis was done to understand the changes and establish any evident/possible trends in water quality conditions over the past decade. The data analysis was completed by means of various statistical methods. The statistical parameters that were used for the general statistical analysis were:

Average or arithmetic mean: $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ (3-1)

Standard deviation: $\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2}$ (3-2)

Geometric mean: $\ln(GM) = \frac{1}{n}\sum_{i=1}^{n} ln x_i$ (3-3)

The arithmetic mean was selected to determine general changes in average water quality conditions over the study period as well as any trends in these changes. The standard deviation was selected to observe the degree of variation in average water quality conditions.

For microbiological statistical evaluation of raw data the geometric mean is one of the most acceptable international parameters. Microbiological data acquired from uncontrolled marine environments can vary significantly from high to low even when collected at the same beach. Data does not always conform to a certain tendency. The geometric mean is the statistical parameter chosen to compare patterns of the two indicator bacteria as it uses the logarithm to smooth out the data and transform it to a central tendency (Bartram and Rees, 2000).

3.3.1.2. SAWQ Guidelines

The Department of Environmental Affairs published a new set of water quality guidelines in 2012. This new set of guidelines contains revised requirements for microbiological water quality. Table 3-2 shows the microbiological requirements for coastal water quality in South Africa.

Table 3-2: Water Quality Requirements for Microbiological Indicator Organisms (DEA, 2012)

CATEGORY	Enterococci (Counts per 100ml)	E.coli (Counts per 100ml)
Excellent (E)	≤ 100 (95 percentile)	≤ 250 (95 percentile)
Good (G)	≤ 200 (95 percentile)	≤ 500 (95 percentile)
Sufficient or Fair (minimum requirement)	≤ 185 (90 percentile)	≤ 500 (90 percentile)
Poor (P) (unacceptable)	>185 (90 percentile)	>500 (90 percentile)

There are various percentile ranking formulae used internationally in the water industry such as Hazen, Tukey, Weibull, Blom, and Excel. In order to give a good estimation, each method requires at least a certain number of samples, e.g. Hazen – 10, Tukey – 13, Weibull – 19, Blom – 13, and Excel – 1 (Bartram and Rees, 2000).

According to WHO (2003) the Hazen percentile calculator is the preferred method for determining the percentiles. However, it requires at least 10 sets of sample data. Since samples were taken fortnightly, and on occasion at most 6 times a month, the Hazen percentile calculator could not be used to analyse the data monthly.

To determine the percentiles for each month the Excel calculator was used as it only requires one sample. For consistency, the Excel calculator was also used to determine the annual percentiles even though the quantity of sample sets were sufficient to use the Hazen percentile calculator.

Excel percentile calculator: $r_{excel} = 1 + \frac{P}{100}(n-1)$ (3-4)

Where:

P – percentile value (e.g. 95 for 95 percentile)

n – sample size

3.4. Results

The outcome of the data analysis is presented in a comparative manner. The results for each type of analysis are given for E.coli and Enterococcus. In this way it is possible to compare the patterns of each of the indicator bacteria.

In an attempt to determine any general seasonal trends in the indicator bacteria levels, seasonal averages of both E.coli and Enterococcus were determined for each beach over the study period. For each year, the seasons were given a ranking from 1 to 4, where 1 indicates the season with the highest concentration of indicator bacteria and 4 indicates the lowest. Furthermore, the season which yielded the highest average level of indicator bacteria has been highlighted for each year.

To monitor variations of the concentrations of indicator bacteria since 2003, annual averages and standard deviations were determined. These parameters were used to establish any general trends or patterns in water quality variations for each year throughout the study period.

The geometric means of E.coli and Enterococcus concentrations have been compared graphically. This was done to determine which of the two indicator bacteria concentrations have changed more critically over the duration of the study period and to identify any evident patterns in these changes.

The concentrations of both indicator bacteria were analysed using the microbiological water quality requirements as stipulated by the SAWQ Guidelines (2012). Data was analysed monthly and annually. For the monthly analysis, data was analysed for each month in each year over the study period and for the annual analysis the data was analysed for each year in the study period (January to December). Percentiles for each period (month and year) were determined and compared to the water quality requirements in order to classify water quality as Excellent (E), Good (G), or Poor (P) as per the description in Section 3.3.1.2. The outcomes have been tabulated to identify any changes in the microbiological water quality conditions over the course of each year as well over the duration of the study period. Poor water quality conditions were particularly highlighted in the tables to clearly depict the frequency and patterns of the occurrences of poor water quality conditions.

One beach has been chosen to display the full set of typical results and main findings of the statistical analysis. This is presented in section 3.4.1. Thereafter, detailed summaries of each statistical analysis have been given for each section along the Durban coastline. The full set of detailed results for all 42 beaches is attached as Appendix A.

3.4.1. Typical Results – Westbrook Beach

- **Seasonal Trends**

The ranking of seasonal averages for E.coli and Enterococcus are shown in Tables 3-3 and 3-4 respectively. The highest levels of E.coli were found to be either in autumn and winter consistently. These are typically the dry seasons in the Durban region. It is evident that spring did not yield the greatest levels of E.coli, with exception to 2013. From 2009 to 2012 summer has consistently yielded the second highest concentration.

Table 3-3: Westbrook – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**153 (1)**	6.70 (2)	0.00 (2)	**177 (1)**	6.70 (4)	**613 (1)**	**280 (1)**	6.70 (4)	57.3 (3)	**59.3 (1)**	16.7 (3)
Winter	0.00 (4)	6.70 (2)	**20.0 (1)**	133 (2)	**536 (1)**	8.30 (4)	20.0 (4)	**555 (1)**	**81.0 (1)**	14.4 (3)	32.2 (2)
Spring	20.0 (3)	6.70 (2)	0.00 (2)	16.7 (3)	123 (2)	56.2 (2)	78.1 (3)	15.0 (3)	33.7 (4)	10.6 (4)	**218 (1)**
Summer	6.70 (2)	**66.7 (1)**	**20.0 (1)**	10.0 (4)	22.2 (3)	31.7 (3)	200 (2)	29.0 (2)	74.7 (2)	20.6 (2)	8.3 (4)

The highest average concentrations of Enterococcus are shown to be evenly distributed between summer, and autumn, though not consistently. In Durban summer is the season when the most rains occur and the seasons before it are typically dry. Spring never yielded the highest results and has consistently ranked third from 2008 to 2012. Autumn yielded the highest levels for both bacteria four times in the study period (2003, 2006, 2009, and 2012). There are no other clear correlations between the two indicators.

Table 3-4: Westbrook – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**273 (1)**	0.00 (4)	140 (2)	**240 (1)**	13.3 (4)	197 (2)	**199 (1)**	7.50 (4)	12.8 (4)	**300 (1)**	26.7 (2)
Winter	13.3 (3)	33.3 (2)	**253 (1)**	179 (2)	**292 (1)**	75.2 (4)	31.7 (4)	66.6 (2)	97.2 (2)	35.6 (2)	**145 (1)**
Spring	73.3 (2)	6.70 (3)	66.7 (3)	46.7 (4)	250 (2)	111 (3)	71.7 (3)	37.8 (3)	32.4 (3)	35.0 (3)	-
Summer	0.00 (4)	**347 (1)**	66.7 (3)	53.3 (3)	83.3 (3)	**209 (1)**	127 (2)	**110 (1)**	**103 (1)**	5.40 (4)	-

- **Annual Trends**

The annual averages and standards deviations for E.coli and Enterococcus are depicted in Figures 3-6 and 3-7 respectively. It is evident that the average concentration of E.coli has varied over the study period. Averages have decreased and increased inconsistently. Peaks from 2007 to 2010 are up to 19 times greater than the lowest levels in 2005. It is clear that there is significant variation in E.coli concentrations. However, there is no trend in the variation. Average concentrations in 2013 are greater than at the start of the study period.

The standard deviations were found to be relatively large in some cases. This indicates that the data set is spread over a large range and bacteria levels vary greatly throughout each of those years. Values more than double the average show that even though the average levels are not exceptionally high, levels of E.coli have varied significantly from the average on occasion within many of the years in the study period. Higher standard deviations also correlate to the higher averages from 2007 to 2010, with 2010 standing out significantly. The standard deviation in 2010 is approximately six times greater than the average. This is due to extremely high counts of E.coli (9300 CFU/100ml) enumerated in one sample in that year. Similarly, the standard deviation for 2008 is almost five times that of the average. This is as a result of large sample sizes ranging from 1500CFU/100ml to 3500CFU/100ml.

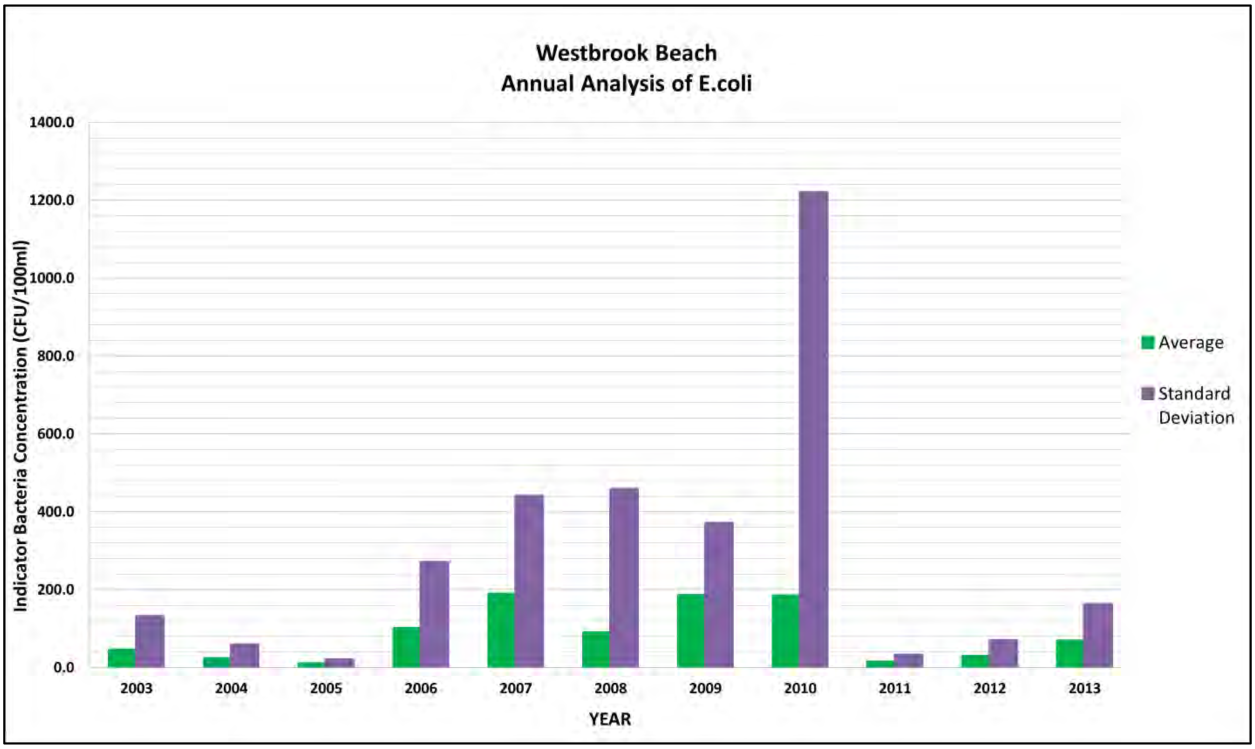

Figure 3-6: Annual Analysis of E.coli at Westbrook Beach

Generally average Enterococcus concentrations were consistent from 2003 to 2009; thereafter changes in average concentration became slightly more variable. From 2010 to 2011 average levels of Enterococcus decreased slightly, with an increase in 2012 and then a decrease again in 2013. The lowest average level of Enterococcus occurred in the most recent year of the study.

The standard deviations follow the same consistent trend as the averages from 2003 to 2009. From 2010 to 2013 the standard deviations did not follow the same pattern as the averages. With exception to 2012, generally the standard deviations were not significantly large. The standard deviation in 2012 is approximately six times greater than the average. This is due to extremely high counts of Enterococcus enumerated in one sample in that year (4000CFU/100ml). When comparing the results of the two indicator organisms, Enterococcus has been found to be consistent in comparison to E.coli, which has been more variable.

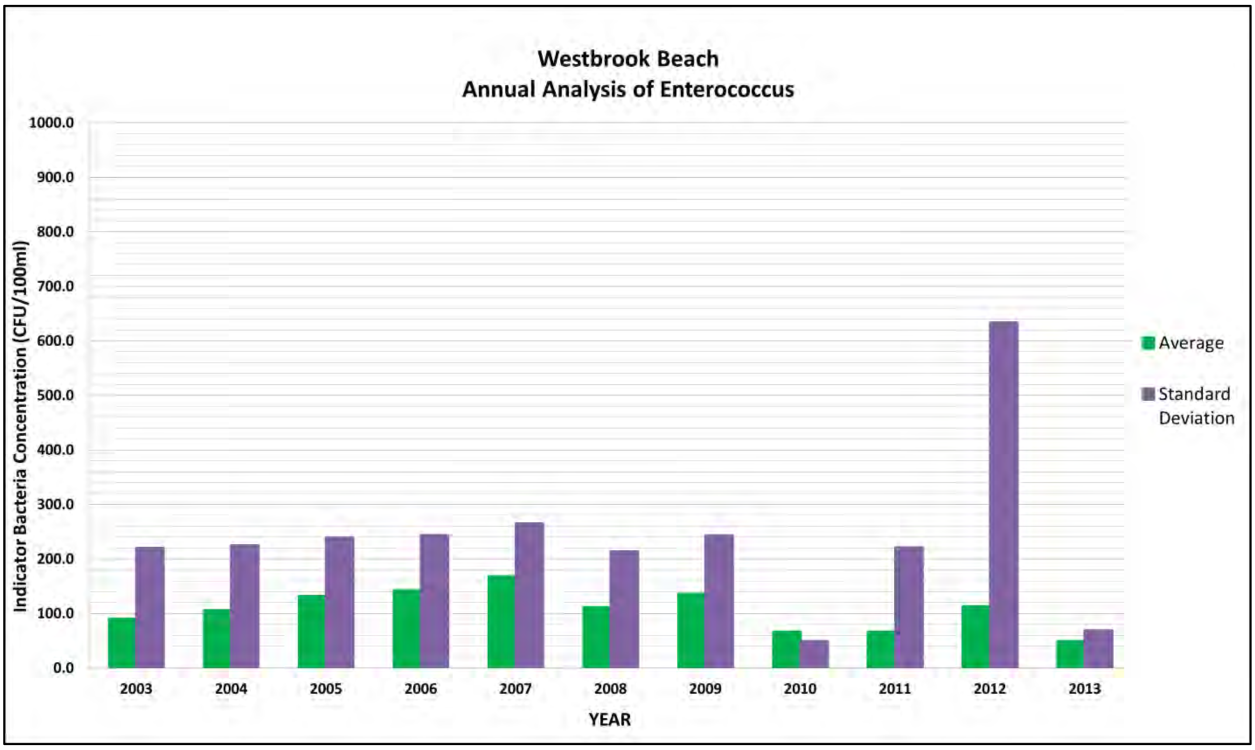

Figure 3-7: Annual Analysis of Enterococcus at Westbrook Beach

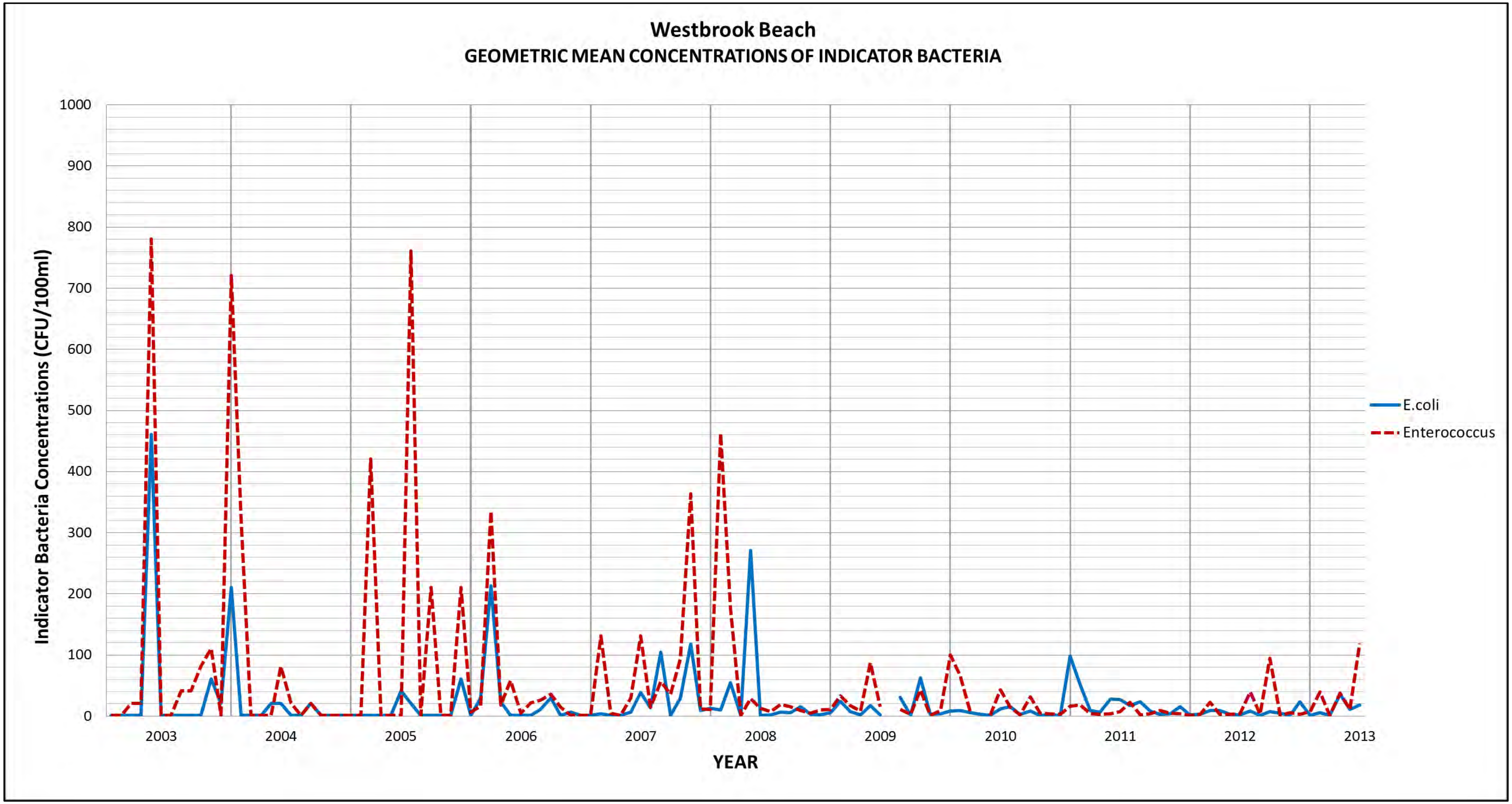

Figure 3-8: Westbrook – Geometric Mean Concentrations of Indicator Bacteria (2003-2013)

The geometric mean concentrations of the E.coli and Enterococcus at Westbrook are compared in Figure 3-8. Enterococcus levels vary from extremely high to extremely low each month throughout the first half of the study period, becoming more consistent in the second half. E.coli also varies in the first half of the study period, though not as greatly as Enterococcus. Generally Enterococcus concentrations are shown to be higher than E.coli although both bacteria follow the same pattern. In the most recent years levels of both indicators have not exceeded 100 CFU/100ml.

- **SAWQ Guidelines**

The microbiological water quality for Westbrook beach has been classified according to the requirements of the new SAWQ Guidelines. Table 3-5 shows the rating of the E.coli levels at Westbrook beach for each month over the study period.

Generally the levels of E.coli indicate excellent to good water quality conditions, with a few occurrences of poor water quality conditions during the middle of the study period. In the most recent years there have been no occurrences of poor water quality conditions based on E.coli concentrations, with the annual rating being consistently excellent for the last four years.

Table 3-5: Westbrook – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	P	E	E	E	E
MAR	E	E	E	G	E	E	E	E	E	E	E
APR	E	E	E	P	E	E	E	E	E	E	E
MAY	G	E	E	E	E	P	P	E	E	G	E
JUN	E	E	E	E	P	E	E	G	E	E	E
JUL	E	E	E	E	E	E	P	P	G	E	E
AUG	E	E	E	P	P	E	E	E	G	E	E
SEP	E	E	E	E	E	E	E	E	G	E	E
OCT	E	E	E	E	E	G	G	E	E	E	E
NOV	E	E	E	E	P	E	E	E	E	E	G
DEC	E	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	G	G	E	G	E	E	E	E

The microbiological water quality rating for Enterococcus is shown in Table 3-6. Annually there have been no occurrences of excellent water quality at Westbrook beach based on Enterococcus concentrations. A clear deterioration in microbiological water quality is evident from 2005 to 2011 as the frequency of poor water quality increases. For the years 2007 to 2010 the water quality has been classified as poor for approximately half of the year, resulting in an annual classification of poor water quality. Throughout many years in the study water quality has been poor in January or February, or both. These are the main summer months in Durban, where the highest rainfall is generally experienced (Brook & Mametse, 1970). This results in increased surface runoffs and as such, increases in the quantities of pathogens entering coastal waters.

When comparing the indicator bacteria, it is clear that Enterococcus levels result in poorer water quality conditions than E.coli. However, higher levels of E.coli are allowed than Enterococcus according to the guidelines.

Table 3-6: Westbrook – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	E	E	E	P	P	P	E	E
FEB	E	P	E	P	P	P	P	P	P	E	E
MAR	E	E	P	P	E	P	E	E	E	P	E
APR	E	E	E	P	E	E	P	P	E	E	E
MAY	P	E	E	G	E	P	P	E	E	E	E
JUN	E	E	E	E	P	P	G	P	P	G	G
JUL	E	-	P	P	P	G	P	P	P	G	-
AUG	E	E	E	P	P	E	E	E	E	E	-
SEP	E	E	P	E	E	P	E	P	E	E	-
OCT	E	E	E	G	P	P	P	E	P	E	-
NOV	E	E	E	E	P	P	E	G	E	E	-
DEC	E	E	P	E	G	G	E	E	E	E	-
Annual	G	P	P	P	P	P	P	P	P	G	G

3.4.2. Section A Summary – Northern Beaches

- **Seasonal Trends**

To highlight common seasonal patterns amongst the Northern beaches, the seasons which produced the highest levels of each indicator bacteria have been summarised in Table 3-7. In addition, any other significant trends have been noted. Comments have been made regarding correlation in trends between E.coli and Enterococcus.

The highest levels of pathogenic pollution occurred in summer and autumn most often at most of the Northern beaches. The Durban region receives most of its rainfall in summer and the months prior to this are often dry (Brook & Mametse, 1970). This provides opportunity for pathogenic pollution to accumulate on catchment surfaces. When it does rain, higher levels of pathogens are transported to the coastal waters via stormwater drains. This results in an increase in pathogenic pollution and consequently, poor water quality conditions. In this way the effect of the first flush can be noted. (Stenstrom and Kayhanian, 2005). Occasionally winter produced the highest average concentrations; however, this was not consistent. The highest counts of pathogenic pollution never occurred during spring.

Table 3-7: Summary of Seasonal Trends – Northern Beaches

	Seasonal trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Westbrook	Autumn/Winter	Autumn/ Summer	Correlation in highest for 4 non-consecutive years
Casuarina	No trends	No trends	Correlation in in highest from 2010 to 2012
La Mercy	Summer/Autumn	Summer/Autumn	No correlation
Umdloti Tidal	Autumn/Winter	Winter	No correlation
Umdloti Main	Autumn/Winter	Winter	No correlation
Umdloti South	Autumn	Autumn/Winter	No correlation
Bronze (Umhlanga)	Summer/Autumn	No trends	Correlation in highest from 2007 to 2009
Umhlanga Rocks Main	Autumn	Summer	No correlation
Umhlanga Rocks Granny's Pool	Summer	Summer	Corresponding ranking order 2006, 2008, 2009, 2011, and 2012.
Umhlanga Rocks Lighthouse	No trends	Summer/Autumn	No correlation
Glenashley	Summer/Winter	Summer/Winter	No correlation
Virginia	Autumn/Winter	No trends	No correlation
Beachwood	Winter	Summer – consistently from 2008 to 2011	No correlation

The season which yielded the highest concentrations of both indicators was not consistent with exception to Beachwood, where the highest average levels of Enterococcus occurred in summer consistently from 2008 to 2011. Although there are no clear trends with regards to the seasonal ranking of each bacterium for Casuarina, the seasons which produced the highest concentrations for E.coli and Enterococcus do correlate consistently from 2010 to 2012. At Bronze beach the same trend is noted for 2007 to 2009.

The most definitive patterns are evident at Umhlanga Rocks Granny"s Pool beach. Not only is there correspondence between the two indicators regarding the season which produce the highest average concentrations, the ranking order corresponds for five years in the study as well.
Apart from these isolated incidences, there is seldom a consistent connection between E.coli and Enterococcus. This indicates that the bacteria behave independently. Different factors affect the growth and survival of each bacterium and they do not behave the same even within the same environment (Austin *et al,* 2014).

- **Annual Trends**

The annual trends observed for each of the Northern beaches are summarised in Table 3-8. The main observations in the changes in average concentrations of the two indicator bacteria are briefly explained. Comments have been made regarding correlation in trends between E.coli and Enterococcus.

Average concentrations of E.coli and Enterococcus fluctuated at the Northern beaches throughout the study period. However, at the end of the study period the averages either remained consistent or increased. If there was a decrease in the average of a particular bacterium, the decrease was marginal.

Many beaches either experienced large averages or notably large standard deviations in bacterial concentrations in 2007. During March 2007 a significant storm event occurred where heavy rains resulted in increased stormwater runoffs. Swells of more than 7m were experienced during the storm surge (Hunter, 2007). E.coli appears to be affected by this storm event more than Enterococcus.

With exception to 2007, generally the standard deviations were not exceptionally large. This indicates that the data set is spread over a small range and generally bacteria levels did not vary greatly throughout the year at most beaches. At most beaches there is no direct relationship evident between the two indicators regarding their average changes over the course of the study, highlighting their independent nature.

Table 3-8: Summary of Annual Trends – Northern Beaches

	Annual trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Westbrook	Random variation, constant increase since start of study	Minimal variation, overall consistent	No correlation
Casuarina (Tongaat)	Increased, more variability in years with large averages	Random variation in averages, ultimately decreased	Large standard deviations in 2007
La Mercy	Increased average, small deviations but largest deviation in 2007	Average has become consistent	Large standard deviations in 2007
Umdloti Tidal	Slight variation but remained consistent	Slight variation but remained consistent	Both remained low, no link between the two
Umdloti Main	Increase in average, increase in variability	Average decreased slightly	Both share large standard deviation in 2011.
Umdloti South	Marginal variation, remained below 50CFU/100ml, largest deviations in 2007	Maintained consistency, remained below 100CFU/100ml	Both remained low
Bronze (Umhlanga)	Increased, largest deviations in 2007	Remained consistent, largest deviations in 2007	Shared largest deviations in 2007
Umhlanga Rocks Main	Varied slightly, ultimate Increase, large deviation in 2007	Varied slightly, ultimately Increased	Both share similar patterns of variation over the years
Umhlanga Rocks Granny's Pool	Increase, large peaks in 2007	Slight variation, remained consistent	No correlation
Umhlanga Rocks Lighthouse	Slight variation, ultimately remained consistent	Increased	No correlation
Glenashley	Slight variation, ultimately remained consistent, large deviation in 2007	Slight variation, ultimately remained consistent	No correlation
Virginia	Decreased and remained consistent from 2010 to 2013, large deviation in 2007	Gradually decreased	Patterns similar, but not consistent
Beachwood	Slight variation, ultimately remained consistent	Slight variation, ultimately remained consistent, large deviation in 2007	No correlation

- **Geometric Mean Trends**

The main observations of the geometric mean comparisons are briefly summarised in Table 3-9. Generally Enterococcus levels were higher than E.coli over the duration of the study. Despite this, both bacteria often shared the same patterns.

Some neighbouring beaches also shared similar trends. Generally from Westbrook through to Umdloti South both bacteria became less variable over the study period and Enterococcus concentrations mostly exceeded E.coli. At Bronze and Umhlanga Rocks Main both bacteria remained erratic and unpredictable. The rest of the Northern beaches did not share trends with their neighbours.

Table 3-9: Summary of Geometric Mean Trends – Northern Beaches

BEACH	GEOMETRIC MEAN TRENDS
Westbrook	Enterococcus exceeded E.coli. Both bacteria followed the same pattern and became less variable in later years.
Casuarina (Tongaat)	Both became more consistent and less than 100CFU/100ml.
La Mercy	Enterococcus exceeded E.coli. Both became more consistent and less than 100CFU/100ml.
Umdloti Tidal	Enterococcus exceeded E.coli. Enterococcus remained variable. E.coli became more stable.
Umdloti Main	Enterococcus exceeded E.coli. Both became less variable and remained low.
Umdloti South	Enterococcus exceeded E.coli. Enterococcus remained variable. E.coli has become more stable.
Bronze (Umhlanga)	Enterococcus exceeded E.coli. Both bacteria remained erratic.
Umhlanga Rocks Main	Enterococcus exceeded E.coli. Both bacteria remained erratic.
Umhlanga Rocks Granny's Pool	E.coli greater initially, then Enterococcus became greater than E.coli. Both bacteria became less variable.
Umhlanga Rocks Lighthouse	Enterococcus remained variable. E.coli became less variable.
Glenashley	Both bacteria remained consistent.
Virginia	Both bacteria remained variable and followed the same pattern.
Beachwood	Both remained variable and did not follow the same pattern.

- **SAWQ guideline ratings**

Table 3-10 shows the annual water quality classification for the Northern beaches based on E.coli. Generally water quality based on this bacterium was excellent to good. The water quality rating remained mostly excellent at Westbrook all the way through to Bronze beach. Water quality based on the presence of E.coli is shown to deteriorate at the Umhlanga beaches. The remainder of the Northern beaches failed to maintain excellent water quality conditions during the latter years of the study.

Table 3-10: Summary of E.coli Microbiological Water Quality Ratings – Northern Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Westbrook	E	P	E	G	G	E	G	E	E	E	E
Casuarina (Tongaat)	E	E	E	G	G	E	E	E	G	E	E
La Mercy	E	E	E	G	G	E	E	E	E	E	E
Umdloti Tidal	E	E	E	G	E	E	E	E	G	E	E
Umdloti Main	E	E	E	E	E	E	E	E	G	E	E
Umdloti South	E	E	E	E	G	E	G	G	G	G	E
Bronze (Umhlanga)	-	-	E	E	E	E	G	E	E	E	G
Umhlanga Rocks Main	E	E	E	E	E	E	E	E	G	E	P
Umhlanga Rocks Granny's Pool	G	E	E	P	P	E	G	E	G	E	P
Umhlanga Rocks Lighthouse	G	G	G	P	E	G	G	G	G	E	P
Glenashley	E	G	E	E	P	E	G	G	G	G	G
Virginia	P	G	E	E	P	E	G	G	G	G	G
Beachwood	G	G	E	E	G	E	G	E	G	G	G

The microbiological water quality ratings for the Northern beaches based on Enterococcus are summarised in Table 3-11. Few occurrences of excellent water quality conditions are evident across all of the Northern beaches. Annually water quality is rated poor more frequently based on this bacterium. The frequency of poor water quality appears to increase down the coastline of the Northern beaches.

Westbrook, Umhlanga Rocks Granny"s Pool, Umhlanga Rocks Lighthouse, Beachwood, Glenashley, and Virginia experienced poor water quality for a quarter to half of the year for many years throughout the study (refer to Appendix A for monthly results). This resulted in frequent poor annual ratings. All the Umdloti beaches and Umhlanga Rocks Main beach are the only beaches to show consistent good or excellent water quality with little or no incidences of poor annual ratings. These beaches are known to be among the more prestigious and popular beaches of the Northern part of the coastline.

Table 3-11: Summary of Enterococcus Microbiological Water Quality Ratings – Northern Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Westbrook	G	P	P	P	P	P	P	P	P	G	G
Casuarina (Tongaat)	G	G	E	P	P	P	P	G	G	E	G
La Mercy	G	G	E	G	E	P	P	G	G	G	G
Umdloti Tidal	E	G	G	P	E	G	G	G	G	G	E
Umdloti Main	G	E	E	G	E	G	G	G	E	E	E
Umdloti South	E	E	E	G	E	G	G	G	G	E	E
Bronze (Umhlanga)	-	-	G	G	P	G	G	E	P	G	G
Umhlanga Rocks Main	G	P	G	G	E	G	G	G	G	G	G
Umhlanga Rocks Granny's Pool	G	G	G	P	P	P	P	G	P	P	P
Umhlanga Rocks Lighthouse	G	G	G	P	G	P	P	P	P	G	P
Glenashley	P	P	G	G	P	G	P	P	P	G	P
Virginia	P	P	G	P	P	P	P	P	P	G	G
Beachwood	P	P	G	P	P	G	P	P	P	G	G

Numerous rivers enter the coastal waters along the coastline of the Northern beaches. In addition, many active waste water treatment works (WWTW) are located along these rivers. Monthly river quality index reports were obtained from eThekwini Water and Waste Services from January 2011 to December 2013. These reports reflect the effectiveness of sanitation of rivers and are used for the qualitative comparison of river water quality ratings to coastal water quality ratings. Full river quality indices are located in Appendix B.

The river quality indices suggest a direct relationship between river water quality and beach water quality, mainly based on the presence of Enterococcus. Poor river quality conditions co-incide with poor beach water quality conditions. When river quality has been classified as „acceptable", the corresponding beach water was „good". Ideal river quality corresponds with excellent beach water quality.

The Tongati River is the Northern-most river in this section of beaches. The Tongaat Central WWTW is located along this river. Discharges affect Westbrook and Casuarina beaches, and to a lesser extent, La Mercy beach. The Umdloti beaches are affected by the presence of the Umdloti River mouth. Furthermore, there are two waste water treatment works located along this river. Discharges from Umdloti WWTW and Verulam WWTW affect the quality of the Umdloti River, and consequently, the quality of the Umdloti beaches. The Ohlanga River affects the water quality of the Umhlanga beaches. In addition, the Phoenix WWTW and Umhlanga WWTW are also contributors to poor water quality conditions.

Moreover, there are many stormwater drains along the coastline of the Northern beaches. The presence of stormwater outlets along the coastline adversely affects coastal water quality as these outlets are direct sources of pathogenic pollution (Johnson, 2012).

3.4.3. Section B Summary –City Beaches

- **Seasonal Trends**

Table 3-12 summarises the seasons which produced the highest levels of each indicator bacteria at the City beaches. Moreover, comments have been made regarding correlation in trends between the two indicator bacteria.

Table 3-12: Summary of Seasonal Trends – City Beaches

	Seasonal trend		
BEACH	**E.coli**	**Enterococcus**	**Comments**
Blue Lagoon	Summer	Summer	No correlation
Laguna	Summer/Autumn	No trends	No correlation
Thekwini	Summer	Autumn	No correlation
Country Club	Autumn	Autumn	No correlation
Dunes -Suncoast	Summer	Autumn	No correlation
Battery	Autumn	No trends	No correlation
Bay of Plenty	No trends	Summer	No correlation
North	Spring	Summer	No correlation
Wedge	Spring	No trends	No correlation
South	No trends	Summer	No correlation
Addington	Summer	Summer	No correlation
uShaka	No trends	No trends	No correlation
Vetch's	Summer	Autumn	No correlation

Although no trends were established in some cases at the City beaches, the highest levels of pathogenic pollution occurred in summer and autumn most often. In Durban summer is generally the rainy season and the seasons which precede it are generally dry. As such, the increase in average concentrations of indicator bacteria in summer can be linked to the first flush effect. The highest counts of pathogenic pollution never occurred during winter. Winter is generally a dry season in the Durban region and stormwater runoffs are expected to be low (Brook & Mametse, 1970). There have been no correlations in the seasonal averages of E.coli and Enterococcus at the City beaches. This indicates that the bacteria behave independently.

- **Annual Trends**

The annual trends observed for each of the City beaches are summarised in Table 3-13. The main observations in the changes in average concentrations of E.coli and Enterococcus are briefly explained and comments have been made regarding any correlations.

Although both indicator bacteria showed variation throughout the study period, there was no correlation between E.coli and Enterococcus in this regard. For Blue Lagoon and Laguna, the average levels of pathogenic pollution varied slightly over the course of the study but ultimately decreased. For the remainder of the City beaches, with exception to Battery and uShaka, generally the average levels increased or remained consistent.
Dunes beach is the only beach to show clear correlation between the two bacteria. Average concentrations for both E.coli and Enterococcus remained consistent at this beach and counts rarely exceeded 150/100ml.

Generally the standard deviations were not extremely large along this section of beaches, with a few random exceptions. Blue Lagoon appears to be the only City beach possibly affected by the 2007 storm event, with exceptionally large deviations in Enterococcus concentrations for that year. Occasionally large deviations were noted at some of the City beaches, however, this occurred randomly and is likely due to extremely high bacterial counts enumerated in one sample in a particular year.

Table 3-13: Summary of Annual Trends – City Beaches

	Annual trend		
BEACH	**E.coli**	**Enterococcus**	**Comments**
Blue Lagoon (Umgeni South)	Slight variation, ultimately decreased	Slight variation, ultimately decreased. Largest deviation in 2007	No correlation in variation
Laguna	Decreased	Slight variation, ultimately decreased	No correlation in variation
Thekwini	Slight variation, remained consistent	Initially decreased, ultimately increased	No correlation in variation
Country Club	Slight variation, ultimately increased	Slight variation, ultimately increased	No correlation in variation
Dunes (Suncoast)	Remained consistent	Remained consistent	Both remained below 150CFU/100ml in most cases
Battery	Gradually decreased	Slight variation, ultimately remained consistent	No correlation
Bay of Plenty	Slight variation, ultimately remained consistent	Slight variation, ultimately increased	No correlation
North	Slight variation, ultimately increased, large deviations in 2006, 2008, 2009	Slight variation, ultimately increased, large deviations in 2012	No correlation
Wedge	Slight variation, ultimately increased but still remained low, large deviations in 2010	Slight variation, ultimately remained consistent, large deviations in 2009	No correlation
South	Slight variation, ultimately increased	Slight variation, ultimately increased	No correlation
Addington	Remained consistent	Variation, ultimately increased, large deviation in 2009	No correlation
uShaka	Remained consistent	Decreased and became less variable	No correlation
Vetch's	Increased	Variation, ultimately increased	No correlation

- **Geometric Mean Trends**

Table 3-14 contains the summary of the main observations of the geometric mean comparisons at the City beaches. Generally Enterococcus levels were higher than E.coli over the duration of the study with clear exception to Blue Lagoon, Dunes and uShaka. Both bacteria often shared the same patterns even though concentrations differed.

Some beaches shared similar trends with their direct neighbours. From Laguna through to Dunes both bacteria are shown to remain erratic. Apart from Vetch"s beach, the concentrations of the indicators did not become any less variable. Battery beach is the only beach to show nearly identical geometric mean concentrations for both bacteria.

Table 3-14: Summary of Geometric Mean Trends – City Beaches

BEACH	GEOMETRIC MEAN TRENDS
Blue Lagoon (Umgeni South)	E.coli exceeded Enterococcus; both bacteria followed the same pattern.
Laguna	Both bacteria remained erratic and followed the same pattern.
Thekwini	Both bacteria followed the same erratic pattern though concentrations differed.
Country Club	Enterococcus exceeded E.coli in most cases. Both bacteria remained erratic.
Dunes (Suncoast)	E.coli exceeded Enterococcus. Both bacteria remained erratic but followed the same pattern.
Battery	Both bacteria followed the same pattern, geomeans almost identical
Bay of Plenty	Enterococcus exceeded E.coli in most cases. Both bacteria followed the same pattern though concentrations differed.
North	Enterococcus exceeded E.coli in most cases. Both bacteria followed the same pattern though concentrations differed.
Wedge	Enterococcus exceeded E.coli in most cases. Both bacteria remained erratic.
South	Enterococcus exceeded E.coli, both bacteria follow same pattern.
Addington	Enterococcus greater and more erratic than E.coli.
uShaka	E.coli exceeded Enterococcus; both bacteria followed the same pattern.
Vetch's	Both bacteria became more consistent and followed the same pattern.

- **SAWQ guideline ratings**

The microbiological water quality ratings for the City beaches based on E.coli are summarised in Table 3-15. The first six beaches in this section are shown to have experienced poorer water quality conditions than the rest. With exception to South and uShaka beaches, based on this bacterium the water quality is shown to deteriorate from excellent to good at Bay of Plenty through to Vetch‟s.

Table 3-15: Summary of E.coli Microbiological Water Quality Ratings – City Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Blue Lagoon (Umgeni South)	P	G	G	P	P	P	P	G	P	G	P
Laguna	G	G	G	P	E	P	P	G	G	G	E
Thekwini						G	G	G	P	G	G
Country Club	G	E	G	G	G	G	P	G	G	G	G
Dunes (Suncoast)						G	G	G	P	G	G
Battery	P	P	P	G	G	G	P	G	G	G	G
Bay of Plenty	E	G	G	E	E	G	E	G	G	G	G
North	E	E	E	E	E	E	E	E	G	E	G
Wedge	E	G	E	E	E	G	G	G	G	G	G
South	E	G	E	E	E	G	G	G	G	E	E
Addington	E	G	E	E	E	G	E	E	G	G	G
uShaka						G	G	E	E	E	E
Vetch's	E	E	E	E	E	E	E	E	G	G	G

Table 3-16 shows the annual water quality classification for the City beaches based on Enterococcus. Based on this bacterium water quality is rated poor more frequently, in fact, water quality has been poor at every beach throughout most of the study. All of the City beaches experienced poor water quality for at least a quarter to half of the year on several occasions over the course of the study, including the summer months (refer to Appendix A). Consequently, most beaches experienced poor annual water quality conditions throughout most of the study period.

From Blue Lagoon up to Bay of Plenty water quality has been poor for almost the entire duration of the study with exception to one or two years. uShaka and Vetch‟s are the only beaches to have good water quality conditions consistently towards the ends of the study period. Based on both indicators, from 2010 onward uShaka has consistently experienced good/excellent water quality. This beach is a more prominent and popular beach as it is popular with both local and international tourists as it is located at uShaka Marine World.

Table 3-16: Summary of Enterococcus Microbiological Water Quality Ratings – City Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Blue Lagoon (Umgeni South)	P	P	P	P	P	P	P	G	P	P	P
Laguna	P	P	E	P	P	P	P	P	P	P	P
Thekwini						P	P	P	P	P	P
Country Club	P	P	E	P	P	P	P	P	P	P	P
Dunes (Suncoast)						P	P	G	P	P	P
Battery	P	P	P	P	P	P	P	G	P	P	P
Bay of Plenty	G	P	P	P	P	P	G	P	P	P	P
North	G	P	E	G	P	P	G	P	G	G	P
Wedge	G	G	G	P	G	P	P	P	P	G	G
South	G	P	G	G	P	P	G	P	P	G	P
Addington	G	P	P	G	P	P	P	P	P	G	P
uShaka						P	P	G	G	G	G
Vetch's	G	G	E	G	G	P	P	P	G	G	G

Numerous rivers as well as WWTW are located along the coast of the City beaches. Comparison of river quality indices from 2011 to 2013 with corresponding beach water quality ratings indicate that coastal water quality of the City beaches is directly affected by discharges from rivers. Poor river quality conditions co-incide with poor beach water quality conditions. When river quality has been classified as acceptable, the corresponding beach water was good. Ideal river quality corresponds with excellent beach water quality.

The Umgeni River has numerous WWTW along its tributaries, including Northern WWTW, Kwadabeka WWTW and New Germany WWTW. Blue Lagoon and its neighbouring beaches are affected by this. Blue Lagoon and Laguna notably received poor ratings based on both indicators consistently and most frequently.

The Umhlantuzana and Umbilo Rivers have their mouths at the Durban harbour. The Umhlantuzana WWTW and Hillcrest WWTW are located along the Umhlantuzana River and the Umbilo WWTW is located along the Umbilo River. The Central WWTW is also located at the Durban Harbour. Beaches located near the harbour; namely Vetch‟s, uShaka, Addington, Wedge, South and North, are affected. In addition to pollution from rivers, pathogenic pollution from numerous stormwater drain outlets further jeopardises the quality of the City beaches.

3.4.4. Section C Summary – Bluff Beaches

- **Seasonal Trends**

To highlight common seasonal patterns amongst the Bluff beaches, the seasons which produced the highest levels of each indicator bacteria have been summarised in Table 3-17. Comments have been made regarding correlation in trends between E.coli and Enterococcus.

Table 3-17: Summary of Seasonal Trends – Bluff Beaches

	Seasonal trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Garvies	Summer, same ranking order for last 2 years	Summer/Autumn	No correlation
Anstey's	Summer/Autumn same ranking order for last 2 years	No trends	No correlation
Brighton	Autumn	Summer/Autumn	Share same ranking from 2008 onward.
Treasure	Summer/Autumn	Autumn	Share same ranking from 2011 onward
Umlaas	Autumn	Autumn	No correlation

At the Bluff beaches the highest levels of pathogenic pollution occurred in summer and autumn most frequently. However, this was not consistent over the duration of the study. Once again the effect of the first flush may be linked to highest levels of pathogenic pollution occurring during the rainy season. The highest counts of pathogenic pollution never occurred during the dry seasons: spring and winter.

Some patterns were observed at the Bluff beaches. At Brighton and Treasure beach the seasonal ranking of average bacterial concentrations correlated during the latter years of the study period at these beaches. The ranking order for E.coli appears to have become consistent towards the end of the study at Garvies and Anstey"s beach. Identification of such patterns may assist in predicting water quality by means of pathogenic pollution counts.

- **Annual Trends**

Table 3-18 contains the summary of the annual trends observed for each of the Bluff beaches. The main observations in the changes in average concentrations of the indicator bacteria are briefly explained. Comments have been made regarding possible correlation in trends between the E.coli and Enterococcus.

Table 3-18: Summary of Annual Trends – Bluff Beaches

	Annual trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Garvies	Increase in average and deviation	Increase in average and deviation	Share same patterns
Anstey's	Increased, became consistent, large deviation in 2007	Marginal variation, ultimately remained consistent	No correlation
Brighton	Increased	Increased	No correlation
Treasure	Variation, decreased slightly, large average and deviation in 2007	Slight variation, remained the same.	No correlation
Umlaas	Variation, ultimately remained consistent, large deviation in 2007	Marginal increase	No correlation

Slight variation in the average concentrations of the indicator bacteria were noted at the Bluff beaches. Ultimately, at the end of the study period, the averages either remained consistent or increased. If there was a decrease in the average of a particular bacterium, the decrease was marginal. The only correlation between E.coli and Enterococcus was observed at Garvies beach, where both bacteria exhibited the same patterns of change.

Many beaches either experienced large averages or notably large standard deviations in bacterial concentrations in 2007. This is likely to be due increased stormwater runoffs as a result of the storm event which took place in March 2007. E.coli appears to be affected by this storm event more than Enterococcus.

Generally the standard deviations were not exceptionally large at the Bluff beaches. Instances of extremely large standard deviations were random and infrequent and likely due to extremely high counts of the indictors enumerated in one sample in that year.

- **Geometric Mean Trends**

The main observations of the geometric mean comparisons are briefly summarised in Table 3-19. Both bacteria often shared the same patterns over the course of the study period. At Anstey"s and Brighton the geometric mean concentrations of both E.coli and Enterococcus where found to be in the same range. Where levels of both indicator bacteria did not fall in the same range, generally E.coli levels exceeded Enterococcus. Often the bacteria became more capricious towards the end of the study period.

Table 3-19: Summary of Geometric Mean Trends – Bluff Beaches

BEACH	GEOMETRIC MEAN TRENDS
Garvies	Both bacteria became more variable but followed the same pattern. E.coli exceeded Enterococcus in later years.
Anstey's	Both bacteria remained consistent and followed the same patterns, mostly remained below 200CFU/100ml.
Brighton	Both bacteria increased and became more erratic, concentrations nearly identical in many cases.
Treasure	E.coli exceeded Enterococcus in first half of study. Both bacteria became more consistent and followed the same pattern.
Umlaas	E.coli higher than Enterococcus and more variable

- **SAWQ guideline ratings**

Table 3-20 shows the annual water quality classification for the Bluff beaches based on E.coli. At Garvies Anstey"s and Brighton beach, water quality based on this bacterium is shown to deteriorate from consistent excellency to good. Water quality at Treasure and Umlaas beach has never been rated excellent and is shown to fluctuate between good and poor ratings.

Table 3-20: Summary of E.coli Microbiological Water Quality Ratings – Bluff Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Garvies	E	E	E	E	E	G	G	G	G	G	G
Anstey's	E	E	E	E	E	G	E	E	G	G	E
Brighton	E	E	E	E	E	E	E	E	G	G	G
Treasure	G	G	G	P	P	P	P	G	G	G	P
Umlaas	G	G	G	P	P	P	P	G	P	G	P

The microbiological water quality ratings for the Bluff beaches based on Enterococcus are summarised in Table 3-21. Water quality is rated poor more frequently based on this bacterium. Water quality has been consistently poor at all of the Bluff beaches from 2007 onward. Water quality at Garvies, Anstey"s and Brighton has deteriorated and become consistently poor. At Treasure and Umlaas, however, water quality has been poor for the entire duration of the study.

All of the Bluff beaches experienced poor water quality for at least a quarter of each year in the study. Furthermore, Treasure and Umlaas experienced poor water quality conditions for up to three quarters of many years (refer to Appendix A for monthly results).

Table 3-21: Summary of Enterococcus Microbiological Water Quality Ratings – Bluff Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Garvies	E	E	P	G	P	P	P	P	P	P	P
Anstey's	G	G	G	E	P	P	P	P	P	P	P
Brighton	E	E	E	E	P	P	P	P	P	P	P
Treasure	P	P	P	P	P	P	P	P	P	P	P
Umlaas	P	P	P	P	P	P	P	P	P	P	P

The Umlaas River mouth is located at Umlaas beach. In addition, the Southern WWTW are located along this river. Although Treasure beach and Umlaas beach are mostly affected by the presence of the Umlaas River, Brighton and Anstey"s are also affected to a lesser extent. Studies conducted by Johnson (2012) confirm that effluent discharges from the Umlaas River contribute to pathogenic pollution of the adjacent Bluff beaches.

Comparison of river quality indices from 2011 to 2013 with corresponding beach water quality ratings indicate that coastal water quality of the Bluff beaches is directly affected by discharges from the Umlaas River. Poor river quality conditions co-incide with poor beach water quality conditions. When river quality has been classified as acceptable, the corresponding beach water was good. Ideal river quality corresponds with excellent beach water quality.

There are many stormwater drains along the coastline of the Bluff beaches. Pathogenic pollution from these stormwater drains adversely affects beach water quality. Studies by Johnson (2012) showed that pathogenic pollution at the Bluff beaches increased directly after a rain event due to increased stormwater runoffs.

3.4.5. Section D Summary – Southern Beaches

- **Seasonal Trends**

The seasons which produced the highest average concentrations of E.coli and Enterococcus at the Southern beaches have been summarised in Table 3-22. Comments have been made regarding correlation in trends between the two bacteria.

The highest levels of pathogenic pollution occurred in summer and autumn most often at most of the Southern beaches; however, this does not occur consistently for consecutive years. The increase in average concentrations of indicator bacteria in summer can be linked to the first flush effect as the first rains after the dry seasons generally occur in summer. Occasionally winter produced the highest counts of pathogenic pollution, though this was not consistent. In many cases no trend was observed for Enterococcus.

There is seldom a link between E.coli and Enterococcus seasonal average rankings. Reunion beach is the only beach to show any correlation between the two indicators. The seasons which produced the highest average for E.coli corresponded to that of Enterococcus from 2003 to 2008 consistently. Apart from this there are no clear links, showing that the bacteria behave independently.

Table 3-22: Summary of Seasonal Trends – Southern Beaches

	Seasonal trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Reunion	Autumn/Winter	Autumn/Winter	Correlation from 2003 to 2008
Isipingo	Summer/Autumn	Summer	No correlation
Dakota (Umbogintwini)	No trend	Summer	No correlation
Amanzimtoti Pipeline	Autumn	Autumn	No correlation
Amanzimtoti Main	No trend	No trend	No correlation
Warner	Summer/ Autumn	Winter	No correlation
Warner Baggies	Autumn	No trend	No correlation
Winkelspruit	Autumn	No trend	No correlation
Karridene	No trend	No trend	No correlation
Umgababa	Autumn	Spring	No correlation
Umkomaas	Summer	Summer/Winter	No correlation

- **Annual Trends**

Table 3-23 contains the summary of the annual trends observed for each of the Southern beaches. The main observations in the changes in average concentrations of E.coli and Enterococcus are briefly explained. Comments have been made regarding correlation in trends between the two indicator bacteria.

Average concentrations of E.coli and Enterococcus fluctuated at the Southern beaches throughout the study period. Ultimately, at the end of the study period, the averages either remained consistent or increased. If there was a decrease in the average of a particular bacterium, the decrease was marginal. The two indicators share similar patterns at Isipingo, Warner Baggies, Umgababa and Umkomaas. Apart from this there is no notable correlation in average changes of E.coli and Enterococcus among the Southern beaches.

The Southern beaches do not appear to have been affected by the 2007 storm event as there are no exceptional standard deviations evident for that year. Occasionally large deviations were noted at some beaches; however, this occurred randomly and is likely due to extremely high bacterial counts enumerated in one sample in a particular year.

Table 3-23: Summary of Annual Trends – Southern Beaches

	Annual trend		
BEACH	**E.coli**	**Enterococcus**	**Comment**
Reunion	Decreased	Remained the same	No correlation
Isipingo	Marginal variation, ultimately remained the same	Marginal variation, ultimately remained the same	Both below 200CFU/100ml
Dakota (Umbogintwini)	Increased (data up to 2007)	Increased (data up to 2007)	No correlation
Amanzimtoti Pipeline	Increased and became consistent	Increased and became consistent	No correlation
Amanzimtoti Main	Increased	Slight variation, ultimately remained the same	No correlation
Warner	Increased	Slight variation, ultimately remained the same	No correlation
Warner Baggies	Slight increased	Slight increased	Share same patterns of increase in average
Winkelspruit	Marginal variation, slight increase	Marginal variation, slight decrease	No correlation in average
Karridene	Increased and became consistent	Marginal variation, remained same	No correlation
Umgababa	Marginal increase	Marginal increase	Both below 150CFU/100ml in most years
Umkomaas	Increased	Increased	Follow similar patterns of increase

- **Geometric Mean Trends**

Table 3-24 contains the summary of the main observations of the geometric mean comparisons at the Southern beaches. Over the course of the study period, Enterococcus levels exceeded E.coli at all beaches with exception to Reunion, Isipingo and Dakota. Both bacteria often shared the same patterns although their concentrations differed. At many beaches the two bacteria either remained variable or became more erratic.

Table 3-24: Summary of Geometric Mean Trends – Southern Beaches

BEACH	GEOMETRIC MEAN TRENDS
Reunion	E.coli exceeded Enterococcus; both bacteria followed the same pattern.
Isipingo	E.coli exceeded Enterococcus; both bacteria became less variable and followed the same pattern.
Dakota (Umbogintwini)	E.coli became more variable than Enterococcus.
Amanzimtoti Pipeline	Enterococcus exceeded E.coli, both became less variable and follow same pattern
Amanzimtoti Main	Enterococcus exceeded E.coli, follow same pattern
Warner	Enterococcus exceeded E.coli, both remained erratic and follow same pattern
Warner Baggies	Enterococcus exceeded E.coli, both bacteria followed the same pattern.
Winkelspruit	Enterococcus exceeded E.coli, both bacteria followed the same pattern and became less variable.
Karridene	Enterococcus exceeded E.coli, both bacteria followed the same pattern and became less variable.
Umgababa	Enterococcus exceeded E.coli, both bacteria followed the same pattern remained variable.
Umkomaas	Enterococcus exceeded E.coli, both bacteria followed the same pattern remained variable.

- **SAWQ guideline ratings**

Table 3-25 shows the annual water quality classification for the Southern beaches based on E.coli. Based on this bacterium, water quality is shown to deteriorate from excellent to good over the duration of the study. Reunion experienced poor water quality conditions more frequently than any other Southern beach. The frequency of excellent water quality conditions clearly decreased in the last three years of the study at all of the Southern beaches.

Table 3-25: Summary of E.coli Microbiological Water Quality Ratings – Southern Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Reunion	P	P	P	P	G	P	E	G	P	G	G
Isipingo	G	G	G	G	E	G	G	G	P	G	G
Dakota (Umbogintwini)	E	G	G	G	G	-	-	-	-	-	-
Amanzimtoti Pipeline	E	G	E	E	E	G	E	E	G	G	G
Amanzimtoti Main	E	G	E	E	G	G	E	E	G	G	P
Warner	E	E	E	E	E	G	G	E	P	G	G
Warner Baggies	-	-	-	-	-	E	E	E	G	G	G
Winkelspruit	E	E	G	G	G	E	E	G	G	G	G
Karridene	E	G	G	G	E	E	G	E	G	E	G
Umgababa	-	-	-	-	-	E	E	E	G	G	G
Umkomaas	-	-	-	-	-	E	G	E	G	G	G

The microbiological water quality ratings for the Southern beaches based on Enterococcus are summarised in Table 3-26. Water quality is rated poor more frequently based on this bacterium. In the latter years of the study water quality has been consistently poor along the entire section of beaches. However, Reunion and Amanzimtoti Main have good ratings in 2013. Lack of data for the second of half of 2013 influences this outcome and it is possible that the trend of poor water quality continued.

All of the Southern beaches experienced poor water quality for at least half of the year for most years in the study, including the summer months. A clear deterioration in water quality in the last three years at Karridene, Umgababa, and Umkomaas is noted. From 2011 onward the frequency of poor water quality conditions increased throughout the course of each year at these beaches (see Appendix A for monthly analysis).

Table 3-26: Summary of Enterococcus Microbiological Water Quality Ratings – Southern Beaches

BEACH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Reunion	P	P	P	P	P	P	P	P	P	P	G
Isipingo	G	G	G	G	G	P	P	P	P	P	P
Dakota - (Umbogintwini)	P	E	P	G	P	-	-	-	-	-	-
Amanzimtoti Pipeline	G	G	P	P	P	P	G	P	P	P	P
Amanzimtoti Main	G	P	E	G	P	P	G	P	P	P	G
Warner	G	P	E	E	P	P	P	P	P	P	P
Warner – Baggies	-	-	-	-	-	P	P	P	P	P	P
Winkelspruit	P	P	P	G	P	G	P	P	P	P	P
Karridene	G	P	G	P	G	G	E	G	P	P	P
Umgababa	-	-	-	-	-	E	G	G	P	P	P
Umkomaas	-	-	-	-	-	G	G	G	P	P	P

Numerous rivers enter the coastal waters along the coastline of the Southern beaches. In addition, many active WWTW are located along these rivers. The river quality indices suggest a direct relationship between river water quality and beach water quality, mainly based on the presence of Enterococcus. Poor river quality conditions co-incide with poor beach water quality conditions. When river quality has been classified as „acceptable", the corresponding beach water was „good". Ideal river quality corresponds with excellent beach water quality.

Reunion and Isipingo are affected by the presence of the Isipingo River mouth. Furthermore, there are two waste water treatment works located along this river. Discharges from Isipingo WWTW and Amanzimtoti WWTW affect the quality of the Isipingo River. The Amanzimtoti beaches are affected by discharges from the Manzimtoti River. The Little Manzimtoti River and Kingsburgh WWTW have an effect on Warner beach and the Lovu River affects the quality of Winkelspruit beach"s waters. The location of the Msimbazi River mouth affects Karridene beach. Umgababa beach is affected by the presence of the Umgababa River mouth. Umkomaas beach is affected by the Ngane and Umkomazi Rivers. The Ngane River also has the Magabeni WWTW located along its tributaries and the Umkomazi River has the Umkomaas WWTW. In addition to river discharges, outflows from stormwater drains located along the coastline of the Southern beaches contribute to pathogenic pollution and consequently the quality of the water is threatened.

3.5. Conclusions

Over the past decade pathogenic pollution has increased throughout the Durban coastline, resulting in the deterioration of coastal water quality. An increased presence of indicator bacteria indicates increased quantities of pathogens. Generally the highest levels of pathogenic pollution occurred in summer and autumn at most beaches along the coastline. The seasons which precede summer are usually dry seasons, thus the first flush effect can be noted. Although significant deviations were noted on occasion, this was not consistent along the coastline. Both indicator bacteria often shared the same patterns throughout the study period even though concentrations differed. The variability of pollution has increased; with neighbouring beaches often share the same patterns and variation in water quality.

Beaches located near river mouths are adversely affected. Generally the beaches located at river mouths experienced the worst water quality conditions. This is most notable at the City and Bluff beaches. The Umgeni River mouth is at Blue Lagoon beach. Blue Lagoon and its closest neighbour Laguna consistently experience poor water quality conditions throughout the study period. With the Umlaas Rivers waters meeting the coastal waters directly at Umlaas beach, this beach and its neighbour, Treasure beach experienced poor water for the entire duration of the study. Effluent discharged from WWTW as well as informal settlement along rivers also poses a threat to beach water quality as this pollution will eventually enter coastal waters. Numerous publications have emphasised and highlighted the poor quality of eThekwini rivers. Publications are contained in Appendix C.

Outflows from stormwater drains have a deleterious effect on the receiving waters as they carry pathogens from the catchments which they serve directly to the ocean. Furthermore, ever-changing climate patterns also contribute to changes in pathogenic pollution. Increased storm activity results in increased stormwater runoffs. As proven in studies conducted by Johnson (2012), the degradation of the quality of the coastal environment is directly caused by increased urban stormwater runoffs.

When compared with the Northern and City beaches, the water quality of the Bluff and Southern beaches is generally poorer, especially during the latter years of the study. Beach water quality appears to degenerate southwards down the coastline. The Northern and City beaches are the more prestigious beaches in Durban and are more popular amongst tourists than the Bluff and Southern beaches.

When comparing the indicator bacteria, it is clear that Enterococcus levels result in poorer water quality conditions than E.coli. However, higher levels of E.coli are allowed than Enterococcus. More than double the counts/100ml of E.coli are allowed than Enterococcus as per the SAWQ guidelines. Health risks are more severe due to the presence of Enterococcus as compared to E.coli. Although warnings are put up at many beaches about stormwater drain outflows, this is not enough to prevent beach goers from ingesting contaminated waters and becoming ill.

CHAPTER 4:
CASE STUDY – BLUE FLAG

4.1 Introduction

The Blue Flag Programme is an initiative implemented by non-profit organisation, the Foundation for Environmental Education (FEE) for beaches and marinas. The original concept of the award was based on criteria covering sewage treatment and bathing water quality. This was further expanded to include waste management, coastal planning and protection.

The Blue Flag programme"s primary objectives are to improve understanding of the coastal environment and to encourage local authorities, together with their partners, to include environmental issues in decision making processes. There is no legal obligation to meet the Blue Flag criteria; nevertheless, the programme is used voluntarily to promote tourism The Blue Flag is an excellent tool used to attract tourists. If the Blue Flag is flying at a beach, beach goers can be guaranteed that the beach is safe, the water quality is good, and environmental information is displayed at the beach (kzndae.gov.za, 2014).

It is a standard requirement by FEE that the member organisation in each country is a national, non-governmental organisation (NGO). In South Africa, the blue flag programme is managed and implemented by the NGO, the Wildlife and Environmental Society of South Africa (WESSA).

4.1.1. Blue Flag in Durban

Durban was the first South African city to implement the international programme. By 2008 the eThekwini Municipality had 10 beaches boasting the Blue Flag Award. Controversially the city manager at that time, Michael Sutcliffe, made the decision to withdraw from the programme. This was done in favour of his own Sutcliffe System (Pullan, 2012).

Various classification systems are used globally to manage beaches and promote beach tourism. Ultimately the core focus is environmental management and water quality. The Kwa-Zulu Natal Department of Economic Development and Tourism has identified the need for the province to adopt at least one beach management system with an international accreditation (KZNDED, 2014). The province has adopted the Blue Flag programme to promote beach tourism in KZN. Through the Department of Environmental Affairs, the eThekwini Municipality began the process of reapplying to the Blue Flag Programme in November 2012. Durban mayor James Nxumalo announced that Durban had officially re-joined the programme in June 2013, five years after the withdrawal in 2008 (Carnie and Wolhuter, 2013). The public have been kept aware on the progress of this venture via numerous newspaper articles, and publications by WESSA, contained in Appendix C.

As of October 2014 WESSA have published the beaches which received the Blue Flag award or pilot status for the award for the 2014/2015 season for South Africa. KZN has a total of 28 beaches on the list; however, eThekwini only has 7 beaches which have received pilot status (explained in Section 4.2.1), namely: Anstey"s, Umdloti Main, Umdloti Tidal, Umgababa, Umhlanga Main, uShaka, and Westbrook.

4.2 Application of Blue Flag Criteria

4.2.1 Blue Flag Criteria for beach water quality

The Blue Flag Programme uses strict criteria to promote the sustainable development of beaches and marinas. The four main categories deal with safety and services, environmental management, environmental education, and beach water quality. There are more than 30 criteria across all the categories and detailed criteria vary slightly from one region to another. Most criteria are imperative and a beach is required to fulfil the imperative requirements in order to receive the Blue Flag award.

The focus of this case study is the microbiological beach water quality aspect of the Blue Flag requirements, and its application in South Africa. Table 4-1 depicts the microbiological water quality criteria for South Africa, as given in the latest South African Water Quality Guidelines published in 2012.

The full set of water quality requirements is attached in Appendix D. The two indicator bacteria used to monitor water quality are E.coli and Enterococcus.

Table 4-1: Microbiological Water quality criteria for Blue Flag beaches in SA

	IMPERATIVE REQUIREMENT	GUIDELINE REQUIREMENT
E.coli	<2000CFU/100ml in 95% of samples	<100CFU/100ml in 80% of samples
Enterococcus	< 100CFU/100ml in 80% of samples	< 50/100ml in 75% of samples

For beaches new to the system, to be eligible for the Blue Flag Award, a beach is required to meet the imperative water quality criteria for the four Blue Flag seasons prior to the season of application for the award. Thereafter, the Blue Flag award must be re-applied for each season, and a beach must meet the requirements in the season previous to the one of application to remain eligible for the award. A season is classified as a 12 month period and can differ for each region. For Durban the Blue Flag season is from 01 November to 31 October each year. Beaches receiving award for the first time will be given „pilot status" for a year. Pilot status is classified as "*an important developmental stage acting as an incubation period for potential Blue Flag sites"* (Blueflag, 2014).

Once a beach has been awarded the Blue Flag it has to continuously meet the guideline and imperative water quality targets. It a beach fails to do so at any time during the Blue Flag season, the flag will be withdrawn immediately.

A minimum of 20 water samples are required for each beach per season and samples must be tested by an independent laboratory. Although the City does its own sampling and testing, for Blue Flag purposes, the Council for Scientific and Industrial Research (CSIR) is the independent laboratory which analyses the beach water samples (Carnie and Wolhuter, 2013).

4.2.2 Analysis methods

As explained in Section 3.1, the Durban coastline has been divided into 4 sections as indicated in Figure 3-1 and described in Table 3-1. A total of 42 beaches are included in the study area. This case study will look at the eligibility of each beach receiving the Blue Flag in the near future seasons, solely based on microbiological water quality.

Since the City withdrew and re-applied to the programme all applications are considered as new applications. Therefore, each beach is required to meet the imperative criteria in Table 4-1 for the four seasons prior to the season of application. Although the CSIR analyses the water samples for the Blue Flag programme, only sample data provided by EMWSS was available at the time of this case study. The same sampling and testing methods are followed by EMWSS and CSIR as stipulated in the SAWQ Guidelines (2012); however, it must be noted that it is not guaranteed that the same number of samples were analysed by both laboratories. As such, the available data has been used to determine if a beach may or may not be eligible for the Blue Flag award based on microbiological water quality conditions, and is not directly associated with Blue Flag South Africa. Blue Flag requires a minimum of 20 samples to be tested for each season. EMWSS provided more sample data than what is required by Blue Flag.

Based on the available data at the time of this case study, the season for application is taken as 2013/2014. As such, the four seasons prior to the season of application are described as follows:

- November 2009 to October 2010 (2009/2010)
- November 2010 to October 2011 (2010/2011)
- November 2011 to October 2012 (2011/2012)
- November 2012 to October 2013 (2012/2013)

Data for these seasons were analysed to determine which beaches would have been eligible to receive the Blue Flag award for the 2013/2014 season and what the likelihood of each beach would be of receiving the award in near future seasons. For Enterococcus, data was only provided up to and including June 2013.

The Hazen percentile calculator is the preferred method for determining percentiles according to WHO (2003) and was used to conduct this case study.

Hazen Percentile Calculator: $r_{Hazen} = 0.5 + \frac{Pn}{100}$ (4-1)

Where:
P – percentile value (e.g. 95 for 95th percentile)
n – sample size

4.3 Results

The concentrations of both indicator bacteria were analysed using the Hazen Percentile calculator. The outcome was then compared to the requirements in Table 4-1 and used to determine if each beach met the imperative criteria for microbiological water quality for both E.coli and Enterococcus for each season. The results have been tabulated for each beach. If the beach met the criteria for a particular year a Y for YES is indicated in the table, if not, an N for NO is indicated.

4.3.1 Microbiological requirements

4.3.1.1 Section A – Northern Beaches

4.3.1.1(a) Westbrook

Although Westbrook beach is predominantly a swimming beach, other recreational activities such as fishing and surfing also take place. There is also a ski boat club at this beach.

Plate 4-1: Westbrook Beach

Table 4-2 shows that based on E.coli Westbrook beach met the criteria consistently. Based on Enterococcus however, the beach failed to meet the requirements for the 2009/2010 season. Despite this, the beach managed to meet the criteria for the following three seasons. Westbrook has received pilot status for the 2014/2015 season. This indicates that Westbrook continued to meet the requirements during 2013/2014.

Table 4-2: Westbrook – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	Y

4.3.1.1(b) Casuarina

Swimming is one of the many activities enjoyed at Casuarina beach. In addition, a park and a soccer field as well as a restaurant are located at the beach. This beach is also popular amongst fishermen.

Plate 4-2: Casuarina Beach

Casuarina met the criteria for both bacteria throughout the four seasons which were analysed, as depicted in Table 4-3. Despite this, this beach did not make the cut for the 2014/2015 list of awardees. This may be due the beach not maintaining and/or not meeting the criteria in the other categories.

Table 4-3: Casuarina – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	Y

4.3.1.1(c) La Mercy

La Mercy beach"s recreational area attracts many locals where activities such as swimming, fishing, kite surfing and many others are enjoyed. Although La Mercy met the criteria for E.coli consistently, it failed to do the same for Enterococcus. This is portrayed in Table 4-4. La Mercy would have to meet the imperative requirements for the four seasons after 2012/2013 and may possibly be eligible to receive the award in 2017/2018.

Plate 4-3: La Mercy Beach

Table 4-4: La Mercy – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	N

4.3.1.1(d) Umdloti Tidal

This designated swimming beach is popular amongst the local community as the natural rock formation creates a safe swimming area. Table 4-5 shows that Umdloti Tidal met the criteria for both E.coli and Enterococcus consistently. It is apparent that this beach has managed to maintain this as it has received pilot status for 2014/2015.

Plate 4-4: Umdloti Tidal Beach

Table 4-5: Umdloti Tidal – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	Y

4.3.1.1(e) Umdloti Main

Some of the recreational activities enjoyed at Umdloti Main beach include: surfing, kite surfing, fishing, and of course swimming. This beach is also well known for dolphins that swim close to the beach. Umdloti Main followed the same trend as its neighbour, Umdloti Tidal, having met the criteria for both E.coli and Enterococcus consistently. This is represented in Table 4-6. This beach also managed to maintain this as it has received pilot status for 2014/2015.

Plate 4-5: Umdloti Main Beach

Table 4-6: Umdloti Main – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	Y

4.3.1.1(e) Umdloti South

Umdloti South beach is popular amongst sunbathers and swimmers alike. This beach as well as the other Umdloti beaches is being used to promote tourism in the area.

Plate 4-6: Umdloti South Beach

Table 4-7 shows the Blue Flag Microbiological Results for Umdloti South. Although Umdloti South met the criteria for both bacteria consistently it did not receive pilot status. This may be due to the beach not meeting all of the other criteria in the other categories.

Table 4-7: Umdloti South – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	Y

4.3.1.1(f) Bronze (Umhlanga)

Bronze beach hosts a variety of recreational activities such as swimming, surfing, body-boarding and fishing. The Blue Flag Microbiological Results are summarised in Table 4-8. Bronze beach was on the path to obtaining the award until the 2012/2013 season. It failed to meet the Blue Flag requirements for Enterococcus in this season, impeding its chances on having the Blue Flag fly on Bronze beach in the near future. Bronze would have to meet the imperative requirements for the four seasons after 2012/2013 and may possibly be eligible to receive the award in 2017/2018.

Plate 4-7: Bronze Beach

Table 4-8: Bronze – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	N

4.3.1.1(g) Umhlanga Rocks Main

There are many hotels and guest houses located along the coastline of all the Umhlanga beaches. Umhlanga Rocks Main beach is popular amongst locals and tourists. The list of activities that take place include: swimming, surfing, scuba-diving, fishing, kite barcoding and many more.

Plate 4-8: Umhlanga Rocks Main Beach

Table 4-9 shows that Umhlanga Rocks Main beach met the criteria for both bacteria consistently. It is apparent that this beach has managed to maintain this as it has received pilot status for 2014/2015.

Table 4-9: Umhlanga Rocks Main – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	Y	Y	Y

4.3.1.1(h) Umhlanga Rocks Granny's Pool

The view from the magnificent pier at Umhalnga Rocks Granny‟s Pool beach attracts many visitors, both local and international.

Plate 4-9: Umhlanga Rocks Granny's Pool Beach

Although the criteria for E.coli were met for each of the four seasons, this beach struggled to do the same for Enterococcus. This is shown in Table 4-10. Umhlanga Rock‟s Granny‟s Pool would need to meet the Blue Flag criteria for both bacteria in the 2013/2014 season and the seasons onwards to become eligible for the award.

Table 4-10: Umhlanga Rocks Granny's Pool – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	Y	N

4.3.1.1(i) Umhlanga Rocks Lighthouse

Umhlanga Rocks Lighthouse beach is enjoyed by swimmers and fishermen. The presence of the lighthouse on the shore also attracts locals and tourists. This beach is often used as a wedding venue.

Table 4-11 shows the Blue Flag Microbiological Results for Umhlanga Rocks Lighthouse. Despite meeting the criteria for E.coli, Umhlanga Rocks Lighthouse only managed to do so one time during four seasons analysed. Like its northern neighbour, Umhlanga Rock‟s Granny‟s Pool would need to meet the Blue Flag criteria for both bacteria in the 2013/2014 season and the seasons onwards to become eligible for the award.

Plate 4-10: Umhlanga Rocks Lighthouse Beach

Table 4-11: Umhlanga Rocks Lighthouse – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	N

4.3.1.1(j) Glenashley

There are numerous guesthouses and B&B‟s near Glenashley beach. Activities at this beach include: swimming, fishing and surfing. Table 4-12 shows the Blue Flag Microbiological Results for Glenashley. Although Glenashley beach managed to meet the microbiological requirements for E.coli, it failed to meet the criteria for Enterococcus consistently. As such, its chances of receiving the Blue Flag award have been hindered. Glenashley may become eligible to receive the award for the 2017/2018 season if it continuously meets the criteria for both E.coli and Enterococcus.

Plate 4-11: Glenashley Beach

Table 4-12: Glenashley – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	N

4.3.1.1(k) Virginia

Virginia beach is a tranquil beach where many beachgoers go to relax by sunbathing and fishing. Virginia beach failed to meet the Blue Flag requirements for Enterococcus initially, as depicted in Table 4-13. This trend changed in the 2011/2012 season. If this trend continues Virginia beach may qualify for the award for the 2015/2016 season.

Plate 4-12: Virginia Beach

Table 4-13: Virginia – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	Y

4.3.1.1(l) Beachwood

The Golf course and mangroves nearby Beachwood attract many visitors to the area and the beach itself. Table 4-14 shows that Beachwood appears to have the same trend as its northern neighbour, Virginia beach. It failed to meet the criteria initially. Beachwood may become eligible for the Blue Flag award if it continues to meet the criteria as it has done from the 2011/2012 season.

Plate 4-13: Beachwood Beach

Table 4-14: Beachwood – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	Y

4.3.1.2 Section B – City Beaches

4.3.1.2(a) Blue Lagoon (Umgeni South)

Blue Lagoon is not a designated swimming beach due to the close presence of the Umgeni River mouth. However, many recreational activities still take place there. Blue Lagoon is a popular fishing spot. The model boating pond and canoe club are also located near Blue Lagoon beach, attracting many local water sports enthusiasts.

Plate 4-14: Blue Lagoon Beach

Although Blue Lagoon met the criteria for E.coli consistently, this beach will not be in the running to fly the Blue Flag in the immediate future as it has failed to meet the requirements for Enterococcus until 2012/2013. This is shown in Table 4-15. Blue Lagoon needs to continuously meet the imperative requirements for both bacteria from 2012/2013 to 2015/2016 in order to stand a chance for the 2016/2017 season.

Table 4-15: Blue Lagoon – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	Y

4.3.1.2(b) Laguna

Many recreational activities take place at Laguna beach, however, swimming is the most popular. In addition, this beach also has paddling pools, increasing its popularity. Table 4-16 shows that Laguna beach shows the same pattern as Blue Lagoon. This beach failed to meet the criteria for Enterococcus up to the 2012/2013 season and needs to consistently meet the criteria for both bacteria. If this is successful Laguna beach may be eligible for the award in the 2016/2017 season.

Plate 4-15: Laguna Beach

Table 4-16: Laguna – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	Y

4.3.1.2(c) Thekwini

Thekwini beach is primarily a swimming beach frequented by many locals. Table 4-17 shows the Blue Flag Microbiological Results for Thekwini beach. Thekwini beach met the criteria for E.coli for the four seasons analysed, however, failed to do the same for Enterococcus. Due to this, Thekwini beach will not be in line to receive the Blue Flag award in the immediate future seasons. Thekwini beach will need to meet the criteria for both E.coli and Enterococcus for the four seasons after 2012/2013. If it manages to do so successfully Thekwini beach may be eligible to receive the award in 2017/2018.

Plate 4-16: Thekwini Beach

Table 4-17: Thekwini – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.2(d) Country Club

Country Club beach is a designated swimming beach although other activities such as fishing, surfing and jet skiing also take place. According to Table 4-18, Country Club beach will not be flying the Blue Flag in the near future. This beach has met the criteria for E.coli for the seasons analysed. In contrast, it failed to do the same for Enterococcus. Country Club may become eligible for the Blue Flag award in the 2017/2018 season if it meets the criteria for both bacteria for the four seasons after 2012/2013.

Plate 4-17: Country Club Beach

Table 4-18: Country Club – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.2(e) Dunes (Suncoast)

Dunes – Suncoast beach is located at Suncoast casino where a grassed sunbathing area is provided. Swimming and surfing are the most popular activities at this beach. Table 4-19 shows that Dunes beach may have met the criteria for E.coli consistently but it will not be flying the Blue Flag anytime soon as it has constantly failed to meet the criteria for Enterococcus.

Plate 4-18: Dunes Beach

Table 4-19: Dunes – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.2(e) Battery

Battery beach is a popular swimming spot. It also has paddling pools and slides which attract many visitors. Table 4-20 shows the Blue Flag Microbiological Results for Battery beach. This beach failed to meet the requirements for Enterococcus for the four seasons analysed. As such, this beach will not be eligible to receive the Blue Flag in the near future.

Plate 4-19: Battery Beach

Table 4-20: Battery – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.2(f) Bay of Plenty

Many recreational activities take place at Bay of Plenty beach, however, this beach is most popular amongst surfers and body boarders. Table 4-21 suggests that Bay of Plenty beach may only qualify for the Blue Flag award in the 2017/2018 season. Although it consistently met the criteria for E.coli, unfortunately it has not been consistent with Enterococcus. It met the requirements for Enterococcus for two out of four seasons but could not maintain this.

Plate 4-20: Bay of Plenty Beach

Table 4-21: Bay of Plenty – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	N

4.3.1.2(g) North

Many activities take place at North beach, such as swimming, fishing and body boarding. North beach also has paddling pools and a salt water swimming pool.

Plate 4-21: North Beach

North beach may have met the criteria for E.coli consistently but it did not manage to do the same for Enterococcus. This is depicted in Table 4-22. Since North beach failed to meet the requirements for Enterococcus in the 2012/2013 season, it will have to meet the requirements for both bacteria consistently for the four succeeding seasons in order to become eligible to fly the Blue Flag.

Table 4-22: North – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	N

4.3.1.2(h) Wedge

Wedge beach is not a designated swimming beach, however, many recreational activities do take place there. These activities include surfing and fishing. Table 4-23 shows that although Wedge beach met the criteria for E.coli consistently, it failed to meet the criteria for Enterococcus during the first two seasons of the study. However, Wedge beach did manage to meet the microbiological requirements for Enterococcus thereafter. If the trend from 2011/2012 continues consistently, Wedge beach may be eligible to receive the Blue Flag award in the 2015/2016.

Table 4-23: Wedge – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	Y

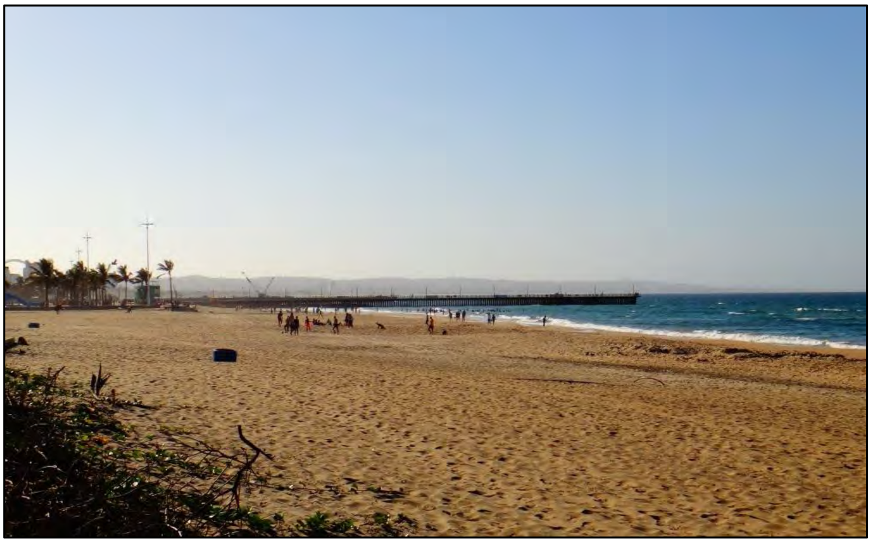

Plate 4-22: Wedge Beach

4.3.1.2(i) South

South beach is a popular designated swimming beach with paddling pools. Beach goers also fishing, surfing, paddle skiing and body boarding at South Beach.

Plate 4-23: South Beach

Table 4-24 shows the Blue Flag Microbiological Results for South beach. Based on E.coli South beach has met the criteria consistently but this beach will not be in the running to receive the Blue Flag award in near future seasons as it did not meet the criteria for Enterococcus in the same fashion as it did E.coli. South beach would need to meet the Blue Flag criteria for both bacteria in the 2013/2014 season and the seasons onwards to become eligible for the award.

Table 4-24: South – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	N

4.3.1.2(j) Addington

Addington beach is popular amongst the local surfing and body boarding community due to gentle waves and calmer waters. Table 4-25 shows that Addington beach did not manage to meet the criteria for Enterococcus with the same consistency as it did for E.coli. The Blue Flag requirements for Enterococcus were only met for two seasons. Addington may become eligible for the Blue Flag award in the 2017/2018 season if it meets the criteria for both bacteria for the four seasons after 2012/2013.

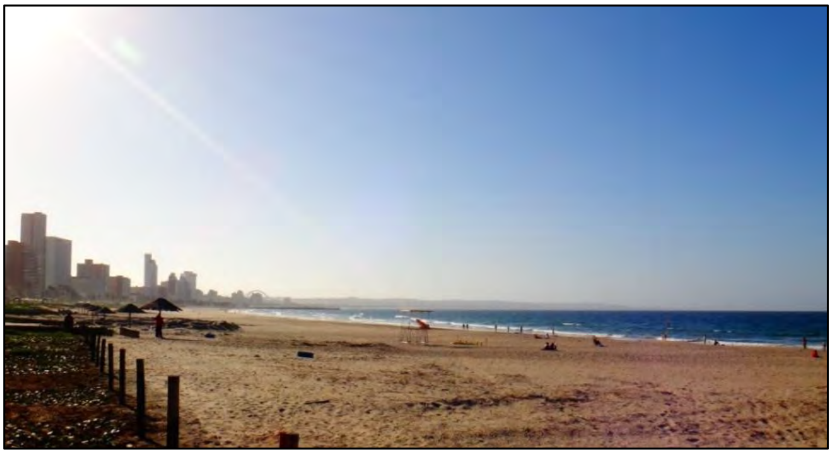

Plate 4-24: Addington Beach

Table 4-25: Addington – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	N

4.3.1.2(k) uShaka

UShaka is located at uShaka Marine World, a popular tourist attraction. Recreational activities enjoyed at this beach are primarily swimming and sunbathing.

Plate 4-25: uShaka Beach

Based on E.coli Westbrook beach met the criteria consistently, as depicted in Table 4-26. Based on Enterococcus however, the beach failed to meet the requirements for the 2009/2010 season. Despite this, the beach managed to meet the criteria for the following three seasons. It is probable that uShaka beach continued to meet the criteria for both bacteria as it has received pilot status for the 2014/2015 season.

Table 4-26: uShaka– Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	Y

4.3.1.2(l) Vetch's

Vetch"s beach is a popular spot for snorkelling, kayaking and boating, and windsurfing. The old pier is visible at low tide.

Plate 4-26: Vetch's Beach

Table 4-27 portrays the Blue Flag Microbiological Results for Vetch"s beach. Vetch"s beach shows great promise as it has met the requirements for E.coli consistently in the four seasons analysed and met the requirements for Enterococcus for all seasons except 2009/2010.

Despite this, Vetch"s beach is not one of the beaches that have received pilot status for the latest season, 2014/2015. This may be due to the beach not continuing to meet the microbiological criteria in the 2013/2014 season, or the beach may have failed to meet other criteria in the other three categories as required by the Blue Flag programme.

Table 4-27: Vetch's – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	Y

4.3.1.3 Section C – Bluff Beaches

4.3.1.3(a) Garvies

Garvies beach is not a designated swimming beach due to the treacherous rock conditions. Despite this, the beach is still utilised for other recreational activities such as sunbathing as well as fishing.

Plate 4-27: Garvies Beach

Table 4-28 shows that based on E.coli, Garvies beach met the criteria consistently. Based on Enterococcus however, this is not the case. Garvies beach failed to meet the criteria for Enterococcus every season. This results in Garvies not being eligible to fly the Blue Flag in immediate future seasons.

This beach may qualify for pilot status in the 2017/2018 season, but this will only be possible if criteria for both bacteria are consistently met for the four preceding seasons.

Table 4-28: Garvies – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.3(b) Anstey's

Anstey‟s beach is the most popular of all the Bluff beaches. Recreational activities such as swimming, kayaking, surfing, and fishing are enjoyed at this beach. Furthermore, Anstey‟s has two paddling pools.

Plate 4-28: Anstey's Beach

Table 4-29 summarises the Blue Flag Microbiological Results for Anstey‟s beach. Based on E.coli, Anstey‟s beach met the criteria consistently. This beach did however failed to meet the requirements for Enterococcus for the 2009/2010 season. Despite this, the beach managed to meet the criteria for the following three seasons. Anstey‟s beach is the only Bluff beach to have received pilot status for the 2014/2015 season. This indicates that Anstey‟s continued to meet the requirements during 2013/2014.

Table 4-29: Anstey's – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	Y	Y	Y

4.3.1.3(c) Brighton

Brighton beach is a designated swimming beach and other activities such as fishing, paddling and surfing take place. Brighton beach may have met the requirements for E.coli throughout the four seasons analysed but it failed to meet the criteria for Enterococcus three out of the four seasons. This is depicted in Table 4-30. Brighton beach would have to meet the imperative requirements for the four seasons after 2012/2013 and may possibly be eligible to receive the award in 2017/2018.

Table 4-30: Brighton – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	N

Plate 4-29: Brighton Beach

4.3.1.3(d) Treasure

Although Treasure beach is not a designated swimming beach, many surfers and fishermen frequent it. Based on E.coli Treasure beach met the criteria consistently but never met the criteria for Enterococcus, as shown in Table 4-31. In order for Treasure beach to be in the running to receive the Blue Flag award, the microbiological requirements need to be met consistently for the four seasons after 2012/2013.

Plate 4-30: Treasure Beach

Table 4-31: Treasure – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.3(e) Umlaas

Umlaas beach is located at the Mlaas Canal mouth. Many locals swim at this beach despite the poor condition of the canal. Table 4-32 shows that Umlaas beach failed to consistently meet the criteria for E.coli and it failed to meet the criteria for Enterococcus entirely. Umlaas would need to meet the Blue Flag criteria for both bacteria in the 2013/2014 season and the seasons onwards to become eligible for the award.

Plate 4-31: Umlaas Beach

Table 4-32: Umlaas – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	N	Y	Y
Enterococcus	N	N	N	N

4.3.1.4 Section D – Southern Beaches

4.3.1.4(a) Reunion

Reunion beach is a popular surfing spot and it attracts many locals due to the fenced freshwater pool. Table 4-33 shows the Blue Flag Microbiological Results for Reunion beach. This beach managed to successfully meet the criteria for E.coli for the four seasons analysed. In contrast, it failed to meet the criteria for Enterococcus entirely during this time. As a result, Reunion may only be eligible to receive the Blue Flag award for 2017/2018 season. This is only possible if the criteria for both E.coli and Enterococcus are met consistently for the four preceding seasons.

Plate 4-32: Reunion Beach

Table 4-33: Reunion – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.4(b) Isipingo

Isipingo beach is a designated swimming beach enjoyed mainly by the local community. Besides swimming, fishing also takes place at this beach.

Plate 4-33: Isipingo Beach

According to Table 4-34, Isipingo beach appears to follow the same trend as its northern neighbour. It met the criteria for E.coli consistently but never managed to meet the criteria for Enterococcus. This beach may become eligible for the Blue Flag award in the 2017/2018 season if it meets the criteria for both bacteria for the four seasons after 2012/2013.

Table 4-34: Isipingo – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	N	N

4.3.1.4(c) Dakota

No data was provided for the period of this case study.

4.3.1.4(d) Amanzimtoti Pipeline

Many activities take place at Amanzimtoti Pipeline beach, including swimming and surfing and body-boardng. There is also a freshwater swimming pool at the beach.

Plate 4-34: Amanzimtoti Pipeline Beach

Table 4-35 shows the Blue Flag Microbiological Results for Amanzimtoti Pipeline. This beach met the criteria for E.coli for all four seasons but met the criteria for Enterococcus for just one season, 2009/2010.

If Amanzimtoti Pipeline can constantly meet the criteria for E.coli and Enterococcus for the four seasons after 2012/2013, this beach may qualify for pilot status in the 2017/2018 season.

Table 4-35: Amanzimtoti Pipeline – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(e) Amanzimtoti Main

Amanzimtoti Main beach is a popular swimming beach amongst the local community. Other activities such as fishing, kayaking and surfing also take place at this beach. Table 4-36 shows that Amanzimtoti Main beach shares the same trends as its neighbour Amanzimtoti Pipeline. Although this beach managed to meet the criteria for E.coli consistently, it failed to meet the criteria for Enterococcus for the last three years of the case study. Consequently, it may only be eligible to receive the Blue Flag award for 2017/2018 season. This is only possible if the criteria for both E.coli and Enterococcus are met consistently for the four preceding seasons.

Plate 4-35: Amanzimtoti Main Beach

Table 4-36: Amanzimtoti Main – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(e) Warner

Many recreational activities occur at Warner beach. These activates include: kite surfing, paddle skiing, canoeing, surfing, and fishing.

Based on E.coli Warner beach makes the grade to receive the Blue Flag award, as shown in Table 4-37. Based on Enterococcus, on the other hand, Warner fails to qualify. This beach would have to meet the imperative requirements for the four seasons after 2012/2013 to stand a chance to receive the award in 2017/2018.

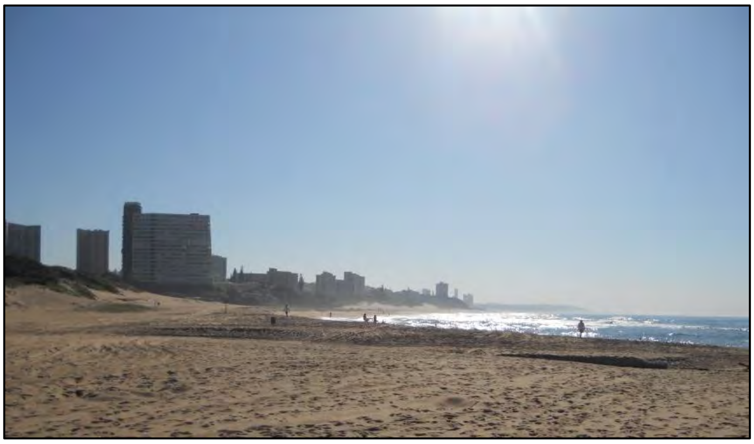

Plate 4-36: Warner Beach

Table 4-37: Warner – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(f) Warner Baggies

Warner Baggies is a hot surfing and body-boarding spot where many completions take place. The Baggies Surf Pro competition takes place at this beach.

Plate 4-37: Warner Baggies Beach

According to Table 4-38, Warner Baggies will not be flying the Blue Flag in the immediate future seasons. Despite consistently meeting the criteria for E.coli, it failed to do so for Enterococcus. Warner Baggies only met the criteria for Enterococcus once, during the 2009/2010 season. In order for this beach to become eligible to receive the Blue Flag award, it will need to meet the criteria for both bacteria consistently for four consecutive seasons.

Table 4-38: Warner Baggies – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(g) Winkelspruit

Many activities take place at Winkelspruit beach, including swimming, body-boarding, and surfing. This beach also has a lagoon that stretches out into the sea for canoeing. Table 4-39 summarises the Blue Flag Microbiological Results for Winkelspruit beach. Winkelspruit beach consistently met the Blue Flag criteria for E.coli for the seasons analysed. For Enterococcus, however, this is not the case. Winkelspruit failed to meet the criteria for three consecutive seasons, impaling its chances of flying the Blue Flag in near future seasons.

Plate 4-38: Winkelspruit Beach

Table 4-39: Winkelspruit – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(h) Karridene

Access to Karridene beach is exclusively via the Protea Hotel. Visitors to the hotel enjoy sunbathing, swimming, surfing and many other recreational activities.

Plate 4-39: Karridene Beach

Based on E.coli Karridene consistently met the criteria, as shown in Table 4-40. Based on Enterococcus, however, it only met the criteria once, during the first season analysed. Therefore, Karridene may only qualify for the Blue Flag Award in the 2017/2018 season. This beach would need to consistently meet the criteria for both E.coli and Enterococcus in order to achieve this.

Table 4-40: Karridene – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(i) Umgababa

This designated swimming beach is enjoyed by the local community and also boasts reefs that are popular amongst divers. There are also braai facilities at this beach.

Plate 4-40: Umgababa Beach

Table 4-41 shows the Blue Flag Microbiological Results for Umgababa beach. This beach met the criteria for both bacteria just once during the 2009/2010 season. Thereafter, this beach only managed to meet the criteria for E.coli. Despite failing to meet the criteria for Enterococcus for the last three seasons analysed, Umgababa received pilot status for the 2014/2015 season. It must be noted that CSIR tests water samples for Blue Flag purposes and results obtained may differ to that from EMWSS.

Table 4-41: Umgababa – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	Y	N	N	N

4.3.1.4(j) Umkomaas

Umkomaas beach is not a designated swimming beach. However, boating, canoeing and diving are popular at this beach. Umkomaas beach managed to meet the criteria for E.coli in the four seasons analysed. This is portrayed in table 4-42. Based on Enterococcus, this beach only met the criteria once, in the 2011/2012 season. Since Umkomaas failed to meet the Blue Flag requirements in the 2012/2013 season, it will need to consistently meet the criteria for both bacteria for the four succeeding seasons in order to be eligible for the Blue Flag award in the 2017/2018 season.

Plate 4-41: Umkomaas Beach

Table 4-42: Umkomaas – Blue Flag Microbiological Results

	2009/2010	2010/2011	2011/2012	2012/2013
E.coli	Y	Y	Y	Y
Enterococcus	N	N	Y	N

4.4 Discussion and Conclusion

Based on the results of the past few seasons it is evident that many beaches have not managed to consistently meet the criteria for both E.coli and Enterococcus. All the beaches, except Umlaas beach passed based on E.coli. Unfortunately, most beaches fail based on the presence of Enterococcus.

Currently 4 of the Northern beaches are boasting pilot status: Westbrook, Umdloti Tidal, Umdloti Main, and Umhlanga Main. They have successfully maintained acceptable water quality conditions as required by the Blue Flag programme. Virginia and Beachwood need to maintain acceptable water quality conditions and continue to meet the criteria for both E.coli and Enterococcus. If they do so successfully, these beaches may be flying the Blue Flag soon.

Just one of the City beaches, uShaka, made the 2014/2015 Blue Flag list with pilot status. If Wedge beach continues to meet the requirements, it may receive the award in the 2015/2016 season. The water quality for rest of the City beaches needs to improve significantly before they can become potential Blue Flag beaches.

Anstey‟s beach is the Bluff‟s only hope of introducing the Blue Flag to that section of beaches, as it is the only Bluff beach to make the cut for the 2014/2015 season. The remainder of the Bluff beaches still have a few years before they may be eligible. The water quality conditions of these beaches need to improve for this to be possible.

The Southern beaches have failed to meet the microbiological water quality requirements consistently. Although results of this case study indicate that none of the Southern beaches are eligible for the Blue Flag award, presently Umgababa has pilot status. As the same sampling and testing methods are applied by both CSIR and EMWSS, this discrepancy may be due to a different number of samples tested by the two laboratories.

Although some beaches (Casuarina and Vetch‟s) pass the microbiological water quality criteria for the analysed period, they have not received pilot status as yet. This may be due to these beaches not continuing to meet the microbiological criteria, or failing to meet other Blue Flag criteria. A beach may pass all the water quality criteria but if it fails to meet criteria in other categories, it fails to meet all the requirements and as such it will not be eligible for the Blue Flag.

As discussed in detail in Chapter 3, beach water quality is adversely affected by the presence of numerous rivers and stormwater drains as these are the most direct sources of pathogenic pollution. The Blue Flag criteria are stringent due to the health risks associated with the presence of pathogens in beach water. Due to increased pathogenic pollution, Durban still has a few years to go before it has a "Blue Flag coastline".

CHAPTER 5:
DISCUSSION AND CONCLUSION

5.1. Discussion

Water quality is adversely affected by pathogenic pollution. Water quality data were analysed to determine how the pathogenic water quality of the Durban coastline has changed over the past decade, to establish any trends and to identify possible causes in these changes.

For the Northern beaches, Tables 3-7 to 3-11 show that generally the highest levels of pathogenic pollution occurred in summer and autumn. Annually the average levels of pollution either remained in the same range or increased. Pollution also remained erratic and showed little indication of reduced variability over time. The frequency of poor water quality increases down the coastline of the Northern beaches. Similar seasonal and annual trends have been observed at the City beaches and pollution has become more variable over time (Tables 3-12 to 3-14). Most of the City beaches experienced poor water quality throughout most of the study period (Tables 3-15 and 3-16). For the Bluff beaches, Tables 3-17 to 3-21 show that with few exceptions, annual average pollution has increased in quantity and variability, with the highest averages most notable in summer and autumn. Poor water quality has been consistently evident at all of the Bluff beaches from 2007 onward. Tables 3-22 to 3-26 illustrate that an increase in average pollution at the Southern beaches has resulted in consistently poor water quality along the entire section during the most recent years. This section also exhibits similar seasonal trends as the rest of the coastline.

Based on the outcome of the analysis for each section it is clear that average concentrations of indictor bacteria, and consequently pathogenic pollution, have increased along the entire coastline. As such, the quality of Durban‟s coastal waters has deteriorated. Few beaches showed clear and consistent trends in average indicator bacteria counts and the bacteria have become more erratic. This indicates that the average levels of pathogenic pollution have not only increased in quantity but in variability as well, making it difficult to establish clear trends. Although it is often noted that the highest counts of pathogenic pollution occurred during the rainy seasons, this was not consistent throughout the study. Stretch and Mardon (2005), found the correlation coefficient between rainfall and pathogenic pollution to be low and also highlighted that many other factors affect the quantities of pathogens entering coastal waters.

It is probable that contaminants are present on the surfaces within the stormwater catchments. Polluted runoff from catchments enters the coastal waters via stormwater drain outlets. The size of the catchment being served by a particular stormwater drain also has an impact on the quantity of pollution entering a particular beach. The effect of this is most notable during the first flush. There are numerous other sources of pathogenic discharges along the Durban coastline. These sources include combined sewer overflows, leaky wastewater infrastructure, illegal connections to stormwater infrastructure, direct deposits of raw waste and illegal dumping into stormwater drains.

Discharges from rivers also contribute to pathogenic pollution of coastal waters. The pollution potential of a river is directly related to the size of the river as well as developments along the river. Even moderately polluted river water can have a significant effect of receiving beach waters. Effluent discharged from WWTW as well as dwellers of informal settlements along rivers poses a threat to beach water quality as this pollution will eventually flow into coastal waters. Beaches located in the proximity of river mouths are adversely affected; however, the effect of river discharges is also notable at adjacent beaches.

Although not all beaches receive direct discharges from rivers and SWD‟s, physical processes such as mixing of surface waters and currents result in physical dilution and the transportation of pathogens along the coastline. Consequently, groups of neighbouring beaches often share the same patterns of pathogenic pollution.

Coastal environments are under tremendous pressure due to the rapid development of industries. Due to urban development, the capacity of many municipal sewer systems has become inadequate. Many systems are also outdated and do not have back up plans in the event of a breakdown of a pump or power failures. This results in an increase in raw sewage flowing into rivers, and eventually entering coastal waters.

As new SAWQ guidelines were published, data was analysed to determine how the microbiological water quality conditions compare to these guidelines, and the implications thereof. Enterococcus has been determined to be a more reliable indicator than E.coli. Generally, the presence of Enterococcus results in poorer water quality conditions when compared with E.coli. Water quality at most beaches along the coastline has been rated poor based on Enterococcus in the most recent years of the study at least. This highlights that Durban‟s beach water quality has deteriorated. Many beaches experienced poor water quality for at least a quarter of each year, especially during the summer months, when beaches are frequented most often. Health risks are directly proportional to the quantity of faecal contaminants present. There is a greater risk of illness with a larger presence of pathogens in beach water. The increase in the frequency of poor water quality indicates higher health risks to beach-goers. More severe health risks are associated with the presence of Enterococcus as compared to E.coli. As such higher levels of E.coli are allowed than Enterococcus as per the new SAWQ guidelines (refer to Table 2-1).

As Durban has been reapplying for Blue Flag status for its beaches, the most recent microbiological water quality conditions were compared to the Blue Flag requirements to determine what the implications of these conditions are on this venture. When comparing the past water quality conditions to the stringent requirements, it is clear that many beaches have not managed to consistently meet the microbiological criteria to be eligible for the Blue Flag Award. This is due to increasingly high counts of pathogenic pollution. Despite this, the Northern beaches show the most potential to receive the Award in the near future. Although Durban has been actively applying the Blue Flag programme since 2012, Durban will not have a "Blue Flag Coastline" in the immediate future. The increase in pathogenic pollution adversely affects the City‟s tourism and economy.

5.2. Conclusion

Over the past decade the water quality of Durban‟s beaches has deteriorated. Pathogenic pollution has increased in quantity and variability at most of the beaches along the coastline. The poorest water quality conditions often occur during the rainy seasons and co-incide with severe storm events. However, there are no distinctive patterns in pollution quantities due to the unpredictability of the various sources of pollution.

Sources of pollution that affect the Durban coastline are most notably river and stormwater discharges. Durban‟s coastline will constantly face challenges due to urban and industrial developments, the presence of many WWTW and informal settlements along the rivers, and the presence of numerous SWD‟s.

Although water quality has depreciated along the entire Durban coastline, the southern part of the coastline (Bluff and Southern beaches) appears to be affected more drastically and severely than the northern part (Northern and City beaches). All the Bluff beaches and many of the Southern beaches fall within the South Durban Basin, an industrial hub that is constantly battling environmental issues. Although the northern part of the coastline containing the Northern and City beaches has also experienced degeneration in water quality, it is to a slightly lesser extent. The Northern beaches are generally considered to be more elite and the City beaches form the "Golden Mile". These beaches are the more prestigious beaches where international tourism is focussed on.

Increased pathogenic pollution is hazardous to the health of beach goers. The new SAWQ guidelines highlight that health risks have increased along the entire Durban coastline due to an increase in the frequency of poor water quality conditions. At most of the beaches water quality has been rated poor based on high counts of Enterococcus. The new guidelines show that Enterococcus poses a greater threat to water quality conditions and is associated with more severe health risks than E.coli.

The poor water quality conditions in the most recent years have resulted in most beaches failing to meet the stringent Blue Flag microbiological criteria, thus hindering them from becoming eligible to receive the Blue Flag Award in the near future. Improvement in water quality monitoring and management is required in order for the City to reach its goal of having a "Blue Flag coastline".

Conditions of the coastal environment have a bearing on tourism and thus the economy. Understanding the past trends in pathogenic pollution can assist in the development of a predictive CWQM in future. This can be used as a tool to inform beach goers when it may be unsafe to swim and can assist with the advancement of tourism in the City.

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APPENDIX A: Data Analysis Results

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A.1. Section A – Northern Beaches

A.1.1. Westbrook

- **Seasonal Trends**

Table A-1: Westbrook – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**153 (1)**	6.70 (2)	0.00 (2)	**177 (1)**	6.70 (4)	**613 (1)**	**280 (1)**	6.70 (4)	57.3 (3)	**59.3 (1)**	16.7 (3)
Winter	0.00 (4)	6.70 (2)	**20.0 (1)**	133 (2)	**536 (1)**	8.30 (4)	20.0 (4)	**555 (1)**	**81.0 (1)**	14.4 (3)	32.2 (2)
Spring	20.0 (3)	6.70 (2)	0.00 (2)	16.7 (3)	123 (2)	56.2 (2)	78.1 (3)	15.0 (3)	33.7 (4)	10.6 (4)	**218 (1)**
Summer	6.70 (2)	**66.7 (1)**	**20.0 (1)**	10.0 (4)	22.2 (3)	31.7 (3)	200 (2)	29.0 (2)	74.7 (2)	20.6 (2)	8.3 (4)

The highest levels of E.coli were found to be in autumn and winter consistently. These are typically the dry seasons in the Durban region. It is evident that spring did not yield the greatest levels of E.coli, with exception to 2013. From 2009 to 2012 summer has consistently yielded the second highest concentration.

Table A-2: Westbrook – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**273 (1)**	0.00 (4)	140 (2)	**240 (1)**	13.3 (4)	197 (2)	**199 (1)**	7.50 (4)	12.8 (4)	**300 (1)**	26.7 (2)
Winter	13.3 (3)	33.3 (2)	**253 (1)**	179 (2)	**292 (1)**	75.2 (4)	31.7 (4)	66.6 (2)	97.2 (2)	35.6 (2)	**145 (1)**
Spring	73.3 (2)	6.70 (3)	66.7 (3)	46.7 (4)	250 (2)	111 (3)	71.7 (3)	37.8 (3)	32.4 (3)	35.0 (3)	-
Summer	0.00 (4)	**347 (1)**	66.7 (3)	53.3 (3)	83.3 (3)	**209 (1)**	127 (2)	**110 (1)**	**103 (1)**	5.40 (4)	-

The highest average concentrations of Enterococcus are shown to be evenly distributed between autumn, winter and summer. Spring never yielded the highest results and has consistently ranked third from 2008 to 2012. Autumn yielded the highest levels for both bacteria four times in the study period. There are no other clear correlations between the two indicators.

- **Annual Trends**

The annual averages and standards deviations for E.coli and Enterococcus are depicted in Figures A-1 and A-2 respectively.

It is evident that the average concentration of E.coli has varied over the study period. Averages have decreased and increased inconsistently. Peaks from 2007 to 2010 are up to 19 times greater than the lowest levels in 2005. It is clear that there is significant variation in E.coli concentrations. However, there is no trend in the variation. Average concentrations in 2013 are greater than at the start of the study period.

The standard deviations were found to be relatively large in many cases. This indicates that the data set is spread over a large range and bacteria levels vary greatly throughout each of those years. Values more than double the average show that even though the average levels are not exceptionally high, levels of E.coli have varied significantly from the average on occasion within many of the years in the study period. Higher standard deviations also correlate to the higher averages from 2007 to 2010, with 2010 standing out significantly.

Generally average Enterococcus concentrations were consistent from 2003 to 2009; thereafter changes in average concentration became slightly more variable. From 2010 to 2011 average levels of Enterococcus decreased slightly, with an increase in 2012 and then a decrease again in 2013. The lowest average level of Enterococcus occurred in the most recent year of the study.

The standard deviations follow the same consistent trend as the averages from 2003 to 2009. From 2010 to 2013 the standard deviations did not follow the same pattern as the averages. With exception to 2012, generally the standard deviations were not significantly large. When comparing the results of the two indicator organisms, Enterococcus has been found to be consistent in comparison to E.coli, which has been more variable.

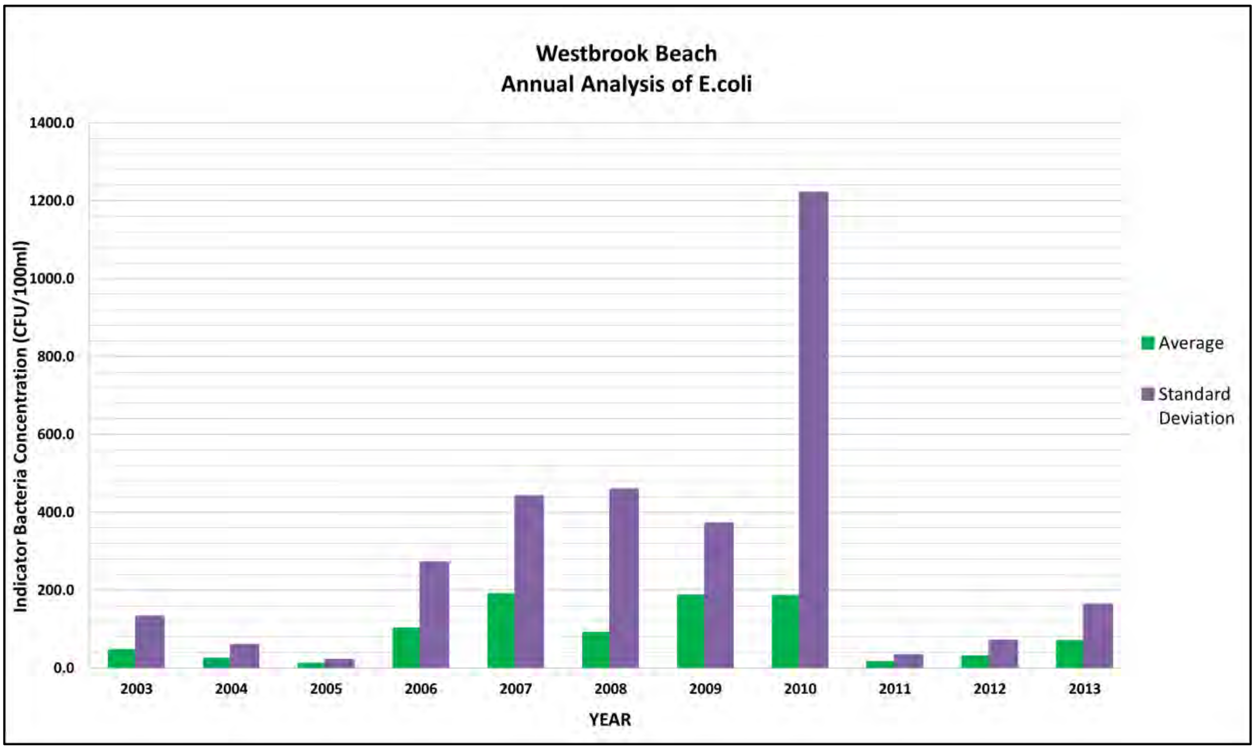

Figure A-1: Annual Analysis of E.coli at Westbrook Beach

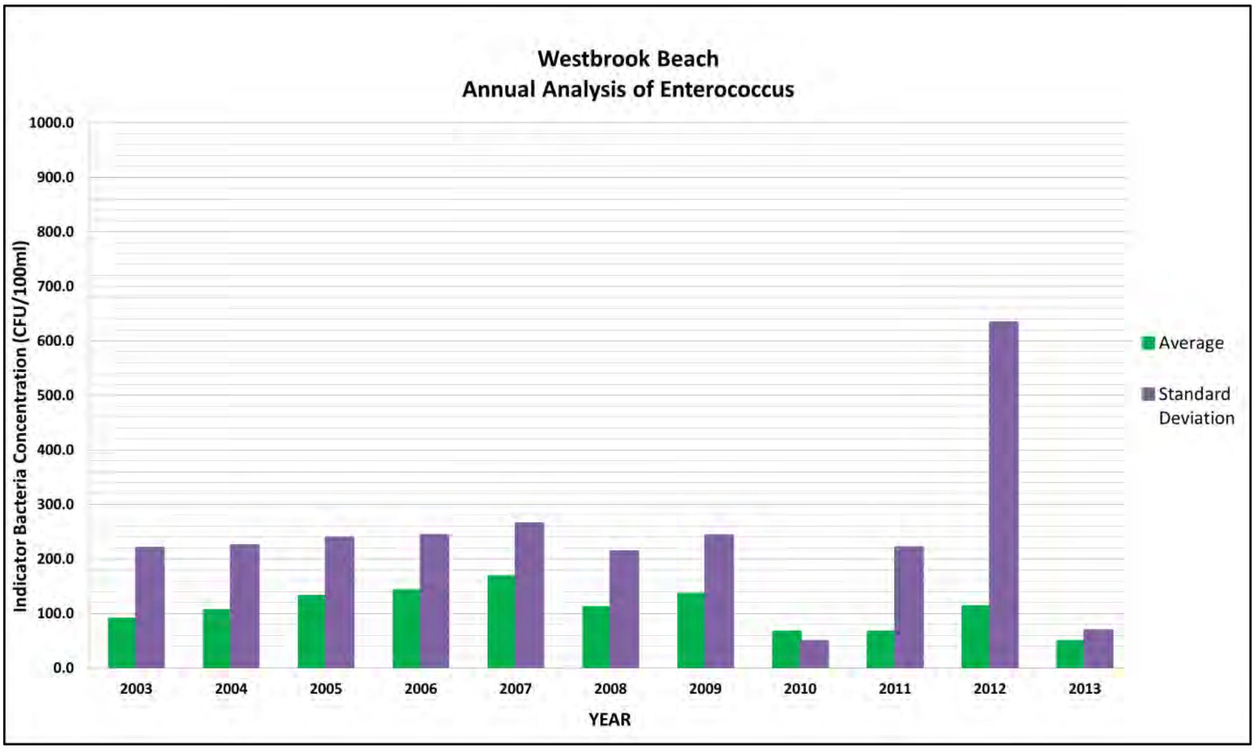

Figure A-2: Annual Analysis of Enterococcus at Westbrook Beach

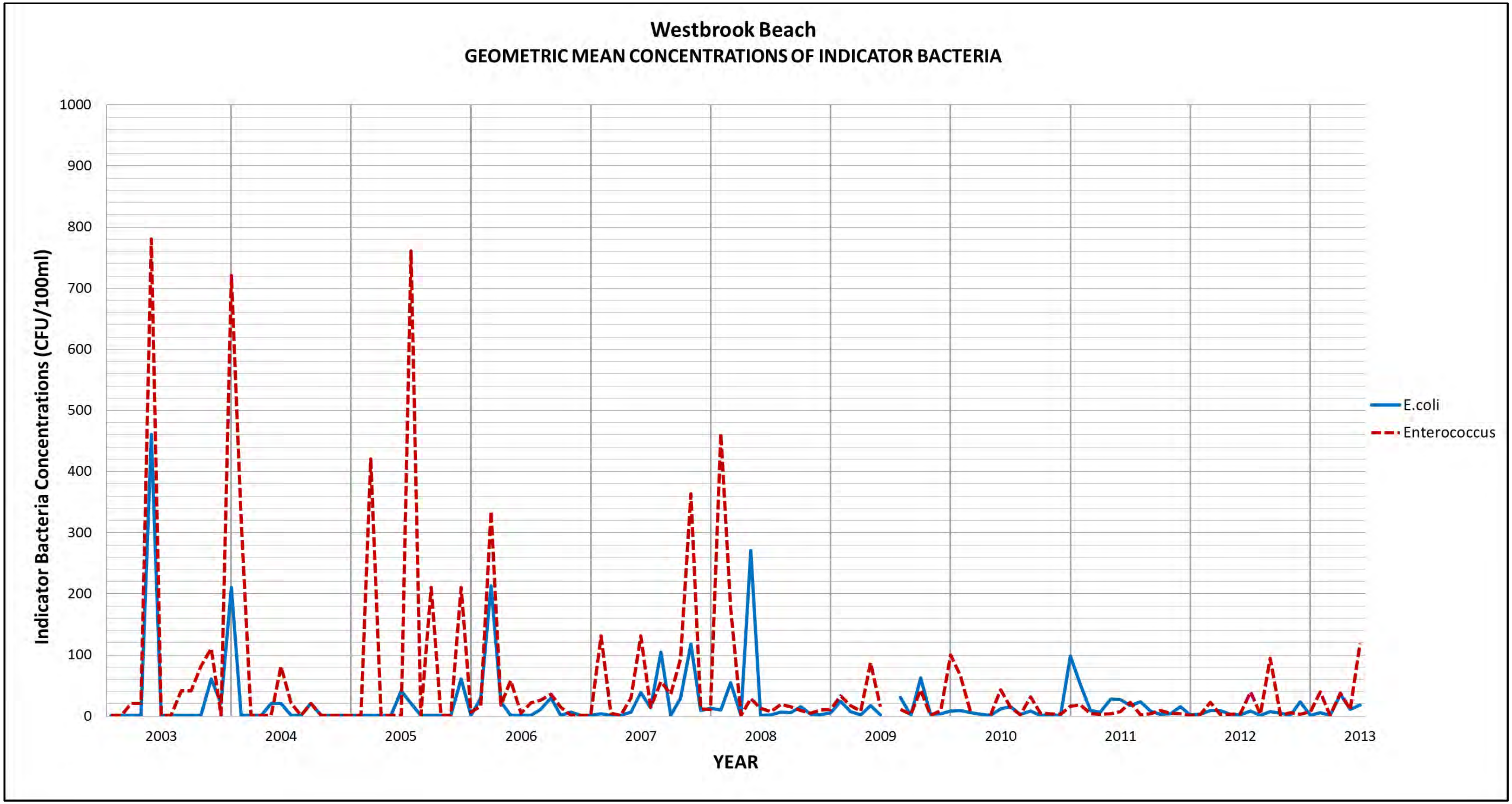

Figure A-3: Westbrook – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric mean concentrations of the E.coli and Enterococcus at Westbrook are compared in Figure A-3. Enterococcus levels vary from extremely high to extremely low each month throughout the first half of the study period, becoming more consistent in the second half. E.coli also varies in the first half of the study period, though not as greatly as Enterococcus. Generally Enterococcus concentrations are shown to be higher than E.coli although both bacteria follow the same pattern. In the most recent years levels of both indicators have not exceeded 100 CFU/100ml.

- **SAWQ Guidelines**

The microbiological water quality for Westbrook beach has been classified according to the requirements of the new SAWQ Guidelines. Table A-3 shows the rating of the E.coli levels at Westbrook beach for each month over the study period.

Table A-3: Westbrook – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	P	E	E	E	E
MAR	E	E	E	G	E	E	E	E	E	E	E
APR	E	E	E	P	E	E	E	E	E	E	E
MAY	G	E	E	E	E	P	P	E	E	G	E
JUN	E	E	E	E	P	E	E	G	E	E	E
JUL	E	E	E	E	E	E	P	P	G	E	E
AUG	E	E	E	P	P	E	E	E	G	E	E
SEP	E	E	E	E	E	E	E	E	G	E	E
OCT	E	E	E	E	E	G	G	E	E	E	E
NOV	E	E	E	E	P	E	E	E	E	E	G
DEC	E	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	G	G	E	G	E	E	E	E

Generally the levels of E.coli indicate excellent to good water quality conditions, with a few occurrences of poor water quality conditions during the middle of the study period. In the most recent years there have been no occurrences of poor water quality conditions based on E.coli concentrations.

The microbiological water quality rating for Enterococcus is shown in Table A-4. Annually there have been no occurrences of excellent water quality at Westbrook beach based on Enterococcus concentrations. A clear deterioration in microbiological water quality is evident from 2005 to 2011. For the years 2007 to 2010 the water quality has been classified as poor for approximately half of the year, resulting in an annual classification of poor. When comparing the indicator bacteria, it is clear that Enterococcus levels result in poorer water quality conditions than E.coli.

Table A-4: Westbrook – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	E	E	E	P	P	P	E	E
FEB	E	P	E	P	P	P	P	P	P	E	E
MAR	E	E	P	P	E	P	E	E	E	P	E
APR	E	E	E	P	E	E	P	P	E	E	E
MAY	P	E	E	G	E	P	P	E	E	E	E
JUN	E	E	E	E	P	P	G	P	P	G	G
JUL	E	-	P	P	P	G	P	P	P	G	-
AUG	E	E	E	P	P	E	E	E	E	E	-
SEP	E	E	P	E	E	P	E	P	E	E	-
OCT	E	E	E	G	P	P	P	E	P	E	-
NOV	E	E	E	E	P	P	E	G	E	E	-
DEC	E	E	P	E	G	G	E	E	E	E	-
Annual	G	P	P	P	P	P	P	P	P	G	G

A.1.2. Casuarina

- **Seasonal Trends**

No seasonal trends are evident as the season which yielded the highest concentration of E.coli differs each year. As with E.coli, the season which yielded the highest concentration of Enterococcus varies each year. For 2010 to 2012 the seasons which yielded the highest Enterococcus levels correspond to that of E.coli.

Table A-5: Casuarina – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	0.00 (3)	**50.0 (1)**	6.70 (3)	26.7 (4)	**400 (1)**	40.7 (2)	4.20 (4)	63.5 (2)	**35.8 (1)**	36.7 (2)
Winter	6.70 (2)	6.70 (2)	10.0 (2)	333 (2)	**787 (1)**	4.00 (4)	**65.0 (1)**	11.6 (3)	49.8 (3)	5.60 (4)	28.3 (3)
Spring	0.00 (3)	0.00 (3)	0.00 (3)	**413 (1)**	160 (2)	25.4 (3)	29.2 (4)	**21.4 (1)**	32.3 (4)	15.0 (3)	**210 (1)**
Summer	**20.0 (1)**	**40.0 (1)**	10.0 (2)	0.00 (4)	33.3 (3)	31.7 (2)	35.4 (3)	14.9 (2)	**69.0 (1)**	17.8 (2)	5.00 (4)

Table A-6: Casuarina – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**227 (1)**	**0.00 (3)**	**270 (1)**	**20.0 (4)**	**46.7 (4)**	**20.0 (4)**	**113 (1)**	**0.00 (4)**	**23.7 (3)**	**278 (1)**	**8.30 (2)**
Winter	**66.7 (2)**	**0.00 (3)**	**0.00 (2)**	**413 (1)**	**513 (2)**	**51.7 (3)**	**1.70 (4)**	**38.9 (3)**	**63.5 (2)**	**71.1 (2)**	**120 (1)**
Spring	**0.00 (3)**	**6.70 (2)**	**0.00 (2)**	**313 (3)**	**527 (1)**	**111 (2)**	**89.2 (2)**	**61.4 (1)**	**19.2 (4)**	**16.1 (3)**	-
Summer	**0.00 (3)**	**200 (1)**	**0.00 (2)**	**350 (2)**	**100 (3)**	**125 (1)**	**76.1 (3)**	**50.1 (2)**	**88.8 (1)**	**11.2 (4)**	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for Casuarina beach are depicted in Figure A-4. E.coli concentrations have clearly increased since 2003. Average concentrations increased drastically in 2006 and 2007, with levels approximately 35 times that of the lowest in 2003. Although the concentrations dropped after 2007, they still remained above the lowest concentrations at the start of the study period. It is clear that there is significant variation in E.coli concentrations. However, there is no consistency in the variation.

The standard deviations were found to be relatively small in most cases. This indicates that the data set is spread over a small range and generally bacteria levels do not vary greatly throughout the year. Larger deviations were found to be associated with the larger averages from 2005 to 2007. This indicates greater variability in E.coli levels during those years.

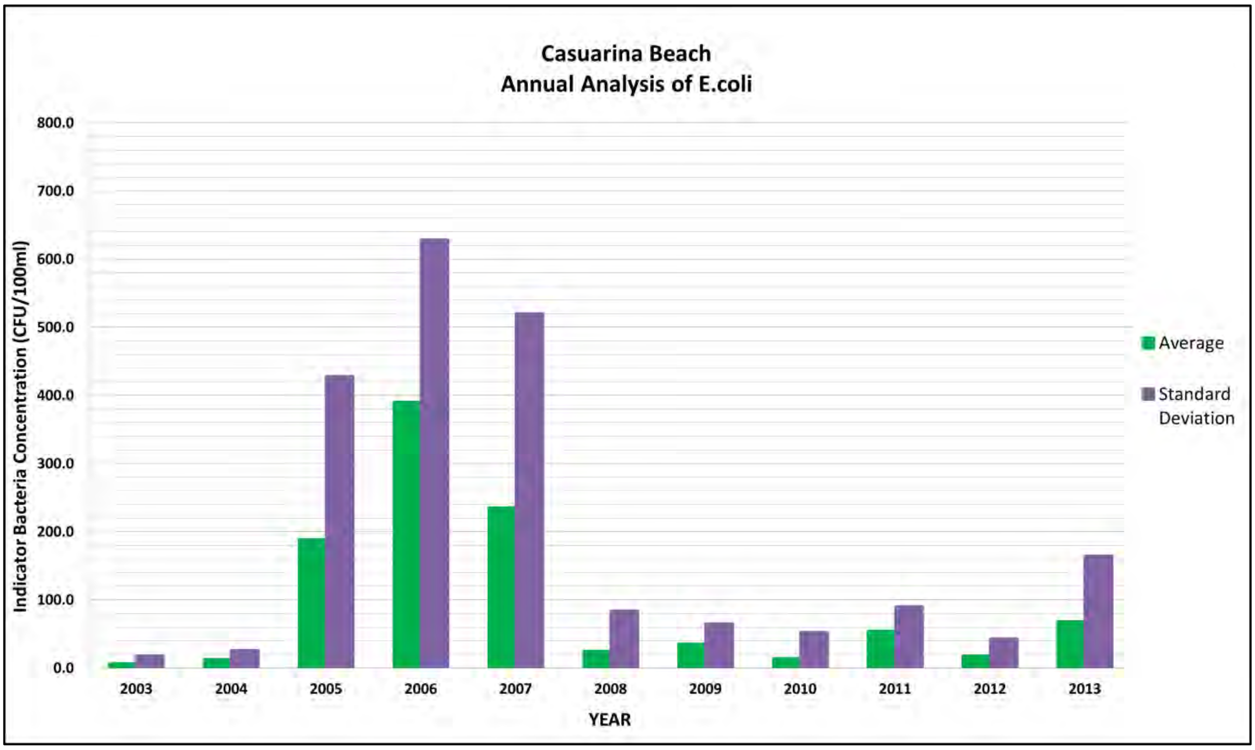

Figure A-4: Annual Analysis of E.coli at Casuarina Beach

Figure A-5 shows the annual averages and standard deviations of Enterococcus. There has been great variability in Enterococcus levels, with inconsistent increases and decreases. As with E.coli, Enterococcus concentrations increased significantly from 2005 to 2007. The lowest average concentration was in 2013.

In most cases the standard deviations increase and decrease with the averages. During the latter years of the study period the standard deviations do not follow the same pattern. The largest deviation was evident is 2012. Both of the indicator bacteria show inconsistent variations throughout the study period, however, there is no correlation between E.coli and Enterococcus.

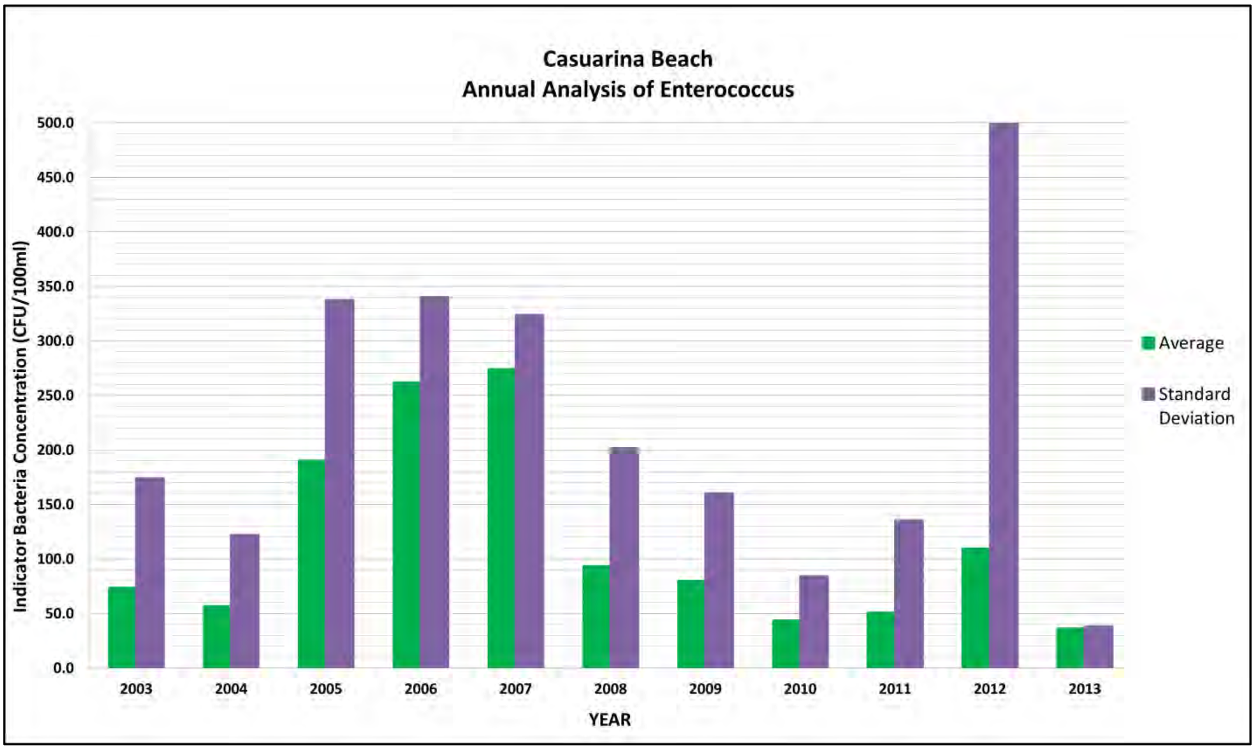

Figure A-5: Annual Analysis of Enterococcus at Casuarina Beach

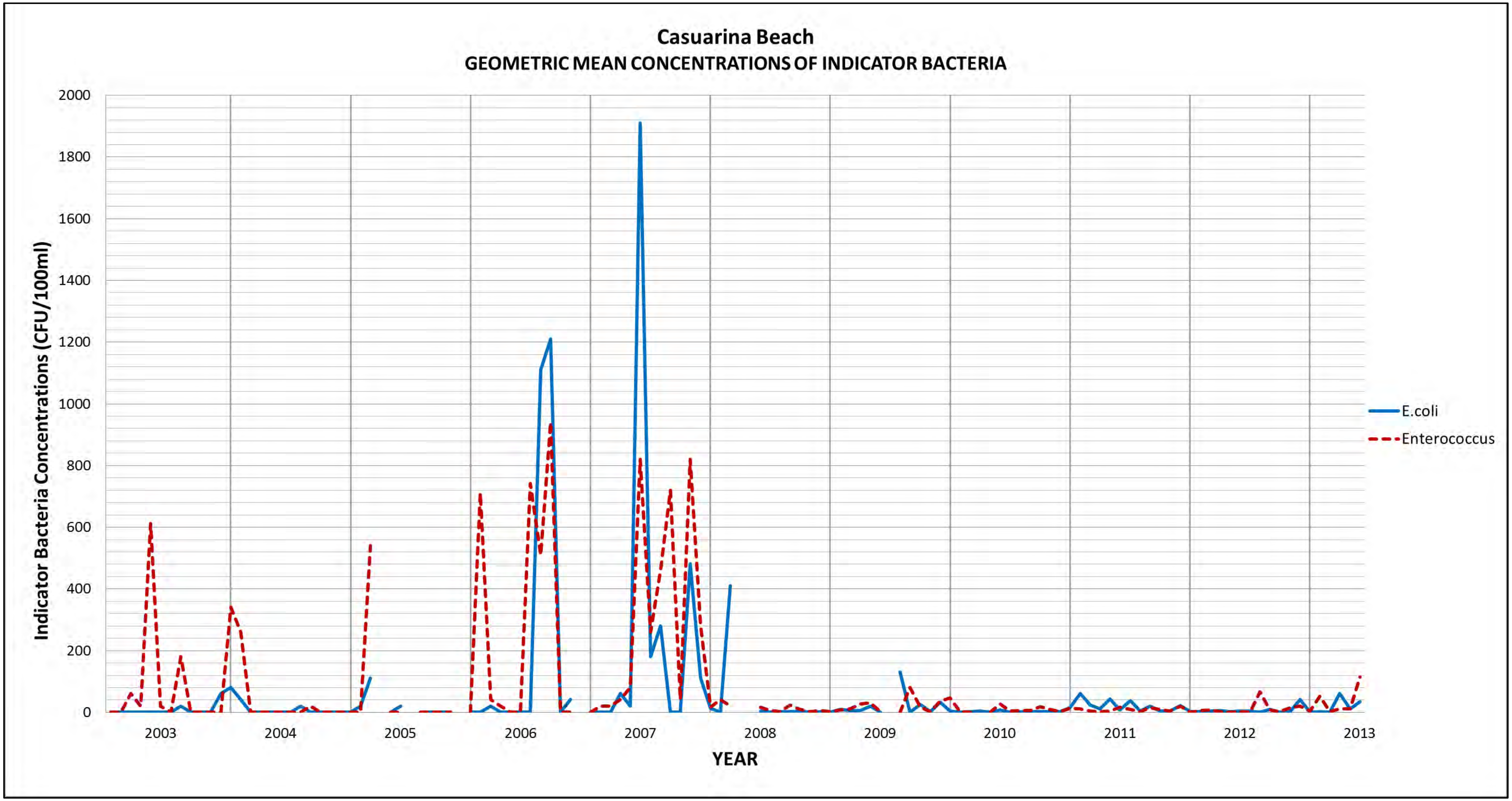

Figure A-6: Casuarina – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-6 illustrates the geometric mean concentrations of the two indicator bacteria. Enterococcus concentrations are clearly higher than E.coli in most cases during the first half of the study period. It is evident that Enterococcus has been significantly variable for the first five years. E.coli became variable between 2006 and 2008. Both E.coli and Enterococcus levels have become more consistent in the most recent years, with concentrations remaining below 100CFU/100ml.

- **SAWQ Guidelines**

Generally the levels of E.coli indicate excellent to good water quality conditions, with very few occurrences of poor water quality conditions. Poor water quality only occurred in 2006 and 2007. This is consistent with the high averages and evident peaks in Figures A-9 and A-11. There have been no occurrences of poor water quality based on E.coli levels since June 2007.

Table A-7: Casuarina – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	G	E	E	G	E	E
APR	E	E	-	E	E	-	G	E	E	E	E
MAY	E	E	E	E	E	-	E	E	E	E	E
JUN	E	E	E	E	P	E	E	E	E	E	E
JUL	E	E	-	E	E	E	G	E	G	E	E
AUG	E	E	E	P	G	E	E	E	E	E	E
SEP	E	E	E	P	E	E	E	E	G	E	E
OCT	E	E	E	E	E	G	E	E	E	E	E
NOV	E	E	E	E	G	E	E	E	E	E	G
DEC	E	E	-	-	E	E	E	E	E	E	E
Annual	E	E	E	G	G	E	E	E	G	E	E

Table A-8: Casuarina – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	E	E	G	E	P	P	E	E
FEB	E	P	E	P	E	E	P	E	P	E	E
MAR	E	E	P	E	E	E	E	E	E	P	E
APR	E	E	-	E	E	-	P	P	G	E	E
MAY	P	E	E	E	E	-	P	E	E	E	E
JUN	E	E	E	E	P	P	E	P	E	E	G
JUL	E	E	-	P	P	E	E	E	P	E	-
AUG	G	E	E	P	P	E	E	E	G	G	-
SEP	E	E	E	P	P	P	P	E	G	E	-
OCT	E	E	E	E	E	P	P	G	E	E	-
NOV	E	E	E	E	P	E	E	G	E	E	-
DEC	E	E	-	-	P	G	P	E	E	E	-
Annual	G	G	E	P	P	P	P	G	G	E	G

Annually water quality based on Enterococcus levels has only been classified as excellent twice. Water quality deteriorated from 2006 to 2009, where the frequency of poor water quality increased significantly. Poor water quality occurred more frequently in summer months in the more recent years of the study. Based on the requirements of the SAWQ guidelines, the quality of Casuarina͞s waters has been classified as poor more frequently based on Enterococcus levels as compared to E.coli.

A.1.3. La Mercy

- **Seasonal Trends**

Seasonal averages of E.coli at La Mercy beach are ranked in Table A-9. Summer and autumn yielded the highest E.coli concentrations most frequently throughout the study period, especially during the most recent years. During the first six years spring ranked consistently high and in the latter years of the study period spring ranked lower more frequently. There are no clear patterns in the seasons which produced the highest counts of E.coli.

Table A-9: La Mercy – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**0.00 (1)**	**0.00 (1)**	0.00 (2)	**333 (1)**	**1333 (1)**	0.00 (3)	19.8 (2)	15.8 (3)	40.6 (3)	**126 (1)**	**95.0 (1)**
Winter	**0.00 (1)**	**0.00 (1)**	0.00 (2)	0.00 (2)	6.70 (3)	**17.1 (1)**	16.7 (3)	20.2 (2)	44.6 (2)	0.70 (4)	13.3 (3)
Spring	**0.00 (1)**	**0.00 (1)**	0.00 (2)	0.00 (2)	13.3 (2)	7.60 (2)	**48.9 (1)**	3.10 (4)	26.9 (4)	18.3 (3)	10.0 (4)
Summer	**0.00 (1)**	**0.00 (1)**	**6.70 (1)**	0.00 (2)	0.00 (4)	0.00 (3)	4.90 (4)	**32.8 (1)**	**55.5 (1)**	23.9 (2)	15.0 (2)

Table A-10 shows the seasonal averages for Enterococcus. Summer and autumn yielded the highest concentrations most frequently. No clear patterns are evident as the season which produced the highest average concentration of Enterococcus varies each year. There has been no correlation between E.coli and Enterococcus seasonal averages.

Table A-10: La Mercy – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	**53.3 (1)**	6.70 (3)	**287 (1)**	**306 (1)**	60.0 (3)	**138 (1)**	17.5 (4)	45.8 (3)	71.7 (3)	68.3 (2)
Winter	100 (2)	20.0 (3)	6.70 (3)	0.00 (4)	80.0 (3)	75.1 (2)	21.7 (4)	42.8 (2)	**118 (1)**	7.30 (4)	**130 (1)**
Spring	**473 (1)**	26.7 (2)	10.0 (2)	73.3 (2)	267 (2)	54.3 (4)	100 (2)	26.4 (3)	20.7 (4)	**122 (1)**	-
Summer	0.00 (3)	**53.3 (1)**	**20.0 (1)**	20.0 (3)	40.0 (4)	**277 (1)**	36.6 (3)	**148 (1)**	78.4 (2)	96.9 (2)	-

- **Annual Trends**

Figure A-7 shows a clear variation in both the annual averages and standard deviations of E.coli concentrations at La Mercy beach since 2003. Average concentrations increased and decreased inconsistently, however concentrations remain clearly higher than at the start of the study period.

In most cases the standard deviations increase and decrease with the averages. The standard deviations were not found to be extremely large with exception to 2007. The extremely large deviation in 2007 indicates that the data set is spread over a large range and concentrations of E.coli varied significantly in 2007.

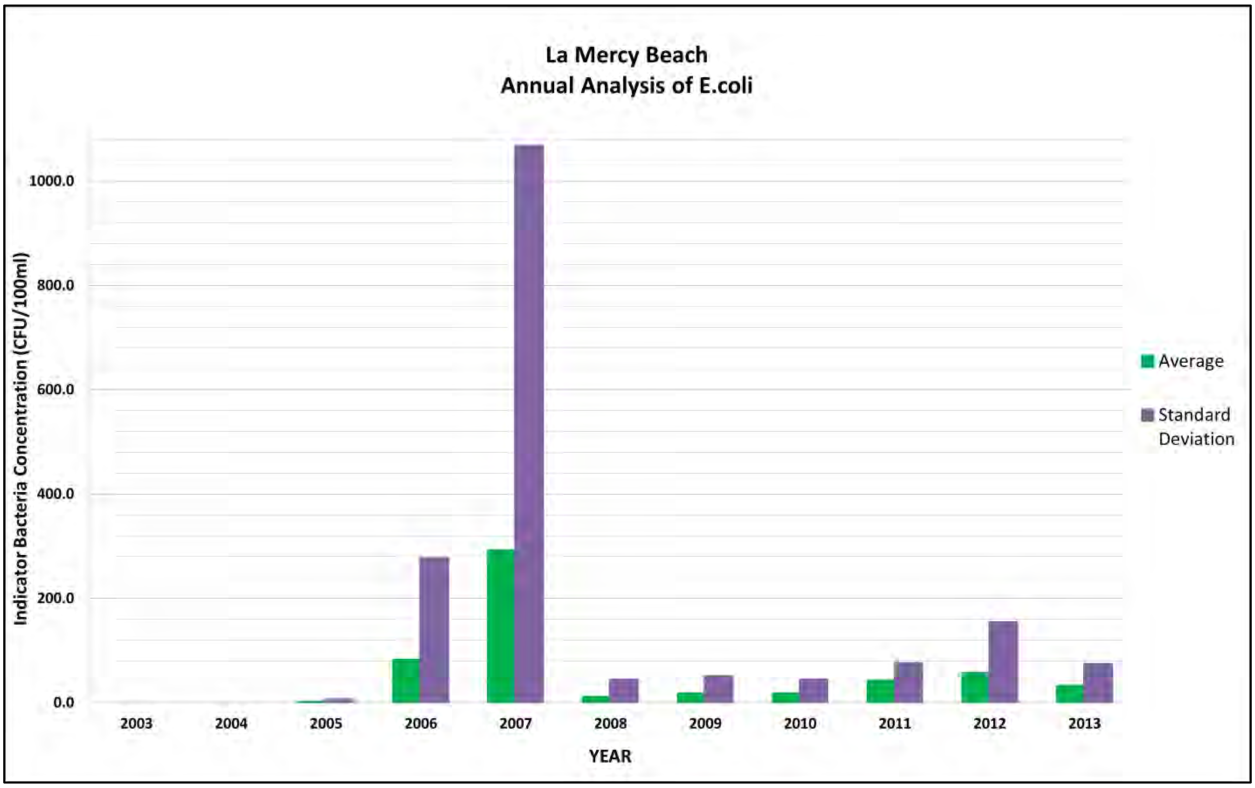

Figure A-7: Annual Analysis of E.coli at La Mercy Beach

The annual averages and standard deviations for Enterococcus are depicted in Figure A-8. The average concentration decreased and increased inconsistently throughout the study period. The average at the end of the study period is approximately half the average at the beginning in 2003. During the first half of the study period no pattern is evident as changes are variable. From 2009 the average concentrations as well as standard deviations have become more consistent. Changes in standard deviations for Enterococcus have been consistent with the averages. Both E.coli and Enterococcus concentrations were highest in 2007. Although both indicator bacteria concentrations fluctuated, there was no link between their variations over the years.

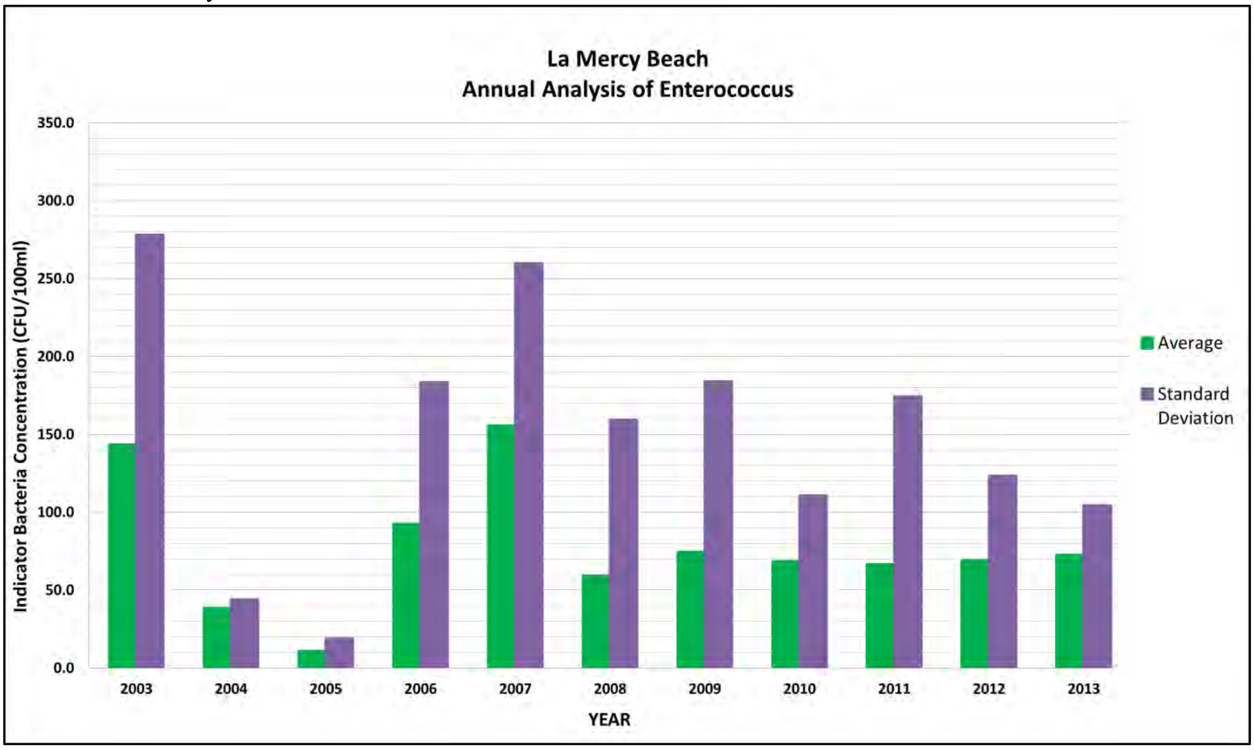

Figure A-8: Annual Analysis of Enterococcus at La Mercy Beach

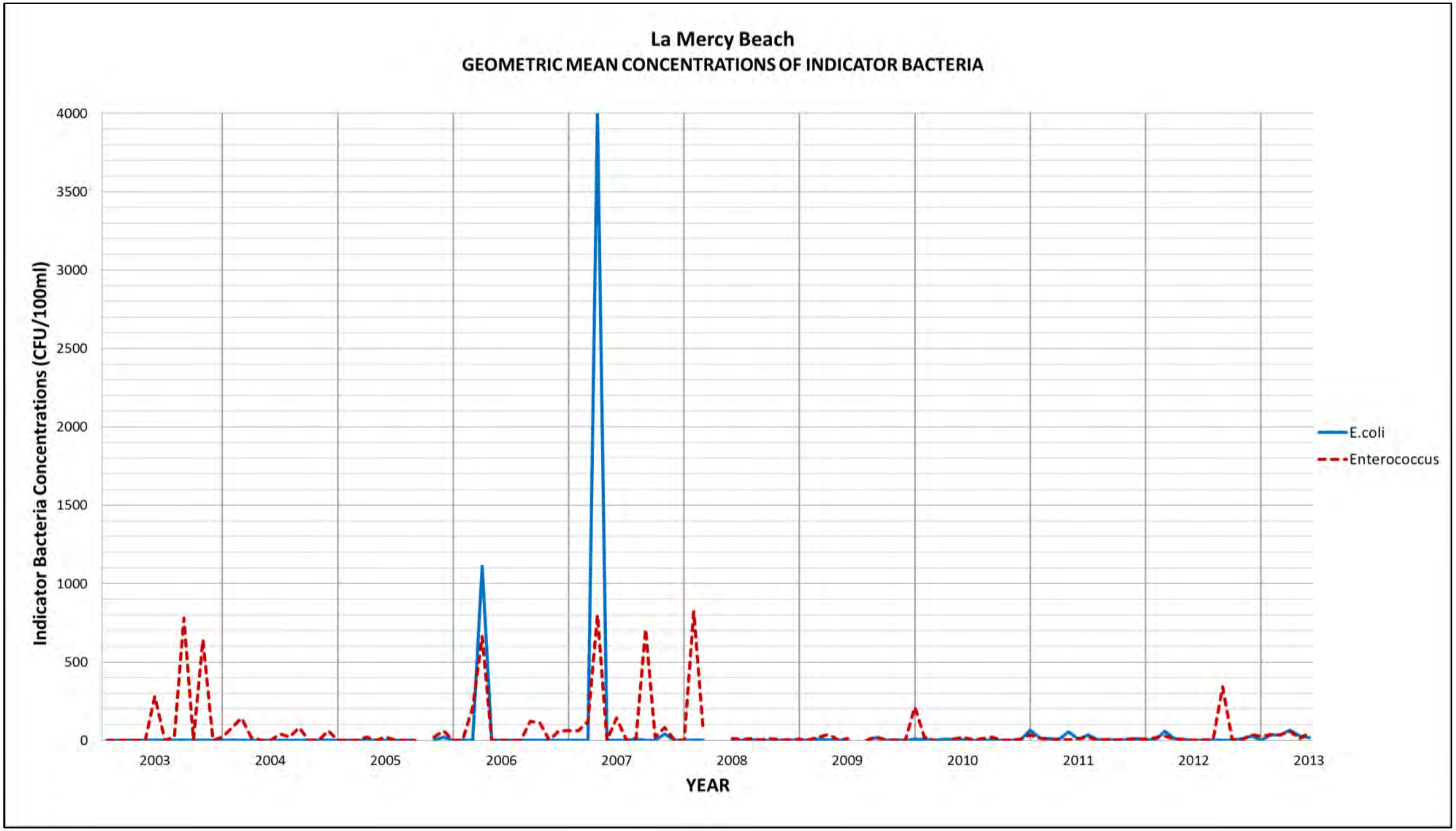

Figure A-9: La Mercy – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-9 shows Enterococcus concentrations are generally higher than E.coli in most cases. During the first half of the study period the variability of Enterococcus concentrations is distinct. E.coli was consistent from 2003 to 2006, where outstanding peaks are evident. In the latter years of the study period concentrations of both indicator bacteria have become less variable, with E.coli becoming more consistent than Enterococcus. Concentrations of E.coli did not exceed 100 CFU/100ml since 2007. Even though Enterococcus concentrations have decreased, generally counts have remained higher than E.coli.

- **SAWQ Guidelines**

Tables A-11 and A-12 summarise the microbiological water quality ratings for E.coli and Enterococcus respectively.

Table A-11: La Mercy – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	G	E	E	E	E	E	G	E
APR	E	E	E	P	P	-	E	E	E	E	E
MAY	E	E	E	E	E	-	E	E	E	G	E
JUN	E	E	E	E	E	E	E	E	E	E	E
JUL	E	E	E	E	E	E	-	E	G	E	E
AUG	E	E	E	E	E	E	E	E	E	E	E
SEP	E	E	E	E	E	E	G	E	G	E	E
OCT	E	E	P	E	E	E	E	E	E	E	E
NOV	E	E	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	G	G	E	E	E	E	E	E

Generally the levels of E.coli indicate excellent to good water quality conditions, with only three occurrences of poor water quality throughout the entire study period. There have been no occurrences of poor water quality based on E.coli levels since April 2007. Annual water quality has been ranked excellent consistently since 2008.

Table A-12: La Mercy – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	G	P	P	P	E
FEB	E	E	E	E	E	G	E	P	P	P	E
MAR	E	G	E	P	G	E	G	E	E	P	G
APR	E	E	E	P	G	-	P	-	G	E	G
MAY	E	E	E	E	E	-	E	E	G	P	E
JUN	P	E	E	E	G	P	G	G	E	E	G
JUL	E	E	E	E	E	E	-	E	P	E	-
AUG	E	E	E	E	G	G	E	G	E	E	-
SEP	P	E	E	G	P	G	P	G	G	E	-
OCT	E	E	G	E	E	G	E	E	E	E	-
NOV	P	E	E	E	E	G	E	E	E	E	-
DEC	E	E	E	E	E	E	E	G	E	G	-
Annual	G	G	E	G	E	P	P	G	G	G	G

Generally water quality based on Enterococcus is good; with the four most recent years yielding an annual good rating. Poor water quality occurred frequently in the summer months in 2010 – 2012. Other occurrences of poor water have been random. Annually water quality has been classified as excellent only twice. According to the annual ratings, generally La Mercy‟s beach water has been classified as excellent based on E.coli concentrations. However, based on Enterococcus, the rating drops to good.

A.1.4. Umdloti Tidal

Sample data for 2005 was not provided for E.coli at Umdloti Tidal.

- **Seasonal Trends**

The E.coli seasonal averages for Umdloti Tidal are ranked in Table A-13. Throughout the study period autumn and winter yielded the highest concentration of E.coli most often. However, no clear seasonal trends are evident as the season which produced the highest counts of E.coli is not consistent each year.

Table A-13: Umdloti Tidal – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (2)	0.00 (4)	-	**167 (1)**	0.00 (2)	0.00 (4)	**33.3 (1)**	4.20 (4)	103 (2)	**73.7 (1)**	**71.7 (1)**
Winter	**6.70 (1)**	**46.7 (1)**	-	100 (2)	**10.0 (1)**	**17.1 (1)**	0.00 (4)	**34.0 (1)**	65.1 (3)	0.00 (4)	30.0 (2)
Spring	**6.70 (1)**	20.0 (2)	-	0.00 (4)	0.00 (2)	9.50 (2)	1.70 (3)	9.70 (3)	7.90 (4)	5.60 (3)	23.3 (3)
Summer	**6.70 (1)**	13.3 (3)	-	6.70 (3)	0.00 (2)	6.70 (3)	16.7 (2)	24.9 (2)	**163 (1)**	6.10 (2)	5.00 (4)

Table A-14 shows the ranking of seasonal averages for Enterococcus. Winter yielded the highest concentration of Enterococcus most frequently, especially during the latter years of the study period. Summer has not yielded the highest level of Enterococcus since 2008. It is clear that there is no seasonal trend based on Enterococcus. There is no evident correlation between E.coli and Enterococcus as the seasons which produced the highest levels of each bacterium differ each year.

Table A-14:Umdloti Tidal – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (2)	6.70 (4)	46.7 (2)	120 (2)	26.7 (3)	40.0 (4)	**67.6 (1)**	40.0 (2)	49.8 (2)	38.1 (3)	15.0 (2)
Winter	6.70 **(1)**	20.0 (3)	26.7 (3)	**127 (1)**	6.70 (4)	79.3 (2)	0.00 (4)	**50.9 (1)**	**105 (1)**	4.70 (4)	**30.0 (1)**
Spring	6.70 **(1)**	**140 (1)**	20.0 (4)	46.7 (4)	33.3 (2)	43.8 (3)	4.20 (3)	19.7 (4)	16.7 (4)	**142 (1)**	-
Summer	0.00 (2)	26.7 (2)	**133 (1)**	113 (3)	**80.0 (1)**	**177 (1)**	44.4 (2)	28.9 (3)	46.4 (3)	45.0 (2)	-

- **Annual Trends**

The annual averages and standard deviations for E.coli are summarised in Figure A-10. Generally it is evident that the average concentration of E.coli varied only slightly throughout the study period, with averages increasing and decreasing randomly. All average counts were found to be blew 100CFU/100ml. Standard deviations were found to be relatively small which indicates that concentrations of E.coli did not varied greatly.

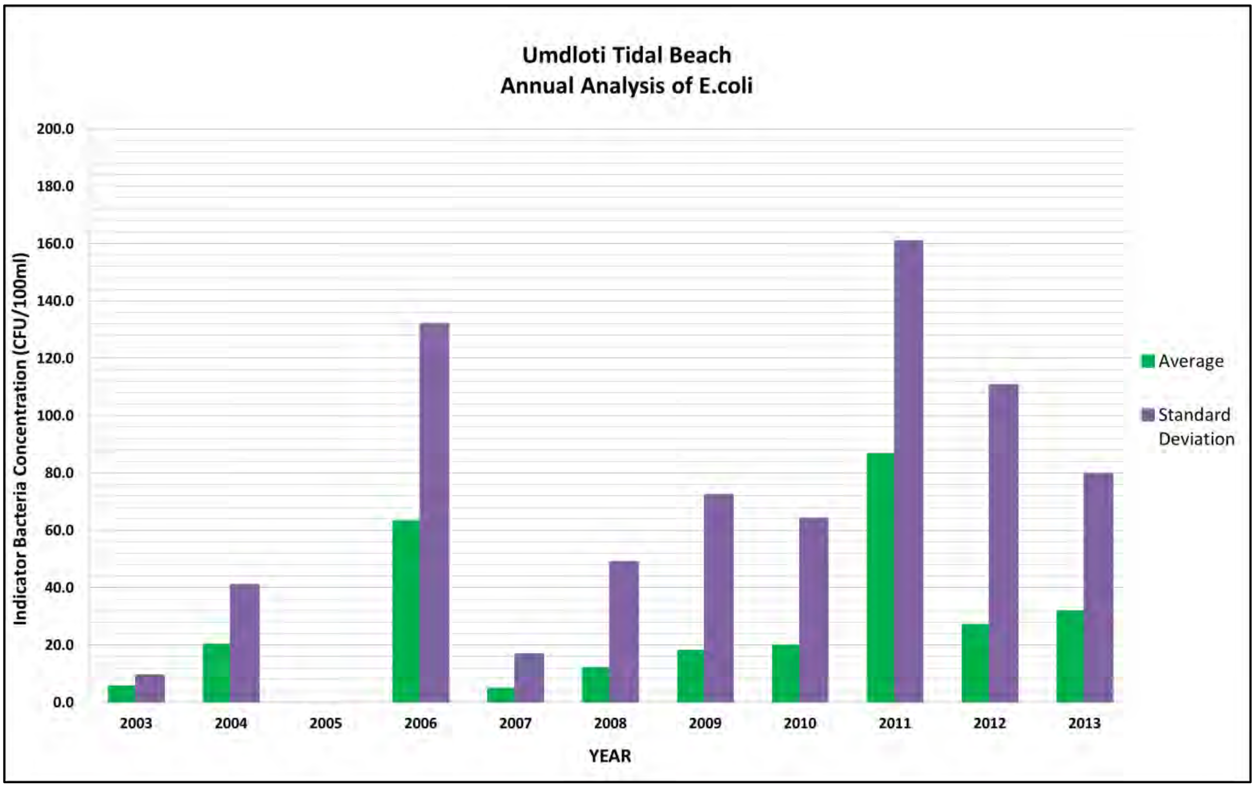

Figure A-10: Annual Analysis of E.coli at Umdloti Tidal Beach

Figure A-11 depicts the annual averages and standard deviations for Enterococcus. The average concentrations varied slightly throughout the study period. Enterococcus increased and decreased marginally, however the changes were inconsistent each year. The standard deviations were not large and increased and decreased as the averages did. Both indicators varied inconsistently and counts remained low but there is no correlation between them.

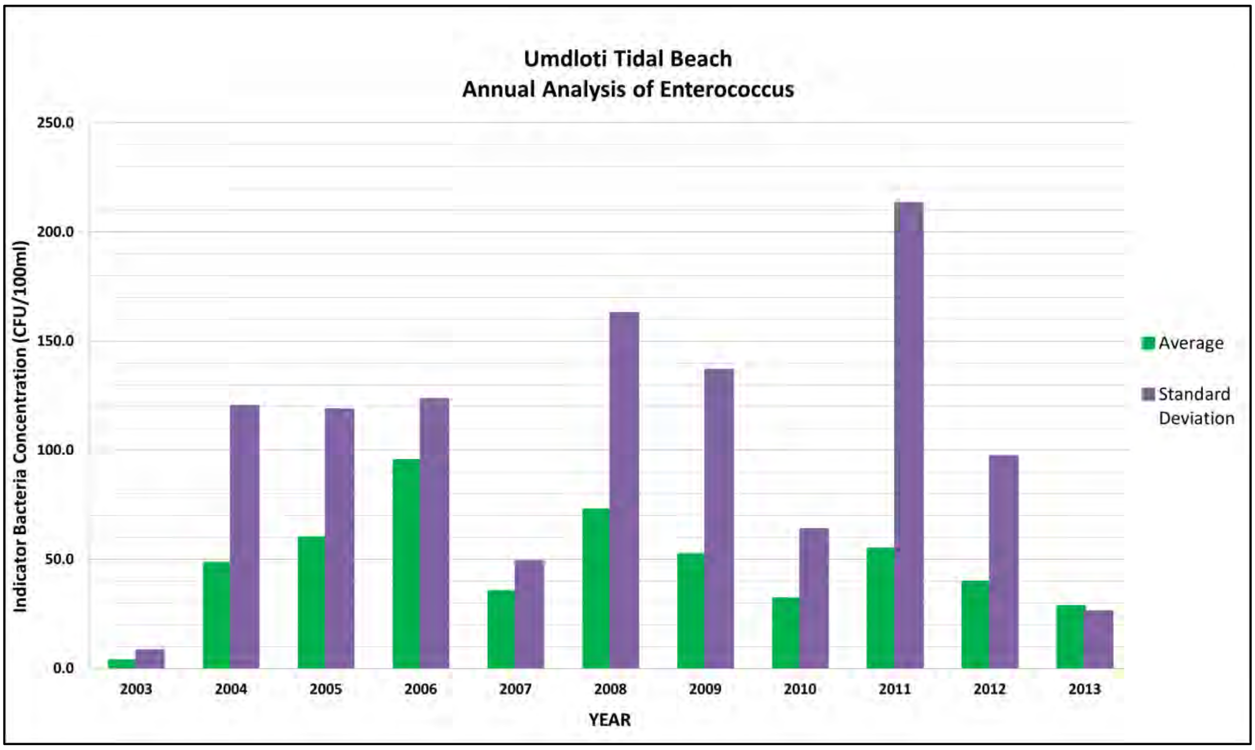

Figure A-11: Annual Analysis of Enterococcus at Umdloti Tidal Beach

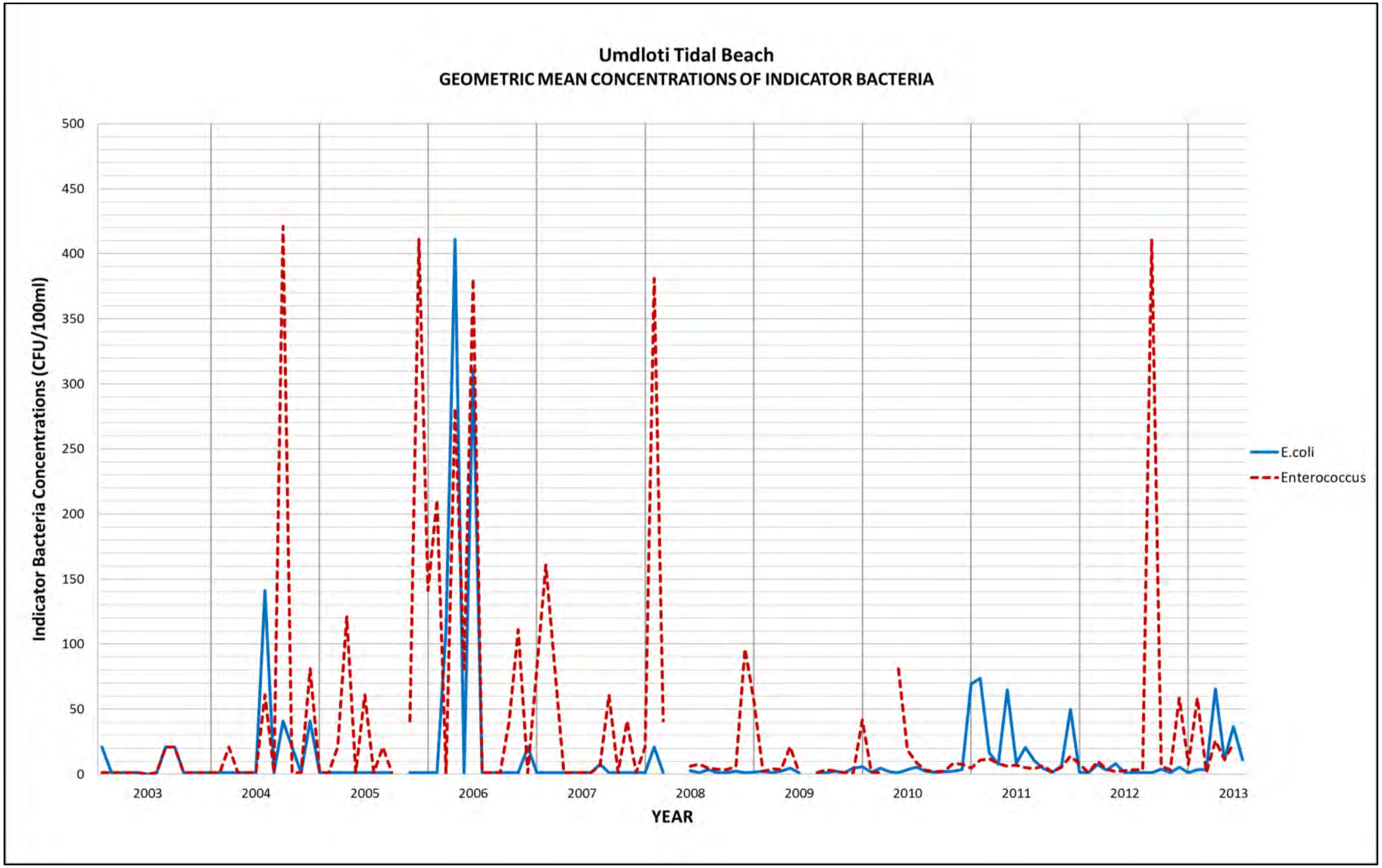

Figure A-12: Umdloti Tidal – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of the two indicator bacteria are illustrated in Figure A-12. Enterococcus is shown to be more erratic than E.coli. Levels of Enterococcus have been higher than E.coli in most cases throughout the study period. Counts of E.coli have not exceeded 100/100ml since 2006. Enterococcus has remained variable throughout the years whilst E.coli has become more stable.

- **SAWQ Guidelines**

Table A-15 shows that the quality of Umdloti Tidal‟s waters has been mostly excellent based on E.coli concentrations. Poor water quality occurred only once during the entire duration of the study period.

Table A-15: Umdloti Tidal – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	-	E	E	E	E	E	P	E	E
FEB	E	E	-	E	E	E	E	E	G	E	E
MAR	E	E	-	E	E	E	E	E	E	G	E
APR	E	E	-	G	E	-	E	E	G	E	E
MAY	E	E	-	E	E	-	G	E	G	G	E
JUN	-	E	-	G	E	E	E	G	E	E	E
JUL	E	E	-	E	E	E	-	E	G	E	E
AUG	E	E	-	E	E	E	E	E	E	E	E
SEP	E	E	-	E	E	E	E	E	E	E	E
OCT	E	E	-	E	E	E	E	E	E	E	E
NOV	E	E	-	E	E	E	E	E	E	E	E
DEC	E	E	-	E	E	E	E	E	G	E	E
Annual	E	E	-	G	E	E	E	E	G	E	E

Table A-16 summarises the microbiological rating of the waters at Umdloti Tidal based on Enterococcus concentrations.

Table A-16: Umdloti Tidal – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	G	E	E	G	E	E	P	E
FEB	E	E	E	P	G	P	E	E	P	E	E
MAR	E	E	E	E	E	E	E	E	G	P	E
APR	E	E	G	P	E	-	E	-	E	E	E
MAY	E	E	E	E	E	-	P	E	P	E	E
JUN	-	E	E	P	E	P	E	P	E	E	E
JUL	E	E	E	E	E	G	-	E	P	E	-
AUG	E	E	E	E	E	E	E	E	E	E	-
SEP	E	P	E	E	E	E	E	E	G	E	-
OCT	E	E	-	E	E	G	E	E	E	E	-
NOV	E	E	E	E	E	P	E	G	E	E	-
DEC	E	E	P	E	E	P	G	G	E	G	-
Annual	E	G	G	P	E	G	G	G	G	G	E

Generally water quality has been classified as good; however, annually water quality has been classified as excellent only 3 times. The occurrence of poor water quality has been erratic and infrequent. Based on annual ratings, generally Umdloti Tidal‟s water has been classified as excellent based on E.coli concentrations. However, based on Enterococcus, the rating drops to good.

A.1.4. Umdloti Main

- **Seasonal Trends**

Seasonal averages for E.coli at Umdloti Main beach are shown in Table A-17. Autumn and winter yielded the highest concentration of E.coli most frequently, especially during the second half of the study period. Summer never produced the highest average.

Table A-17: Umdloti Main – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (2)	0.00 (2)	**33.3 (1)**	20.0 (2)	6.70 (3)	**13.3 (1)**	**36.7 (1)**	3.30 (3)	**96.4 (1)**	**69.3 (1)**	**95.0 (1)**
Winter	0.00 (2)	**20.0 (1)**	0.00 (2)	**52.2 (1)**	**43.3 (1)**	5.70 (2)	0.00 (4)	**32.7 (1)**	69.1 (2)	1.70 (4)	18.3 (3)
Spring	**53.3 (1)**	0.00 (2)	0.00 (2)	10.0 (3)	33.3 (2)	1.90 (4)	2.50 (3)	2.20 (4)	23.1 (4)	3.30 (3)	21.7 (2)
Summer	0.00 (2)	0.00 (2)	0.00 (2)	0.00 (4)	3.30 (4)	3.30 (3)	10.0 (2)	19.0 (2)	67.8 (3)	20.6 (2)	3.30 (4)

Seasonal averages for Enterococcus at Umdloti Main beach are shown in Table A-18. The highest concentrations occurred most frequently during the winter months, especially during the latter years. Although there are trends in seasonal averages for each of the bacteria, these trends do not correlate with each other.

Table A-18: Umdloti Main – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	13.3 (3)	0.00 (4)	26.7 (3)	0.00 (4)	3.30 (4)	36.7 (3)	49.0 (2)	5.00 (4)	42.6 (2)	**36.7 (1)**	21.7 (2)
Winter	**107 (1)**	33.3 (2)	13.3 (4)	52.2 (2)	28.9 (3)	**61.3 (1)**	5.00 (3)	**60.8 (1)**	**103 (1)**	3.30 (4)	**60.0 (1)**
Spring	253 (2)	**173 (1)**	**70.0 (1)**	41.1 (3)	**53.3 (1)**	53.3 (2)	0.80 (4)	34.4 (3)	10.0 (4)	16.7 (2)	-
Summer	0.00 (4)	6.70 (3)	42.2 (2)	**120 (1)**	31.1 (2)	11.1 (4)	**49.4 (1)**	39.0 (2)	17.3 (3)	14.9 (3)	-

- **Annual Trends**

The annual averages and standard deviations for E.coli and Enterococcus are depicted in Figures A-13 and A-14 respectively.

Average concentrations of E.coli varied slightly and have not changed significantly. Averages decreased and increased marginally from year to year. The highest average was determined to have occurred in 2011.

Relatively low deviations throughout most of the study period show minimal variability in E.coli levels. The deviations also increased and decreased in unison with the averages. Standard deviations have increased slightly during the last few years of the study period. This shows that E.coli has become more variable.

Both average concentrations and standard deviations of Enterococcus have decreased gradually since 2003. Standard deviations are not particularly large in many cases throughout the study period, which indicates that data set is spread over a small range and bacteria levels are consistent throughout the year. However, 2011 is shown to have a larger standard deviation associated with a lower average. When comparing the results of the indicator organisms, Enterococcus has been found to be consistent than E.coli, which is more variable.

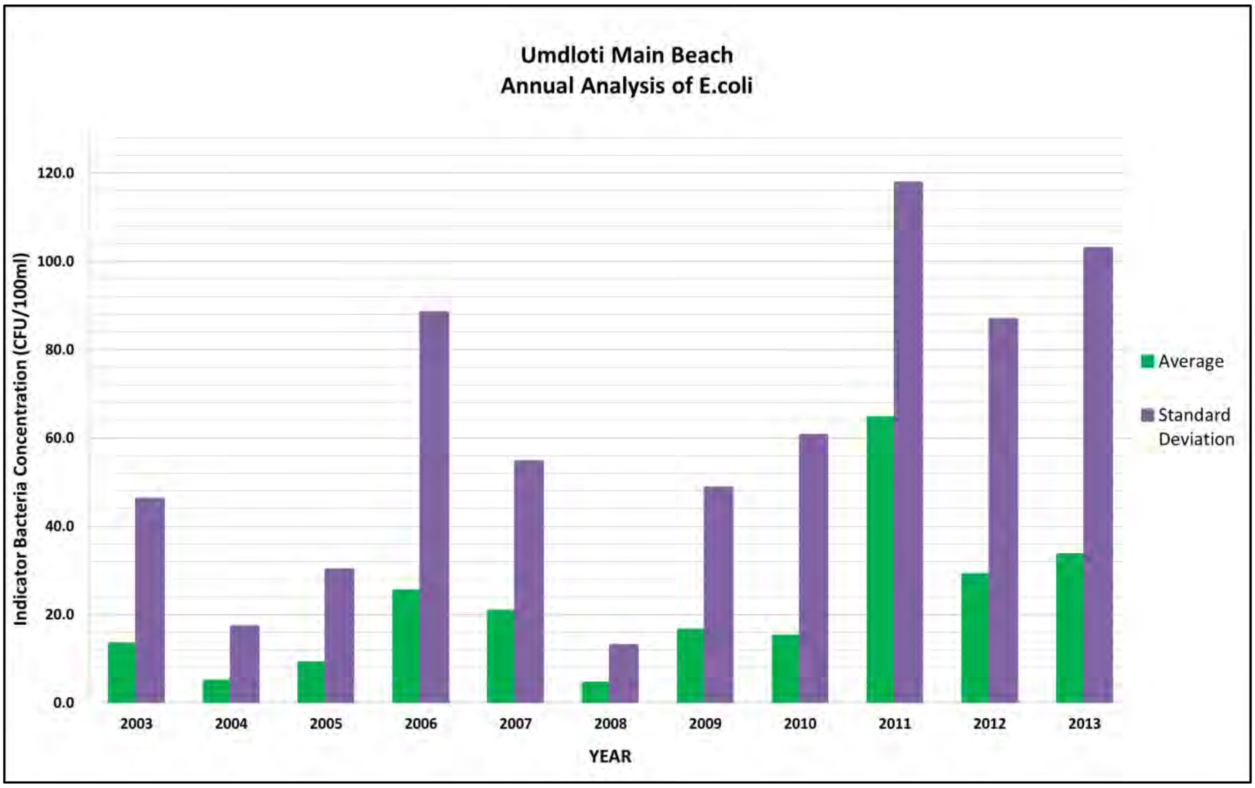

Figure A-13: Annual Analysis of E.coli at Umdloti Main Beach

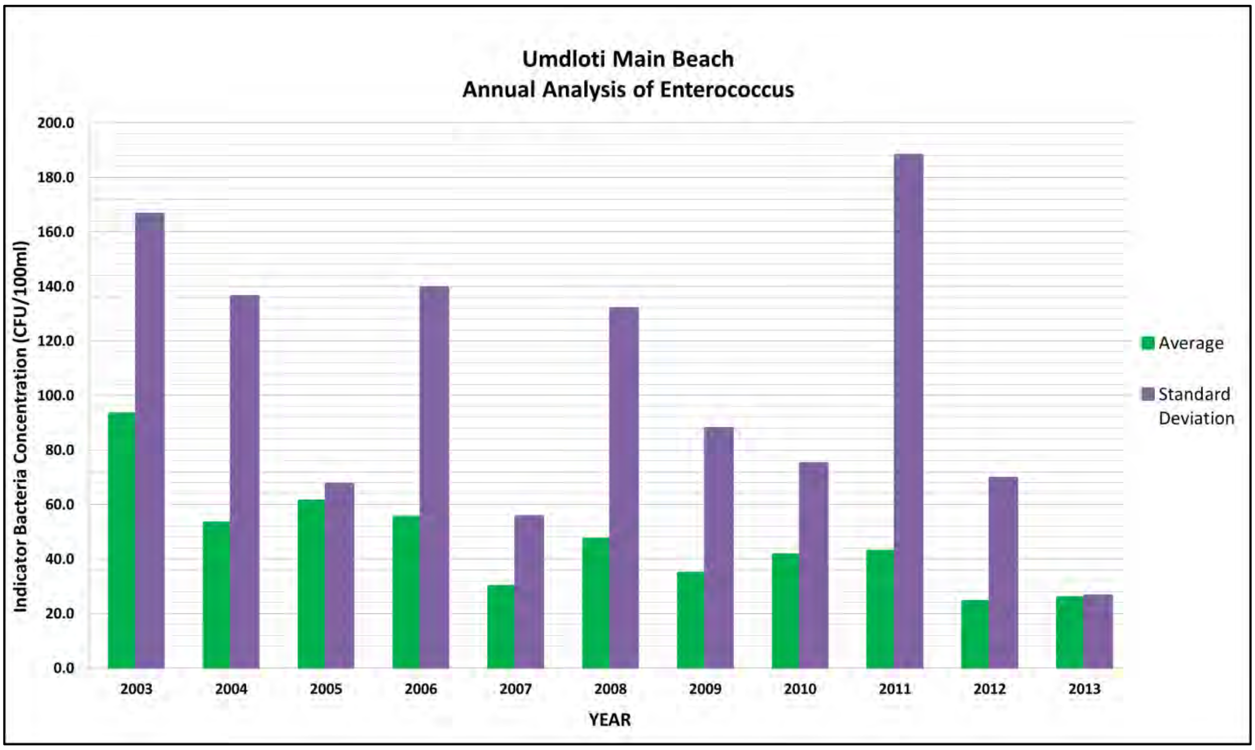

Figure A-14: Annual Analysis of Enterococcus at Umdloti Main Beach

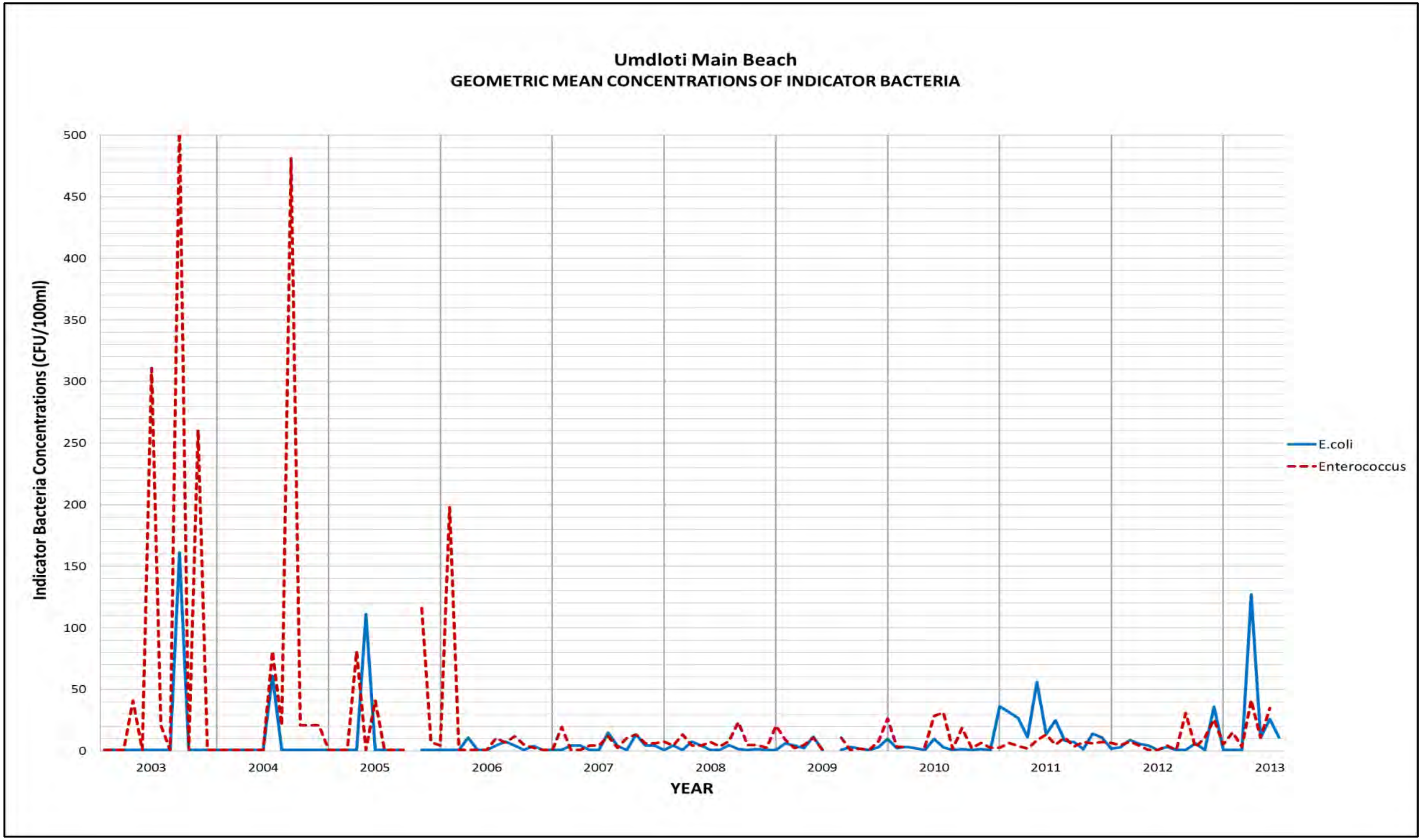

Figure A-15: Umdloti Main – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-15 compares the geometric means of E.coli and Enterococcus at Umdloti Main beach. Concentrations of Enterococcus exceed E.coli during most of the study period. Enterococcus concentrations have clearly decreased and become less variable and have not exceeded 50CFU/100ml since the beginning of 2006. E.coli also decreased and became more consistent from 2006 to 2010, however variability increased slightly thereafter. Counts of E.coli exceed Enterococcus more frequently in the latter years.

- **SAWQ Guidelines**

Table A-19 summarises the microbiological water quality rating based on E.coli at Umdloti Main beach. Water quality was determined to be predominantly excellent. Poor water quality never occurred for the entire duration of the study period. Annually the overall excellent rating was maintained with exception to just one year, 2011, where the rating dropped to good. This correlates to Figure A-13 which also shows higher averages and deviations for that same year.

Table A-19: Umdloti Main – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	E	E	E	E	G	E
APR	E	E	E	E	E	E	E	E	E	E	E
MAY	E	E	E	E	E	E	E	E	G	G	E
JUN	E	E	E	E	E	E	E	G	E	E	E
JUL	E	E	E	E	E	E	-	E	G	E	E
AUG	E	E	E	G	E	E	E	E	E	E	E
SEP	E	E	E	E	E	E	E	E	E	E	E
OCT	E	E	-	E	E	E	E	E	E	E	E
NOV	E	E	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	E	E	E	E	E	G	E	E

Table A-20 shows the microbiological rating for Enterococcus. Generally the levels indicate excellent to good water quality conditions, with the three most recent years of the study being classified as excellent. Poor water quality occurred infrequently and erratically. Based on both indicators, water quality at Umdloti Main beach has been consistently excellent.

Table A-20: Umdloti Main – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	G	G	E	E	E
FEB	E	E	E	G	G	E	G	E	E	E	E
MAR	E	E	E	E	E	G	E	E	E	P	E
APR	E	E	E	E	E	E	E	-	E	E	E
MAY	E	E	E	E	E	E	P	E	P	E	E
JUN	P	E	E	E	E	P	E	G	E	E	G
JUL	E	E	E	E	G	E	-	G	P	E	-
AUG	E	E	E	P	E	G	E	E	E	E	-
SEP	P	G	E	G	E	G	E	G	E	E	-
OCT	E	E	-	G	G	E	E	E	E	E	-
NOV	P	E	P	E	E	E	E	E	E	E	-
DEC	E	E	P	E	E	E	E	G	E	E	-
Annual	G	E	E	G	E	G	G	G	E	E	E

A.1.5. Umdloti South

- **Seasonal Trends**

Seasonal averages of E.coli are ranked in Table A-21. Autumn yielded the highest concentration most frequently and consistently for five consecutive years from 2009 to 2013. In addition, the actual level of E.coli in autumn during this time varies slightly. There are no other seasonal trends evident based on this bacterium.

Table A-21: Umdloti South – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	6.70 (3)	0.00 (2)	0.00 (2)	**13.3 (1)**	6.7 (3)	0.00 (4)	**136 (1)**	**69.2 (1)**	**107 (1)**	**128 (1)**	**78.3 (1)**
Winter	**80.0 (1)**	**53.3 (1)**	0.00 (2)	0.00 (3)	**183 (1)**	8.60 (2)	13.3 (2)	34.0 (2)	57.5 (2)	0.00 (4)	32.8 (2)
Spring	13.3 (2)	0.00 (2)	**10.0 (1)**	6.70 (2)	13.3 (2)	7.60 (3)	1.90 (4)	22.8 (3)	36.2 (4)	4.40 (3)	10.0 (3)
Summer	0.00 (4)	0.00 (2)	0.00 (2)	6.70 (2)	0.00 (4)	**50.0 (1)**	9.4 (3)	20.7 (4)	51.9 (3)	6.10 (2)	3.30 (4)

Table A-22 shows the ranking of the Enterococcus seasonal averages at Umdloti South beach. Autumn and winter produce the highest average concentrations most often during the study period. There is no evident correlation between E.coli and Enterococcus as the seasons which yielded the highest levels of each bacterium differ each year.

Table A-22: Umdloti South – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	13.3 (3)	0.00 (3)	**60.0 (1)**	**160 (1)**	40.0 (4)	0.00 (4)	**55.7 (1)**	**103 (1)**	34.8 (3)	**288 (1)**	23.3 (2)
Winter	**233 (1)**	6.70 (2)	26.7 (2)	13.3 (3)	**96.7 (1)**	50.0 (3)	8.30 (3)	52.1 (3)	**106 (1)**	9.00 (4)	**30.0 (1)**
Spring	40.0 (2)	**80.0 (1)**	10.0 (4)	127 (2)	66.7 (2)	70.5 (2)	5.30 (4)	71.4 (2)	18.9 (4)	9.40 (3)	-
Summer	0.00 (4)	0.00 (3)	13.3 (3)	13.3 (3)	46.7 (3)	**295 (1)**	45.0 (2)	16.5 (4)	48.2 (2)	20.2 (2)	-

- **Annual Trends**

Figures A-16 and A-17 portray the annual averages and standard deviations at Umdloti South for E.coli and Enterococcus respectively.

Averages have decreased and increased marginally throughout the study period, however, the averages have been consistently low. The average concentration of E.coli exceeded 50CFU/100ml once.

The standard deviations were found to be relatively small in many cases. This shows that concentrations of E.coli did not vary significantly throughout most years. Significant deviations are evident in 2007 and 2009. This indicates that the concentrations of E.coli were more variable during these years as compared to the rest of the study period.

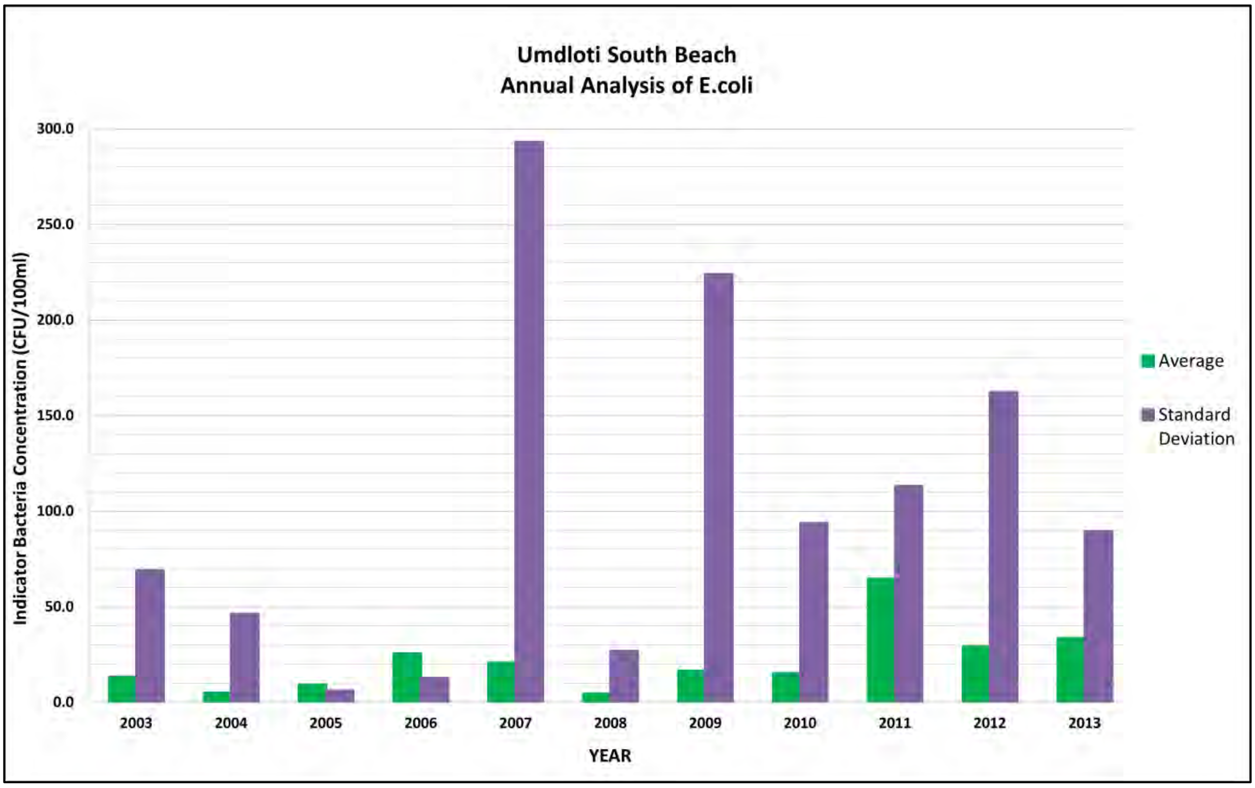

Figure A-16: Annual Analysis of E.coli at Umdloti South Beach

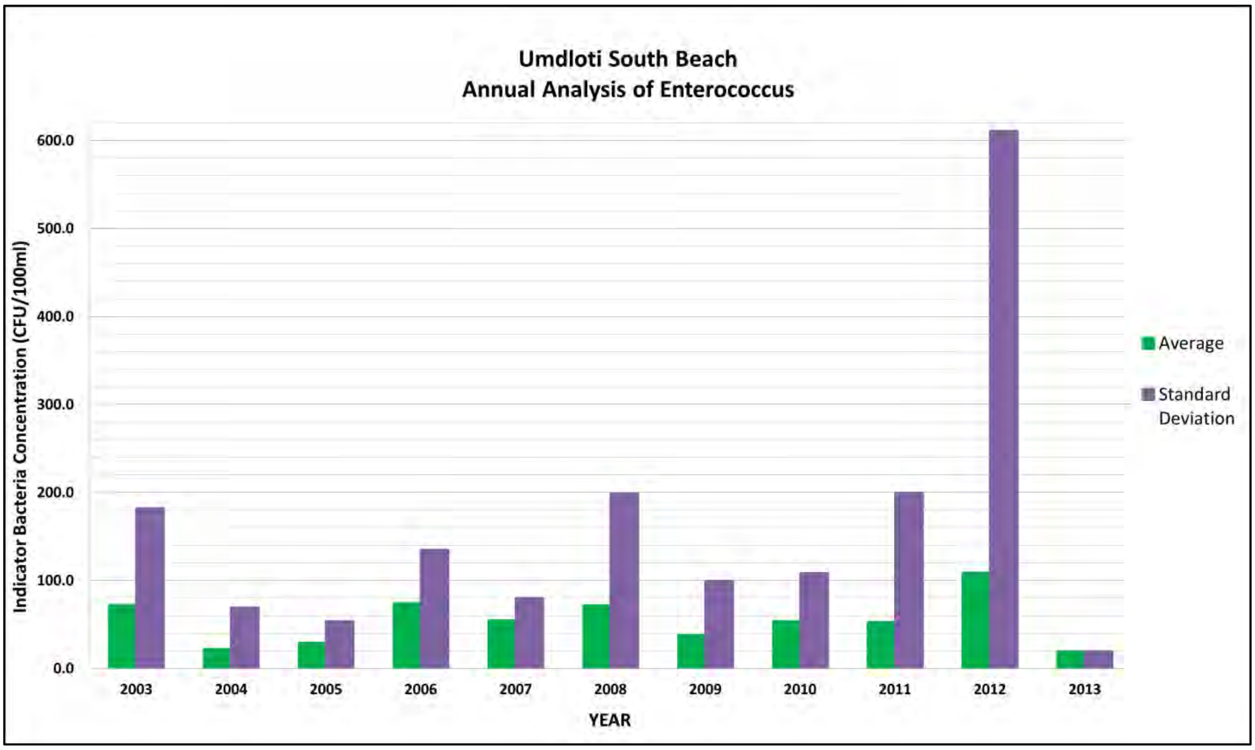

Figure A-17: Annual Analysis of Enterococcus at Umdloti South Beach

Average concentrations of Enterococcus have remained consistent with slight variation throughout most years with exception to the two most recent years. In 2012 the average level of Enterococcus as well as the standard deviation increased significantly. Thereafter there was a drastic decrease. The largest standard deviation occurred in 2012. This deviation of more than 6 times the average indicates that levels of Enterococcus varied greatly during 2012. Although average levels of both bacteria remained low, changes in E.coli and Enterococcus do not correlate with each other.

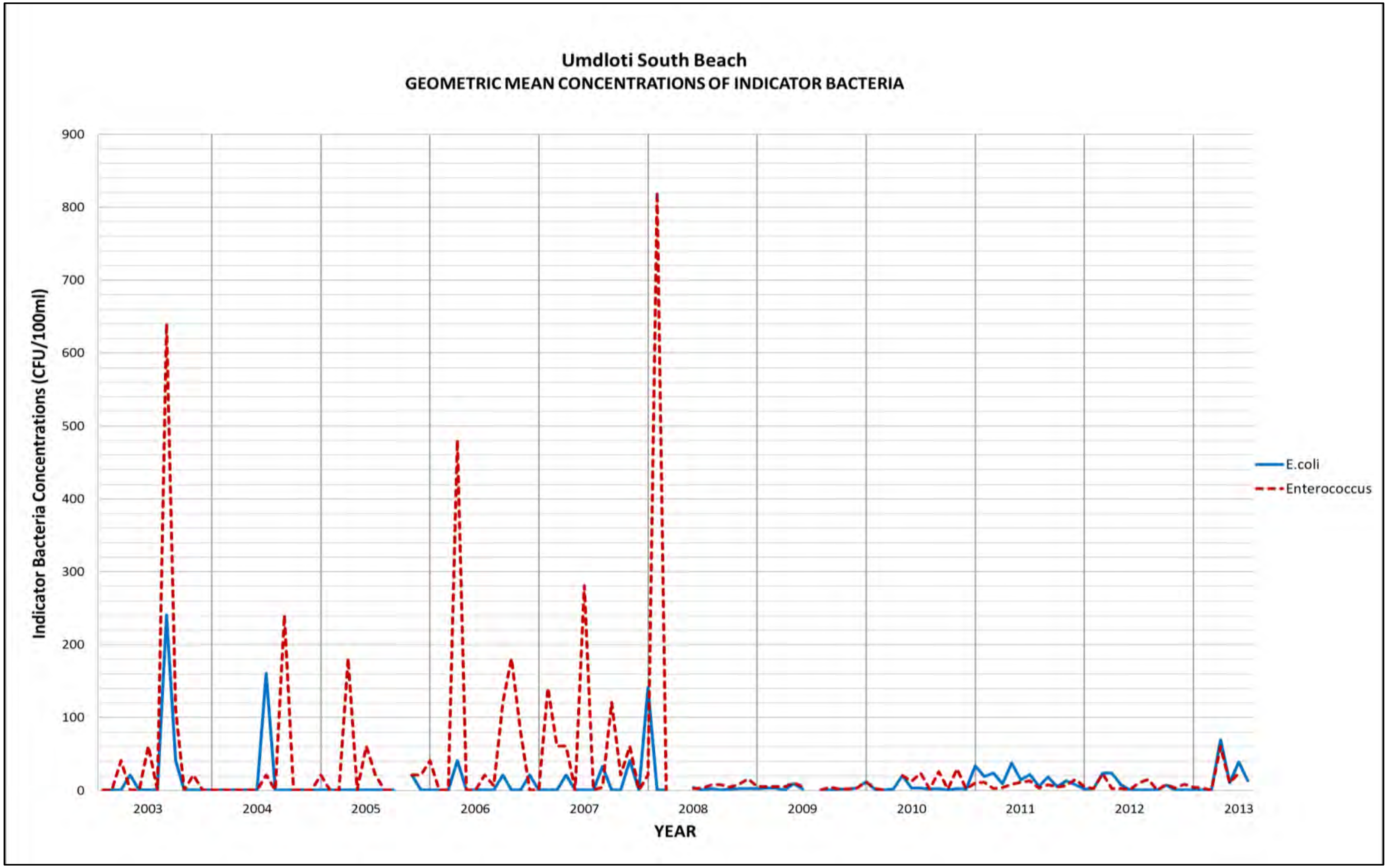

Figure A-18: Umdloti South – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-18 shows the geometric means of the indicator organisms at Umdloti South. It is evident that Enterococcus levels exceeded E.coli on most occasions. Enterococcus levels also varied erratically for the first half of the study period, whilst E.coli was only slightly variable. From 2008 onwards counts of both indicators decreased and became more uniform, with the geometric means rarely exceeding 50CFU/100ml.

- **SAWQ Guidelines**

Table A-23 shows the microbiological water quality rating based on the presence of E.coli. There have been no occurrences of poor water quality at Umdloti South beach from 2003 to 2013. The annual water quality classification is split between excellent and good.

Table A-23: Umdloti South – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	E	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	E	G	E	G	G	E
APR	E	E	E	G	E	-	E	E	E	E	E
MAY	E	E	E	E	E	-	G	G	G	G	E
JUN	E	E	E	E	E	E	E	G	E	E	E
JUL	E	E	E	E	E	E	G	E	G	E	E
AUG	E	E	E	E	G	E	E	E	E	E	E
SEP	E	E	E	E	E	E	E	E	G	E	E
OCT	E	E	-	E	E	E	E	E	E	E	E
NOV	E	E	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	E	G	E	G	G	G	G	E

Table A-24 depicts the water quality rating based on Enterococcus counts. With exception of a few occurrences of poor water quality, the water quality at Umdloti South has generally been rated as excellent and good. Based on both E.coli and Enterococcus, water quality at Umdloti South beach has been consistently excellent to good.

Table A-24: Umdloti South – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	G	G	E	E	E
FEB	E	E	E	E	G	G	G	E	G	E	E
MAR	E	E	E	E	E	E	G	E	E	P	E
APR	E	E	G	G	E	-	E	-	E	E	E
MAY	E	E	E	E	E	-	P	G	P	E	E
JUN	E	E	E	E	G	P	E	G	G	E	E
JUL	E	E	E	E	E	E	G	E	P	E	-
AUG	G	E	E	E	E	E	E	G	E	E	-
SEP	E	G	E	G	G	G	E	G	E	E	-
OCT	E	E	-	G	E	E	E	E	E	E	-
NOV	E	E	E	E	E	G	E	G	E	E	-
DEC	E	E	E	E	E	G	E	E	E	E	-
Annual	E	E	E	G	E	G	G	G	G	E	E

A.1.6. Bronze (Umhlanga)

Sample data for 2003 and 2004 was not provided for both indicator bacteria at Bronze Beach.

- **Seasonal Trends**

Table A-25 shows the seasonal averages of E.coli ranked from highest to lowest. The highest levels of E.coli were found to be in summer and autumn most regularly. It is evident that spring never yielded the highest and in many cases was in fact the lowest. No clear seasonal trends are evident as the season which yielded the highest concentration of E.coli differs each year.

Table A-25: Bronze – Ranking of E.coli Seasonal Averages

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	36.7 (2)	15.6 (2)	**86.7 (1)**	**260 (1)**	35.6 (2)	20.8 (2)	83.7 (3)	66.8 (2)	**165 (1)**
Winter	**53.3 (1)**	6.70 (3)	0.00 (4)	26.5 (2)	18.3 (3)	**27.2 (1)**	104 (2)	13.0 (4)	71.1 (3)
Spring	12.2 (3)	5.60 (4)	70.0 (2)	6.70 (4)	7.20 (4)	5.90 (4)	28.1 (4)	64.4 (3)	160 (2)
Summer	6.70 (4)	**36.7 (1)**	40.0 (3)	8.90 (3)	**101 (1)**	18.1 (3)	**125 (1)**	**92.8 (1)**	35.0 (4)

The seasonal averages for Enterococcus are ranked in Table A-26. As with E.coli, the season which yielded the highest count of Enterococcus differs each year. For 2007 to 2009 the seasons which yielded the highest Enterococcus levels correspond to that of E.coli.

Table A-26: Bronze – Ranking of Enterococcus Seasonal Averages

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**112 (1)**	27.8 (3)	**222 (1)**	**146 (1)**	85.3 (2)	15.8 (4)	65.6 (2)	64.0 (3)	56.7 (2)
Winter	43.3 (3)	**119 (1)**	70.0 (4)	82.8 (3)	26.7 (4)	29.8 (3)	**174 (1)**	57.3 (4)	**120 (1)**
Spring	94.4 (2)	18.9 (4)	207 (2)	48.6 (4)	42.2 (3)	52.3 (2)	19.8 (4)	**137 (1)**	-
Summer	30.0 (4)	93.3 (2)	80.0 (3)	102 (2)	**117 (1)**	**70.4 (1)**	59.1 (3)	69.2 (2)	-

- **Annual Trends**

Figures A-19 and A-20 depict the annual averages and standard deviation for E.coli and Enterococcus respectively.

Average concentrations of E.coli increased and decreased inconsistently. Ultimately the concentration of Enterococcus in 2013 is almost 4 times that at the beginning of the study period. Furthermore, the average concentration of E.coli only exceeded 100CFU/100ml in 2013. The standard deviations were significantly large for a few years in the study, namely 2007, 2008, 2009 and 2013. This indicates that the data set is spread over a large range and bacteria levels vary greatly throughout those years.

Apart from the slight increase in 2007 and decrease in 2010 the average concentration of Enterococcus has been consistent. Standard deviations decreased, showing less variation in Enterococcus at Bronze beach. When comparing the results of the two indicator organisms, Enterococcus has been found to be consistent in comparison to E.coli, which is more variable.

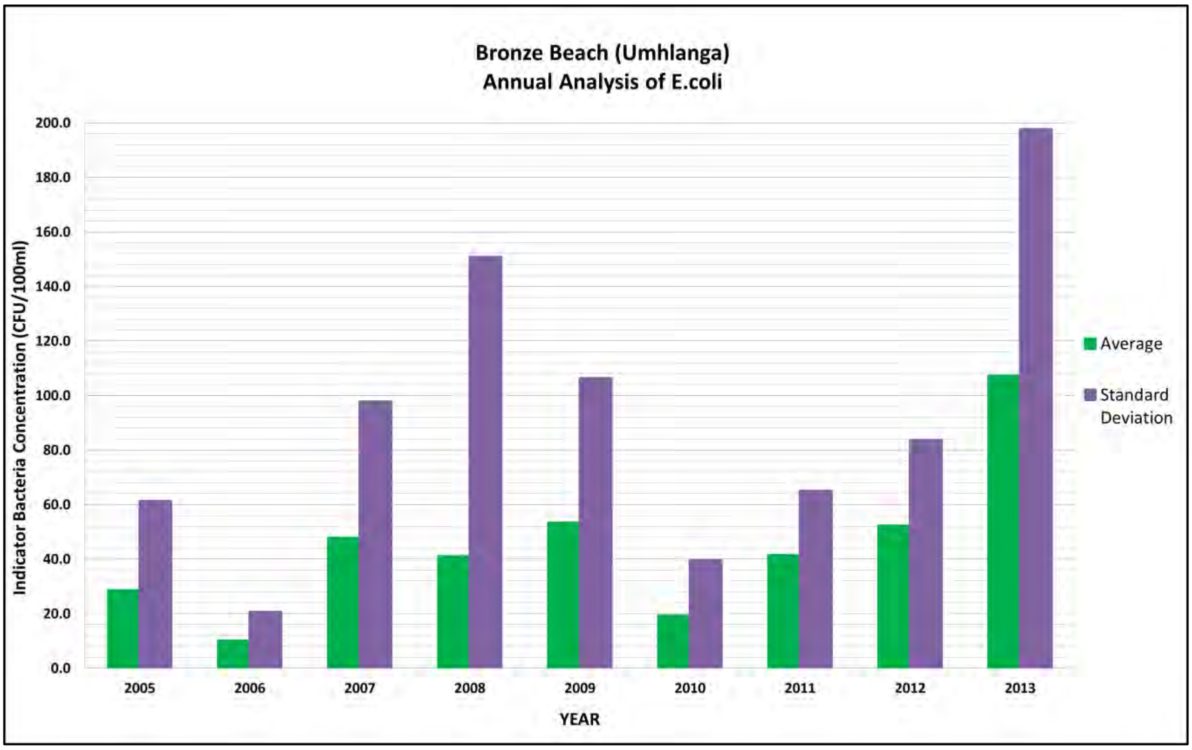

Figure A-19: Annual Analysis of E.coli at Bronze Beach

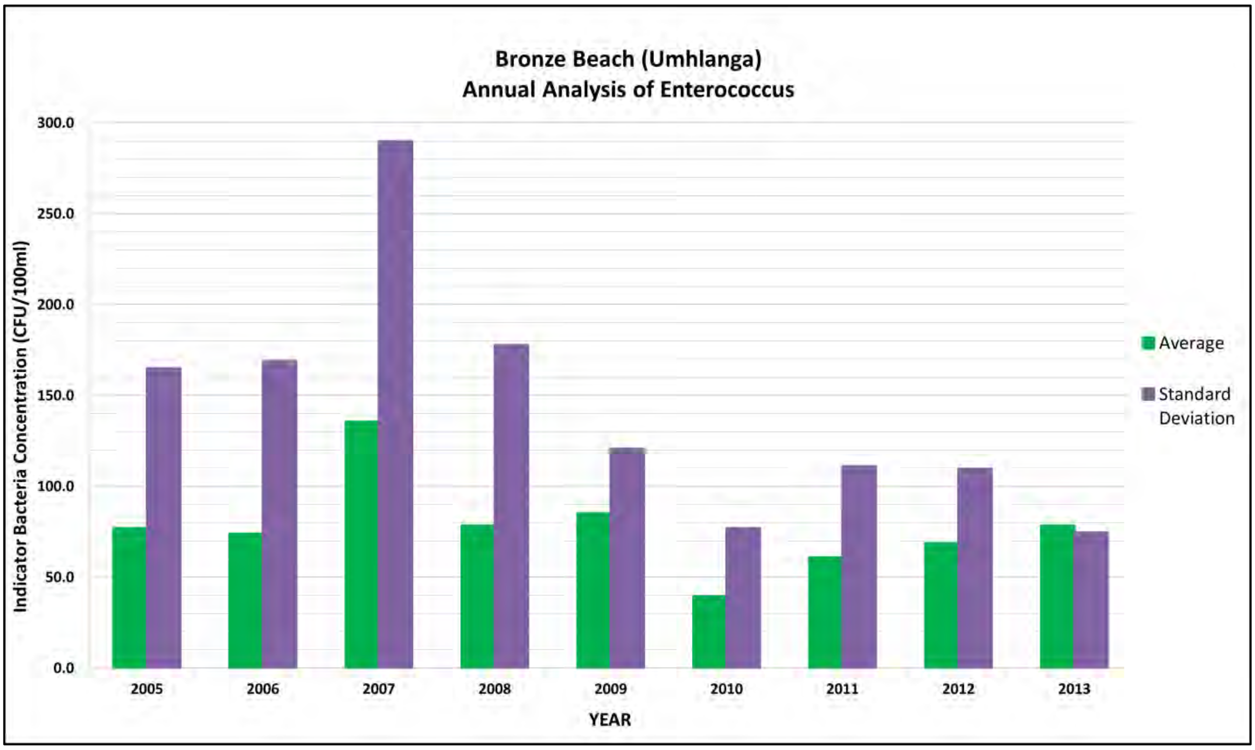

Figure A-20: Annual Analysis of Enterococcus at Bronze Beach

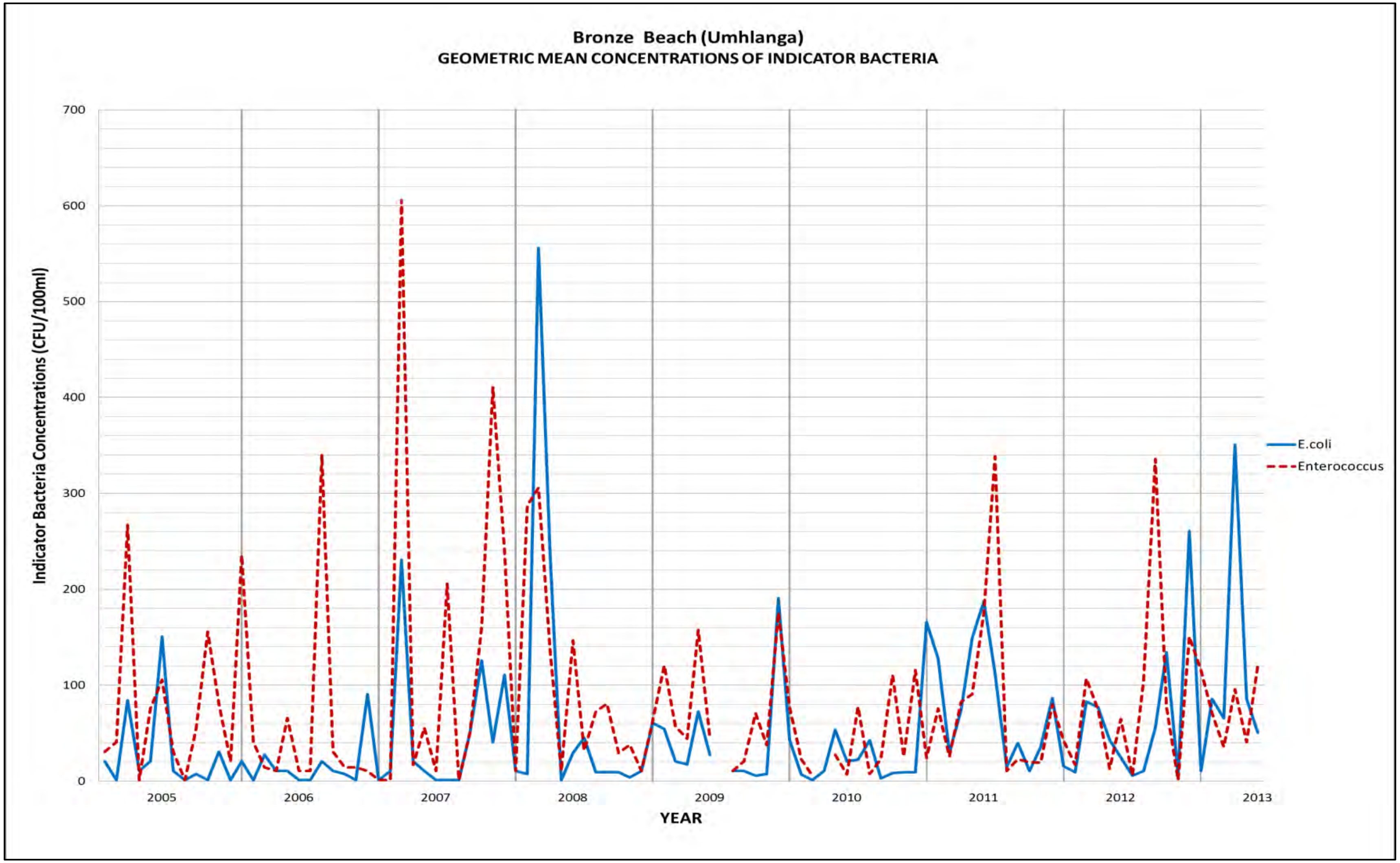

Figure A-21: Bronze (Umhlanga) – Geometric Mean Concentrations of Indicator Bacteria (2005-2013)

Figure A-21 illustrates the geometric means of the indicator bacteria at Bronze beach from 2005 to 2013. Throughout the entire study period both indicator organisms have remained capricious. Enterococcus counts are higher than E.coli throughout most of the study period. Counts of E.coli have been higher than Enterococcus towards the end of the study period.

- **SAWQ Guidelines**

The microbiological water quality rating for E.coli at Bronze beach is shown in Table A-27. Generally the levels of E.coli indicate excellent water quality conditions, with only four occurrences of poor water quality throughout the entire study period. Annually the water quality has maintained an excellent to good rating.

Table A-27: Bronze – E.coli Microbiological Water Quality Rating

	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	G	E	G	E	E
FEB	E	E	E	E	E	E	G	E	E
MAR	E	E	G	P	E	E	E	E	E
APR	E	E	E	G	E	E	E	E	P
MAY	E	E	E	E	E	E	G	E	E
JUN	G	E	E	E	E	E	P	E	E
JUL	E	E	E	E	-	E	G	E	E
AUG	E	E	E	E	E	E	E	E	E
SEP	E	E	E	E	E	E	E	E	E
OCT	E	E	E	E	E	E	E	E	P
NOV	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	G	E	G	G	E
Annual	E	E	E	E	G	E	E	E	G

Table A-28 depicts the microbiological water quality rating for Enterococcus. Annually water quality has been classified as excellent only once. Generally the water quality has been classified as good with significant occurrences of poor water quality throughout the duration of the study period. 2011 had the most occurrences of poor water quality with half the year classified as poor.

Table A-28: Bronze – Enterococcus Microbiological Water Quality Rating

	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	E	E	G	G	E	G	P
FEB	E	E	E	P	P	E	P	E	E
MAR	P	E	P	P	G	E	E	P	E
APR	E	E	E	G	G	P	P	P	G
MAY	E	E	E	E	P	E	P	E	E
JUN	G	E	E	P	G	E	P	G	G
JUL	E	E	P	E	-	P	P	E	-
AUG	E	P	E	P	E	E	E	P	-
SEP	G	E	E	P	E	E	E	P	-
OCT	P	E	G	E	P	P	E	G	-
NOV	G	E	P	G	E	E	E	E	-
DEC	E	E	P	E	P	E	P	P	-
Annual	G	G	P	G	G	E	P	G	G

A.1.7. Umhlanga Rocks Main

- **Seasonal Trends**

The seasonal trends for E.coli and Enterococcus at Umhlanga Rocks Main beach are ranked in Tables A-29 and A-30 respectively. Autumn yielded the highest concentration of E.coli most frequently. Summer consistently yielded the second highest in most of the latter years. The season which yielded the highest concentration of E.coli differs each year. No other seasonal trends are evident.

Table A-29: Umhlanga Rocks Main – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (4)	3.30 (3)	**22.2 (1)**	5.60 (3)	26.0 (3)	**180 (1)**	47.1 (3)	**57.2 (1)**	44.1 (3)	**76.6 (1)**	138 (3)
Winter	**113 (1)**	65.6 (2)	13.3 (2)	3.30 (4)	34.4 (2)	25.4 (2)	6.70 (4)	22.8 (2)	**126 (1)**	6.70 (4)	112 (4)
Spring	16.7 (2)	0.00 (4)	10.0 (3)	15.6 (2)	**60.0 (1)**	11.4 (4)	**66.9 (1)**	5.40 (4)	11.2 (4)	20.0 (3)	**235 (1)**
Summer	14.4 (3)	**78.9 (1)**	3.30 (4)	**16.7 (1)**	6.70 (4)	18.3 (2)	56.4 (2)	8.80 (3)	107 (2)	50.7 (2)	150 (2)

Summer yielded the highest levels of Enterococcus most frequently but not consistently. There are no definitive seasonal trends based on Enterococcus. There has been no correlation between E.coli and Enterococcus seasonal averages at Umhlanga Rocks main beach.

Table A-30: Umhlanga Rocks Main – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	3.30 (4)	70.0 (3)	48.9 (2)	13.3 (4)	**168 (1)**	123 (2)	87.6 (3)	27.5 (3)	68.3 (2)	46.0 (3)	125 (2)
Winter	52.2 (2)	166 (2)	13.3 (3)	**114 (1)**	62.2 (2)	71.6 (3)	23.3 (4)	40.6 (2)	**118 (1)**	66.7 (2)	**165 (1)**
Spring	**139 (1)**	3.30 (4)	**83.3 (1)**	24.4 (3)	46.7 (3)	56.2 (4)	92.2 (2)	11.9 (4)	24.1 (4)	**81.7 (1)**	-
Summer	21.1 (3)	**221 (1)**	**83.3 (1)**	103 (2)	16.7 (4)	**167 (1)**	**125 (1)**	**82.7 (1)**	61.2 (3)	31.4 (4)	-

- **Annual Trends**

Figure A-22 shows the annual averages and standard deviations for E.coli. The average concentrations have decreased and increased inconsistently, however, the concentrations remained low. The average did increase in 2013. Ultimately the concentration of E.coli at the end of the study period is nearly 5 times that at the start.

Relatively small standard deviations in most years of the study period show that the data set is clustered closely around the average and bacteria levels do not vary significantly throughout each year. Once again 2013 was found to have a larger deviation associated with the larger average.

Figure A-23 depicts the annual averages and standard deviations for Enterococcus. As with E.coli, the average concentrations of Enterococcus decreased and increased inconsistently throughout the study period. A significant increase is evident in 2013. Ultimately the concentration of Enterococcus at the end of the study period is nearly 3 times that at the start.

The standard deviations were found to be relatively small in most years of the study period. This indicates, as with E.coli, the data set is not spread over a wide range and bacteria levels do not vary significantly throughout the year. The larger average in 2013 also shows a larger standard deviation, which indicates that greater variations in Enterococcus are linked with larger averages.

Generally E.coli and Enterococcus averages increase and decrease together. Even though levels are different in most cases, a common pattern of change is evident.

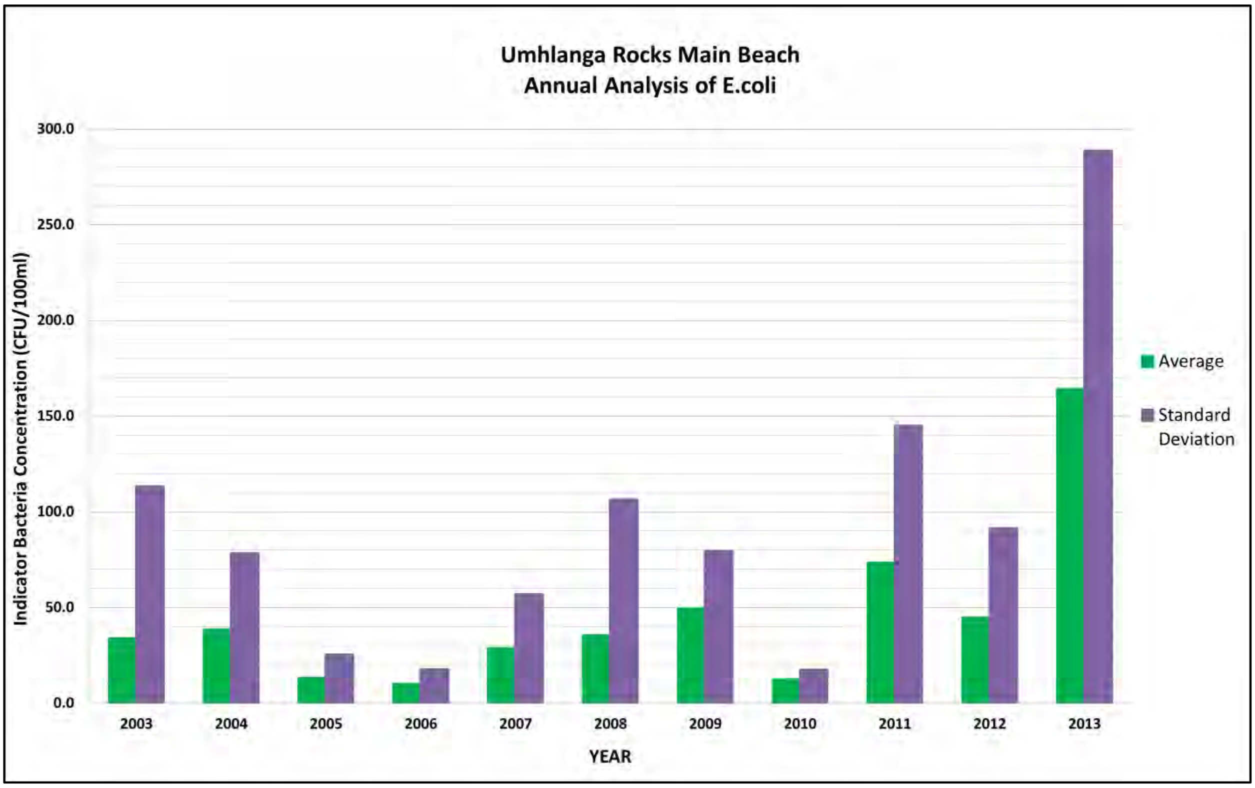

Figure A-22: Annual Analysis of E.coli at Umhlanga Rocks Main Beach

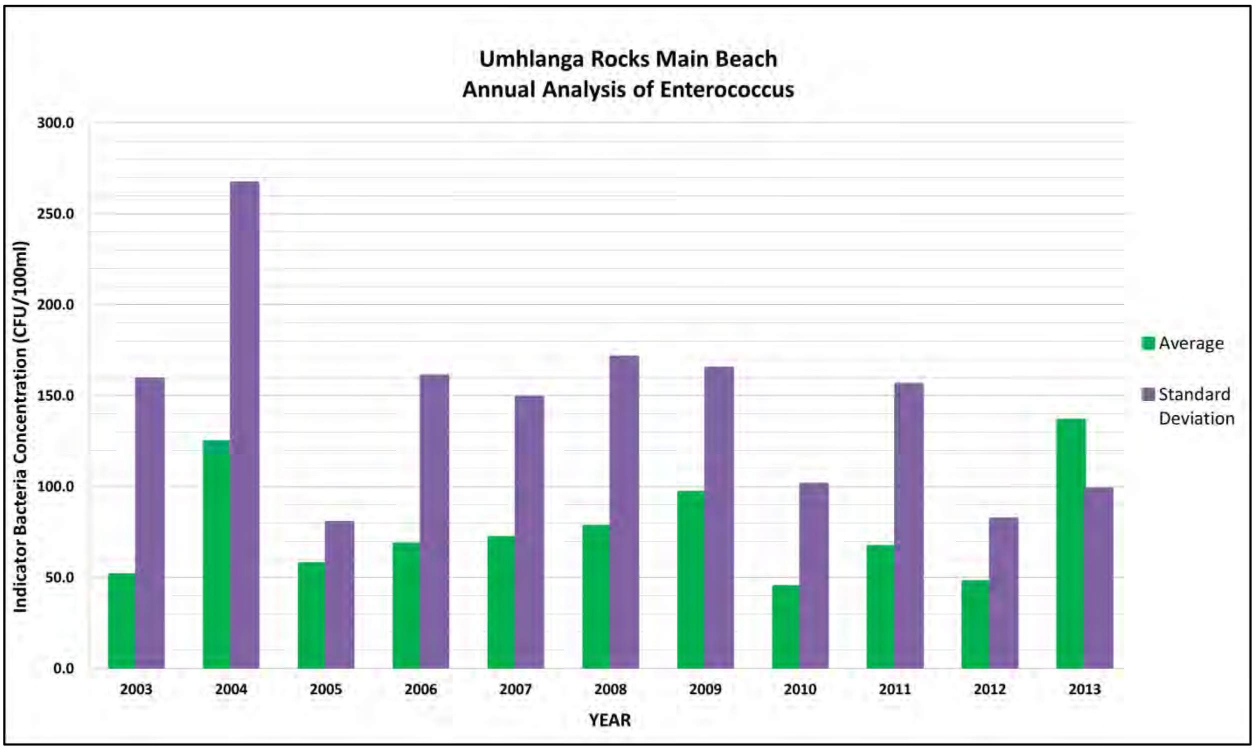

Figure A-23: Annual Analysis of Enterococcus at Umhlanga Rocks Main Beach

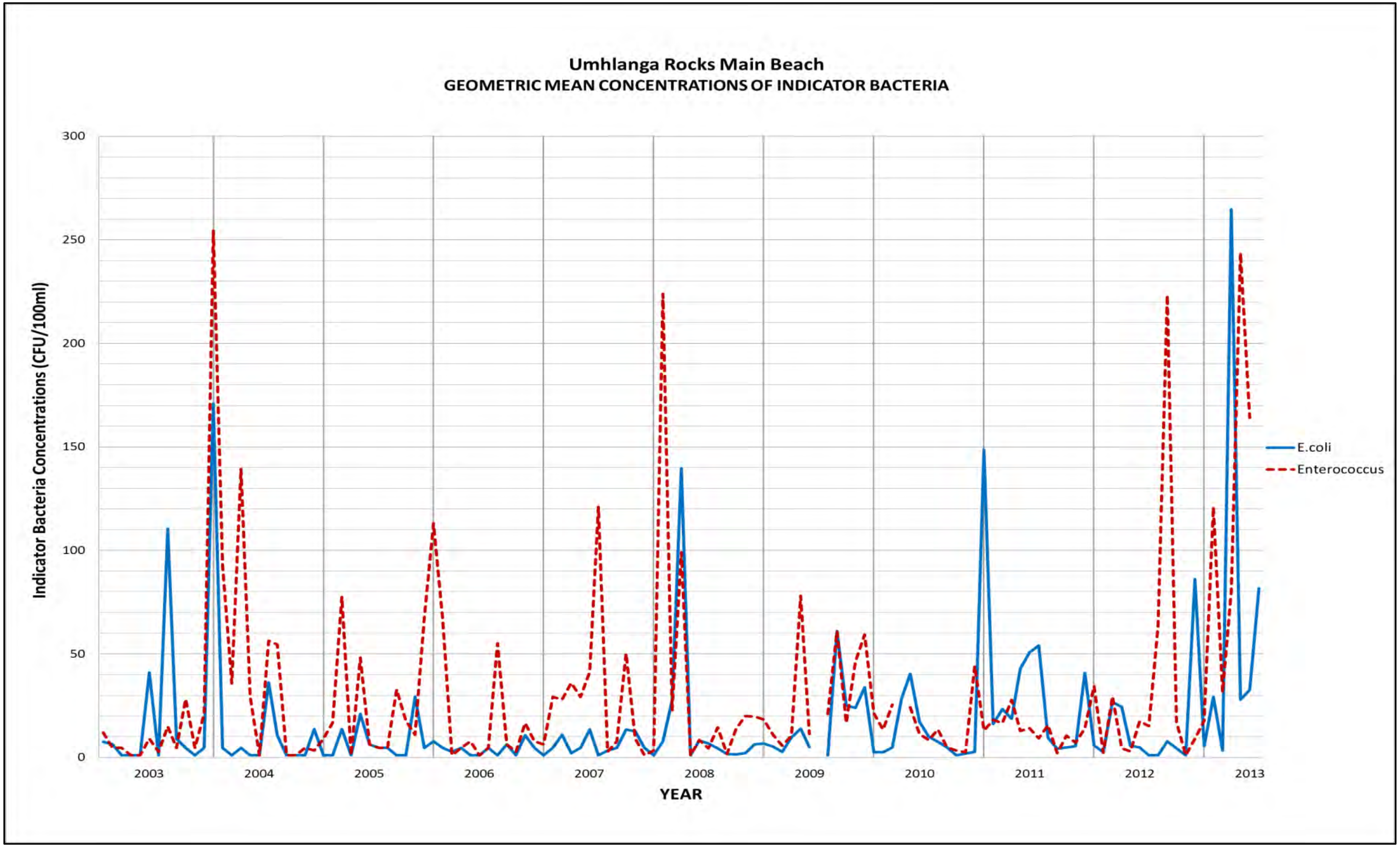

Figure A-24: Umhlanga Rocks Main – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are illustrated in Figure A-24. Both bacteria have been erratic throughout the study period but have rarely exceeded 100 counts per 100ml. Enterococcus exceeded E.coli significantly throughout most of the first half of the study.

- **SAWQ Guidelines**

Table A-31 shows the microbiological water quality rating for E.coli at Umhlanga Rocks Main beach. Based on E.coli concentrations, the water quality has been classified as predominantly excellent up until 2013. In the last year of the study the frequency of the occurrence of poor water quality increased drastically, with almost half of the year falling within the poor rating.

Table A-31: Umhlanga Rocks Main – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	G	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	P	E	E	E	G	E
APR	E	E	E	E	E	E	E	G	E	E	P
MAY	E	E	E	E	E	E	E	E	E	E	E
JUN	E	E	E	E	E	E	E	E	P	E	E
JUL	E	G	E	E	E	E	P	E	G	E	P
AUG	G	E	E	E	E	E	E	E	E	E	E
SEP	E	E	E	E	E	E	E	E	E	E	E
OCT	E	E	E	E	E	E	G	E	E	E	P
NOV	E	E	E	E	E	E	E	E	E	E	P
DEC	E	E	E	E	E	E	E	E	E	E	P
Annual	E	E	E	E	E	E	E	E	G	E	P

The microbiological water quality rating for Enterococcus is shown in Table A-32. Annually water quality has been classified as excellent only once. Generally the annual quality of the beach water has been rated as good. Frequent incidences of poor ratings are evident. Poor water quality has been experienced at least one month each year.

Table A-32: Umhlanga Rocks Main – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	P	E	E	E	G	G	G	P
FEB	E	P	P	G	E	P	G	E	P	E	G
MAR	E	E	G	E	P	P	G	E	G	P	E
APR	E	G	E	E	G	G	G	P	G	E	E
MAY	E	E	E	E	E	E	P	E	P	E	P
JUN	E	E	E	E	E	P	E	E	G	G	G
JUL	E	P	E	E	G	G	G	G	P	E	-
AUG	P	G	E	P	E	E	E	E	G	E	-
SEP	E	E	E	E	E	E	E	E	E	P	-
OCT	P	E	G	E	G	G	G	E	E	E	-
NOV	E	E	G	E	E	P	G	E	E	E	-
DEC	E	E	E	E	E	G	G	G	E	E	-
Annual	G	P	G	P	E	G	G	G	G	G	P

A.1.8. Umhlanga Rocks Granny's Pool

- **Seasonal Trends**

Seasonal averages of E.coli are ranked in Table A-33. Summer yielded the highest concentration most frequently. Winter never produced the highest counts of E.coli but most often yielded either the second highest or the lowest. No definite seasonal trends based on this bacterium are evident.

Table A-33: Umhlanga Rocks Granny's Pool – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	26.7 (2)	0.00 (2)	**13.3 (1)**	280 (3)	240 (3)	0.00 (4)	54.2 (2)	**64.2 (1)**	130 (3)	**86.8 (1)**	120 (3)
Winter	26.7 (2)	0.00 (2)	6.70 (2)	6.70 (4)	33.3 (4)	21.4 (3)	6.70 (4)	60.0 (2)	140 (2)	12.3 (4)	42.8 (4)
Spring	0.00 (3)	**6.70 (1)**	0.00 (3)	**1373 (1)**	1380 (2)	82.9 (2)	51.1 (3)	6.70 (4)	27.6 (4)	30.6 (2)	**240 (1)**
Summer	**100 (1)**	**6.70 (1)**	0.00 (3)	587 (2)	**1933 (1)**	**675 (1)**	**323 (1)**	30.4 (3)	**163 (1)**	28.2 (3)	162 (2)

Table A-34 shows that, as with E.coli, summer yielded the highest concentration of Enterococcus at Umhlanga Rocks Granny"s Pool most frequently and consistently from 2007 to 2011. The actual average concentration of Enterococcus during summer over this period shows a decrease. The ranking of the seasonal averages of the two indicators correspond for 2006, 2008, 2009, 2011 and 2012.

Table A-34: Umhlanga Rocks Granny's Pool – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (4)	**266 (1)**	**320 (1)**	253 (3)	500 (2)	40.0 (4)	101 (2)	85.0 (2)	107 (3)	**706 (1)**	130 (2)
Winter	66.7 (2)	26.7 (3)	26.7 (3)	53.3 (4)	93.3 (4)	89.4 (2)	10.0 (4)	63.3 (3)	116 (2)	52.7 (4)	**210 (1)**
Spring	30.0 (3)	0.00 (4)	30.0 (2)	**420 (1)**	287 (3)	81.0 (3)	35.0 (3)	51.1 (4)	47.8 (4)	64.4 (2)	-
Summer	**406 (1)**	33.3 (2)	20.0 (4)	268 (2)	**560 (1)**	**345 (1)**	**133 (1)**	**115 (1)**	**153 (1)**	57.5 (3)	-

- **Annual Trends**

The annual averages and standard deviations for E.coli are summarised in Figure A-25. Annually the average concentrations of E.coli increased and decreased inconsistently. Ultimately the levels of the bacterium in 2013 are greater than that at the beginning of the study period. Outstanding peaks are evident in 2006 and 2007, with concentrations reaching up to 180 times the lowest in 2004.

Extremely large standard deviations in 2006 and 2007 also indicate that the data set spread over a large range. This highlights that the concentrations of E.coli vary greatly throughout those two years.

Figure A-26 depicts the annual averages and standard deviations for Enterococcus. Slight variation is evident; however the average concentration of Enterococcus has remained comparatively consistent. The standard deviations have not been large except in 2012 where an exceptionally large deviation is clear. There is no correlation between E.coli and Enterococcus averages and standard deviations.

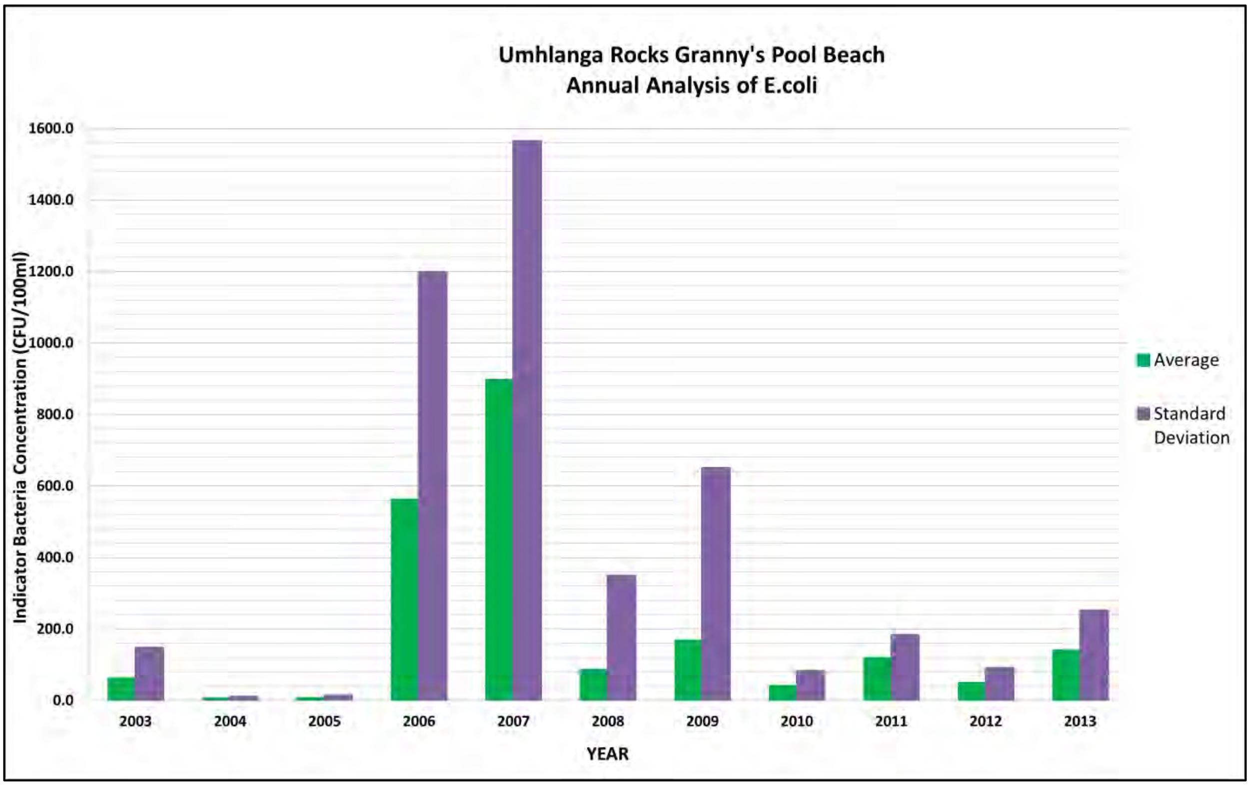

Figure A-25: Annual Analysis of E.coli at Umhlanga Rocks Granny's Pool Beach

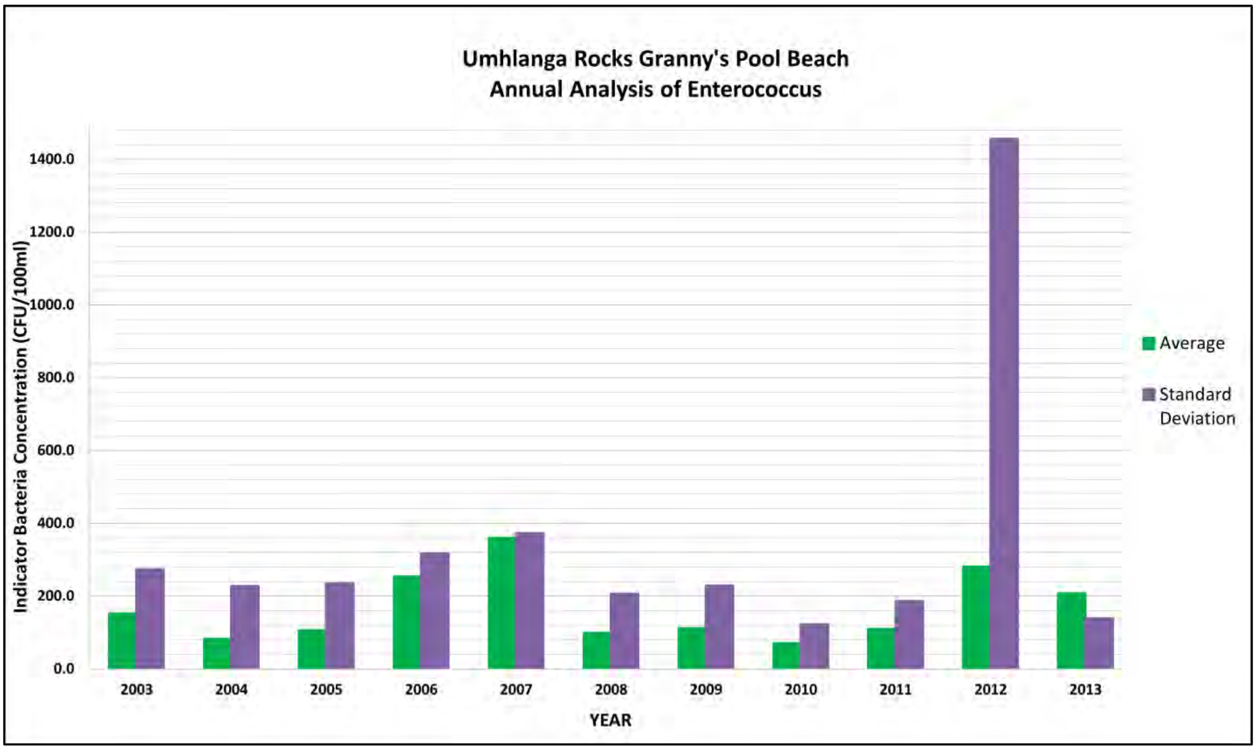

Figure A-26: Annual Analysis of Enterococcus at Umhlanga Rocks Granny's Pool Beach

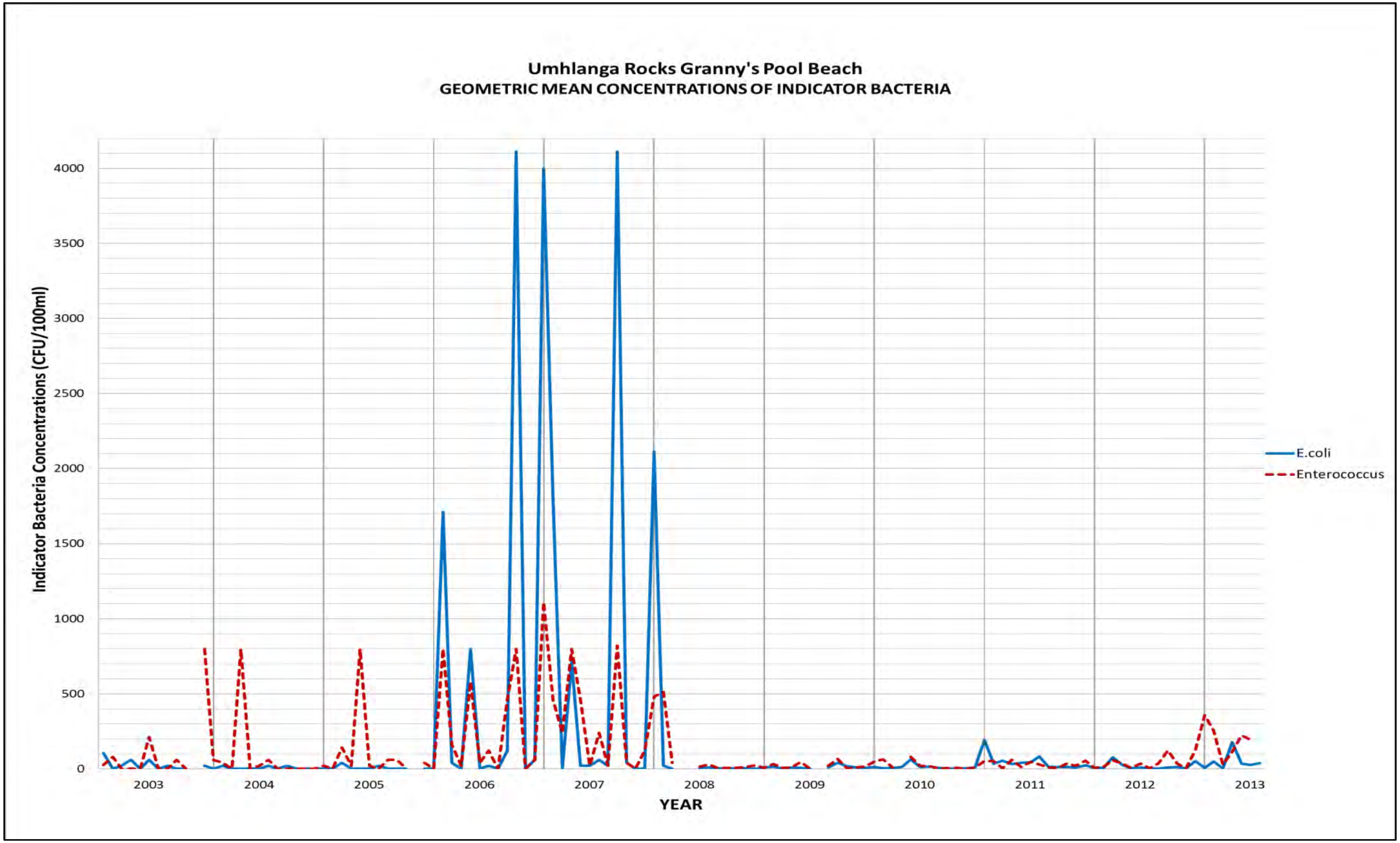

Figure A-27: Umhlanga Rocks Granny's Pool – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-27 compares the geometric means of E.coli and Enterococcus. E.coli levels were consistently higher than Enterococcus from 2006 to 2008. The concentrations of E.coli were extremely high during this time. Levels of both decreased after 2008 and have become less variable. Levels of both bacteria rarely exceeded 200CFU/100ml. Towards the end of the study period Enterococcus counts rose above E.coli.

- **SAWQ Guidelines**

Tables A-35 and A-36 show the microbiological water quality ratings based on E.coli and Enterococcus respectively.

Annual water quality ratings based on E.coli have been erratic, with an even split amongst excellent, good and poor ratings. Frequent occurrences of poor water quality are evident in the summer months during 2006 through to 2009. The last three months of the study have a poor rating.

Table A-35: Umhlanga Rocks Granny's Pool – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	E	E	E	P	P	P	E	G	E	E
FEB	E	E	E	P	P	E	P	E	G	E	E
MAR	E	E	E	G	E	E	E	E	G	G	E
APR	E	E	E	E	P	P	E	G	G	E	P
MAY	E	E	E	P	E	P	E	E	G	E	E
JUN	E	E	E	E	E	E	E	G	P	E	E
JUL	E	E	E	E	E	E	P	E	G	E	E
AUG	E	E	E	E	E	E	E	E	E	E	E
SEP	E	E	E	E	P	E	E	E	E	E	E
OCT	E	E	E	P	E	P	E	E	E	E	P
NOV	-	E	G	E	E	E	E	E	E	E	P
DEC	E	E	E	E	E	E	E	E	G	E	P
Annual	G	E	E	P	P	E	G	E	G	E	P

Annually water quality has been predominantly poor based on counts of Enterococcus, with every year since 2006 through to 2013 being classified as poor. Water quality has never been rated as excellent annually. Incidences of poor water quality are evident every year of the study. The summer months from 2007 to 2011, and then again in 2013, show clear patterns of poor water quality. At least half of each year from 2007 onward has a poor rating due to high concentrations of Enterococcus.

Table A-36: Umhlanga Rocks Granny's Pool – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	E	E	E	P	P	P	P	P	E	P
FEB	E	E	E	G	P	P	P	P	P	E	P
MAR	E	E	G	G	P	E	P	E	P	P	E
APR	E	P	E	E	P	P	G	P	P	G	G
MAY	E	E	P	P	P	P	P	P	P	E	P
JUN	P	E	E	E	E	P	E	P	P	P	P
JUL	E	E	E	G	P	G	P	P	P	E	-
AUG	E	E	E	E	E	E	E	E	E	E	-
SEP	E	E	E	P	P	E	E	G	E	P	-
OCT	E	E	E	P	E	P	E	P	P	E	-
NOV	-	E	P	E	E	P	E	E	E	E	-
DEC	P	E	E	E	G	E	G	G	P	G	-
Annual	G	G	G	P	P	P	P	P	P	P	P

A.1.9. Umhlanga Rocks Lighthouse

- **Seasonal Trends**

Seasonal averages for E.coli at Umhlanga Rocks Lighthouse beach are shown in Table A-37. No seasonal trends are evident as the season which yielded the highest concentration of E.coli differs each year.

Table A-37: Umhlanga Rocks Lighthouse – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	40.0 (2)	20.0 (2)	0.00 (4)	720 (2)	**53.3 (1)**	0.00 (4)	46.0 (4)	125 (2)	114 (2)	44.6 (2)	116 (2)
Winter	0.00 (4)	**633 (1)**	13.3 (3)	13.3 (4)	6.70 (4)	**311 (1)**	148 (3)	**327 (1)**	106 (3)	4.70 (4)	19.4 (4)
Spring	**500 (1)**	0.00 (3)	40.0 (2)	180 (3)	13.3 (3)	72.4 (3)	155 (2)	30.8 (4)	24.0 (4)	**57.8 (1)**	**273 (1)**
Summer	23.3 (3)	0.00 (3)	**1420 (1)**	**807 (1)**	33.3 (2)	141 (2)	**291 (1)**	75.7 (3)	**160 (1)**	14.7 (3)	113 (3)

Table A-38 shows the ranking of the Enterococcus seasonal averages. Summer and autumn produced the highest average count of Enterococcus most often. Spring never yielded the highest average. There has been no clear correlation between the seasonal averages for E.coli and Enterococcus.

Table A-38: Umhlanga Rocks Lighthouse – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**53.3 (1)**	6.70 (4)	33.3 (3)	26.7 (3)	**273 (1)**	60.0 (4)	170 (2)	**215 (1)**	134 (2)	**687 (1)**	**76.7 (1)**
Winter	40.0 (2)	**260 (1)**	160 (2)	0.00 (4)	13.3 (3)	178 (2)	70.0 (4)	212 (2)	119 (3)	17.7 (3)	55.0 (2)
Spring	0.00 (4)	20.0 (3)	10.0 (4)	106 (2)	33.3 (2)	93.3 (3)	102 (3)	91.4 (4)	44.4 (4)	44.4 (2)	-
Summer	33.3 (3)	60.0 (2)	**426 (1)**	**266 (1)**	6.70 (4)	**386 (1)**	**249 (1)**	151 (3)	**157 (1)**	5.60 (4)	-

- **Annual Trends**

Figures A-28 and A-29 portray the annual averages and standard deviations for E.coli and Enterococcus respectively. With exception to 2007 and 2012, average E.coli counts have remained consistently below 200CFU/100ml. The standard deviations have been consistently large throughout the study period indicating that E.coli counts have varied significantly for the entire duration of the study.

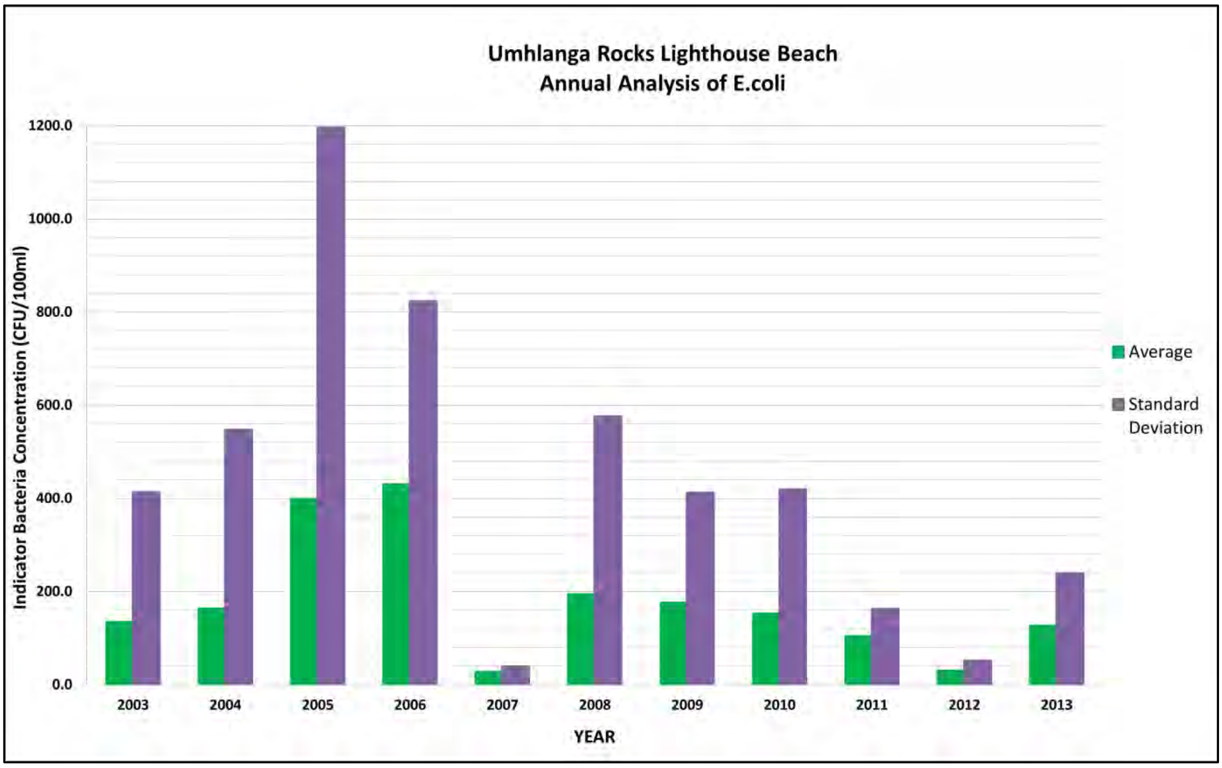

Figure A-28: Annual Analysis of E.coli at Umhlanga Rocks Lighthouse Beach

Average levels of Enterococcus have increased since 2003. The highest counts of the bacterium occurred in 2012 with the average counts being approximate 6 times that at the start of the study period. The standard deviations have remained comparatively large. Furthermore, the largest average is also linked to the largest deviation. There is no correlation between E.coli and Enterococcus averages.

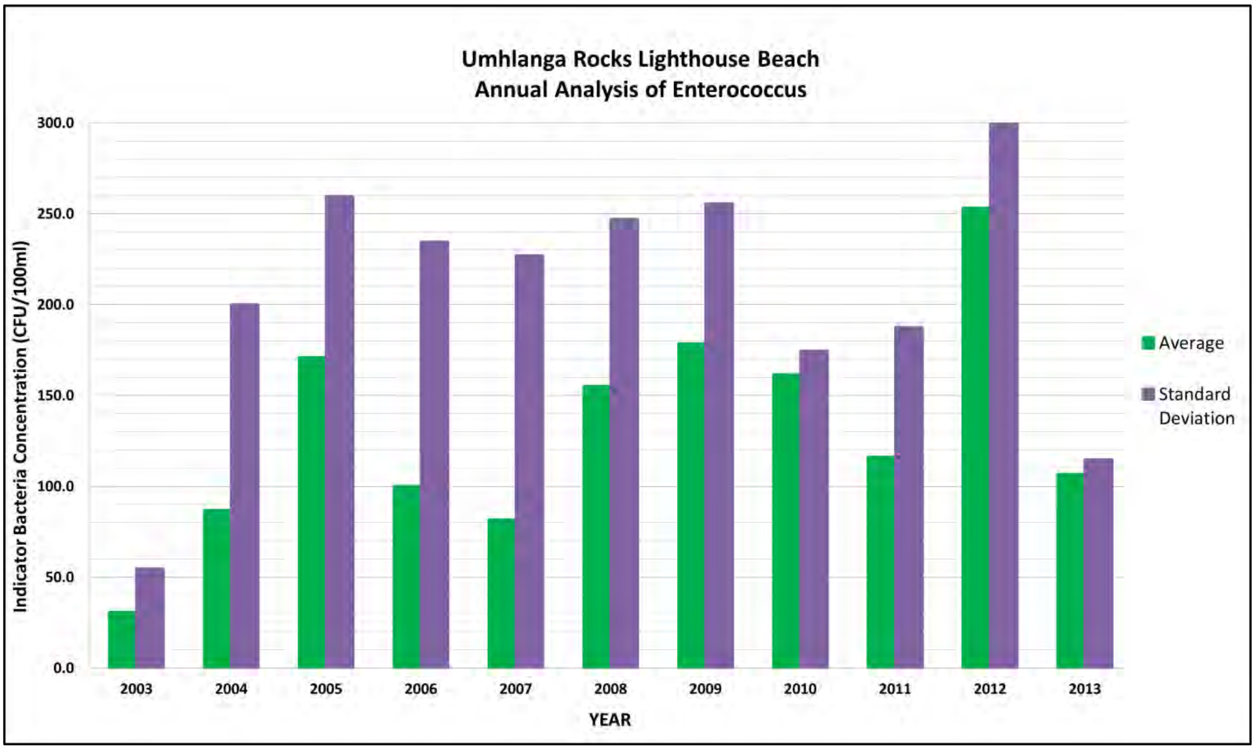

Figure A-29: Annual Analysis of Enterococcus at Umhlanga Rocks Lighthouse Beach

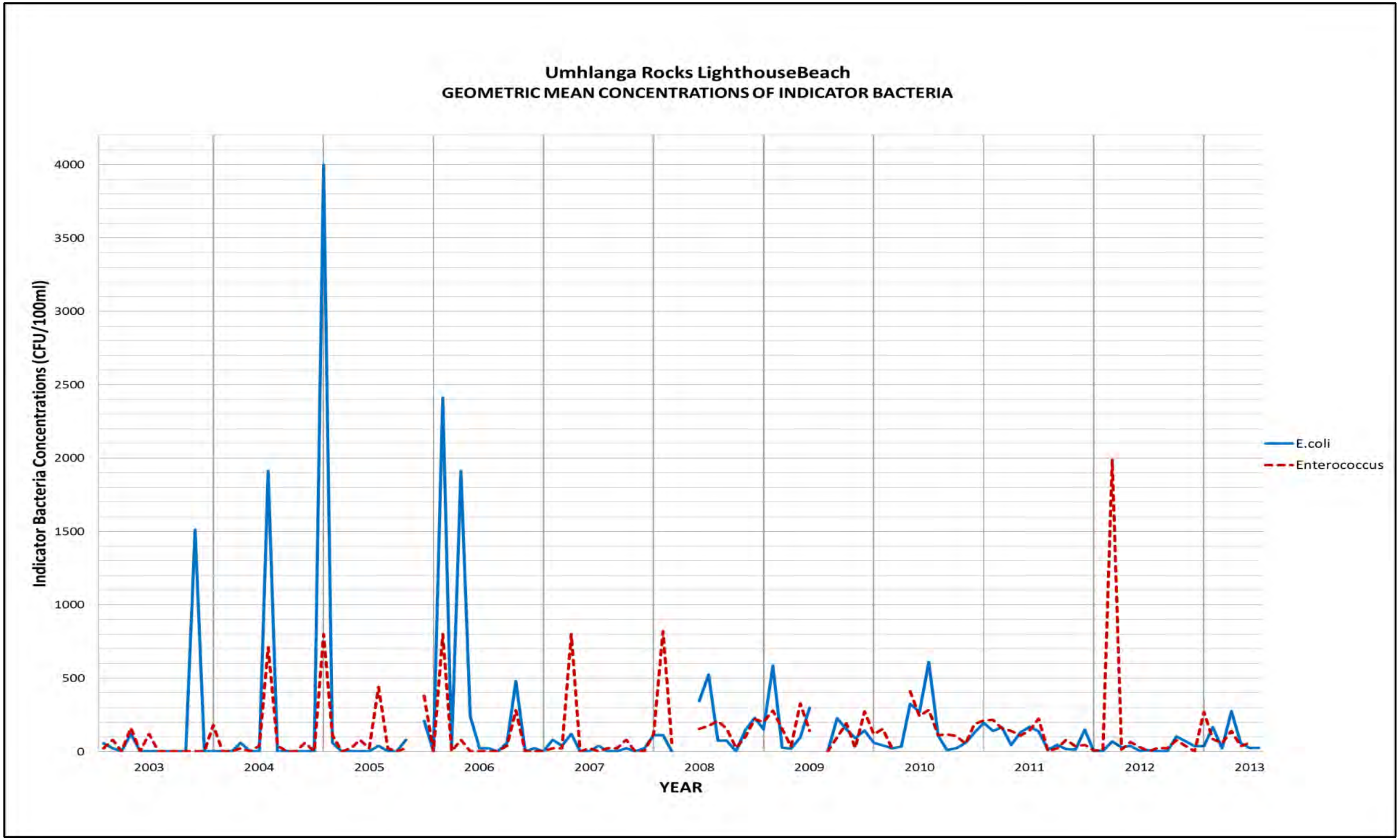

Figure A-30: Umhlanga Rocks Lighthouse – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are compared in Figure A-30. E.coli exceeded Enterococcus throughout most of the study period. Levels of E.coli exceeded 1000 counts on several occasions during the first four years. E.coli has become more consistent after 2006; however counts have exceeded 500 CFU/100ml on a few occasions since then. Enterococcus has remained irregular with an outstanding peak in early 2012.

- **SAWQ Guidelines**

Table A-39 depicts the microbiological water quality rating based on E.coli. Generally, the overall annual water quality has been classified as good. Poor water quality has been infrequent. Although there is only one occurrence of poor quality in 2006 the overall classification is poor. This is due to extremely high counts of the bacterium in February. Although high counts of E.coli also occurred in January 2005, the overall rating for that year is good. This is due to extremely low counts during the rest of the year.

Table A-39: Umhlanga Rocks Lighthouse – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	P	E	E	E	G	E	G	E	E
FEB	E	E	E	P	E	E	P	E	G	E	G
MAR	E	E	E	E	E	E	E	E	G	E	E
APR	E	E	E	E	E	-	E	E	E	E	P
MAY	E	E	E	E	E	-	G	G	G	E	E
JUN	E	E	E	E	E	G	G	G	G	E	E
JUL	E	G	E	E	E	G	-	G	G	E	E
AUG	E	E	E	E	E	G	E	G	E	E	E
SEP	E	E	E	E	E	G	G	E	E	E	E
OCT	E	E	E	G	E	E	G	E	E	E	P
NOV	G	E	-	E	E	G	E	E	E	E	P
DEC	E	E	E	E	E	G	G	G	G	E	G
Annual	G	G	G	P	E	G	G	G	G	E	P

Table A-40 summarises the microbiological water quality rating based on Enterococcus. Annually the waters at Umhlanga Rocks Lighthouse have never been classified as excellent, with the ratings split between good and poor. Frequent occurrences of poor water quality were experienced from 2008 to 2011. In both 2010 and 2011 the water quality was rated poor for approximately three quarters of each year. Although there is only one occurrence of poor quality in 2006 the overall classification is poor. This is due to extremely high counts of the bacterium in October from one sample.

Table A-40: Umhlanga Rocks Lighthouse – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	G	E	E	G	P	P	P	E	P
FEB	E	E	E	G	E	P	P	P	P	E	G
MAR	E	E	E	E	E	E	P	E	P	P	G
APR	G	E	E	E	P	-	E	-	P	E	G
MAY	E	E	E	E	E	-	P	P	P	G	E
JUN	G	E	E	E	E	P	G	P	P	E	E
JUL	E	G	G	E	E	G	-	P	P	E	-
AUG	E	E	E	E	E	G	E	P	E	E	-
SEP	E	E	E	E	E	G	G	P	E	E	-
OCT	E	E	E	P	E	G	G	P	P	G	-
NOV	E	E	-	E	E	P	E	G	G	E	-
DEC	E	E	G	E	E	G	G	P	G	E	-
Annual	G	G	G	P	G	P	P	P	P	G	P

A.1.10. Glenashley

- **Seasonal Trends**

Table A-41 summarises the seasonal averages of E.coli at Glenashley beach. Summer and winter yielded the highest most frequently; however, no clear seasonal trends are evident.

Table A-41: Glenashley – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (4)	13.3 (4)	28.9 (3)	23.3 (1)	40.0 (3)	**105 (1)**	111 (2)	83.3 (2)	138 (3)	**125 (1)**	141 (2)
Winter	**460 (1)**	327 (2)	46.7 (2)	22.2 (2)	**990 (1)**	75.8 (2)	30.0 (3)	**97.2 (1)**	**161 (1)**	37.2 (3)	23.9 (4)
Spring	30.0 (2)	23.3 (3)	46.7 (2)	10.0 (3)	40.0 (3)	27.6 (4)	27.5 (4)	32.9 (4)	35.8 (4)	81.7 (2)	**201 (1)**
Summer	16.7 (3)	**380 (1)**	**50.0 (1)**	**23.3 (1)**	106 (2)	41.1 (3)	**165 (1)**	39.3 (3)	149 (2)	6.10 (4)	38.3 (3)

The seasonal averages of Enterococcus are ranked in Table A-42. Summer and winter yielded the highest concentrations most frequently. Spring yielded the highest concentrations only once during the study period in 2005, and has remained either third or fourth in the ranking thereafter. There is no clear correlation between the two indictors.

Table A-42: Glenashley – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	16.7 (4)	10.0 (4)	28.9 (3)	18.9 (4)	236 (2)	25.0 (4)	81.6 (2)	**173 (1)**	118 (2)	**534 (1)**	90.0 (2)
Winter	**243 (1)**	103 (2)	23.3 (2)	38.9 (3)	**406 (1)**	84.9 (2)	3.30 (4)	92.2 (2)	**142 (1)**	16.1 (4)	**115 (1)**
Spring	133 (2)	23.3 (3)	**95.6 (1)**	120 (2)	60.0 (4)	54.3 (3)	23.3 (3)	45.8 (4)	56.4 (3)	48.3 (3)	-
Summer	70.0 (3)	**276 (1)**	23.3 (2)	**146 (1)**	73.3 (3)	**231 (1)**	**144 (1)**	79.6 (3)	56.2 (3)	51.9 (2)	-

- **Annual Trends**

Figures A-31 and A-32 represent the annual averages and standard deviation for E.coli and Enterococcus respectively. Average concentrations increased and decreased slightly but have remained roughly consistent from 2009 onward. The standard deviations were determined to be relatively large in most cases. The highest average and largest standard deviation was experienced in 2007.

There has been a slight variation in Enterococcus averages; however, they have remained mostly consistent throughout the study period. Average counts of this bacterium have remained distinctly below 200/100ml every year with exception to 2012. The standard deviations have remained relatively small. However, the deviation in 2012 is extremely high. There is no correlation between E.coli and Enterococcus averages and deviations.

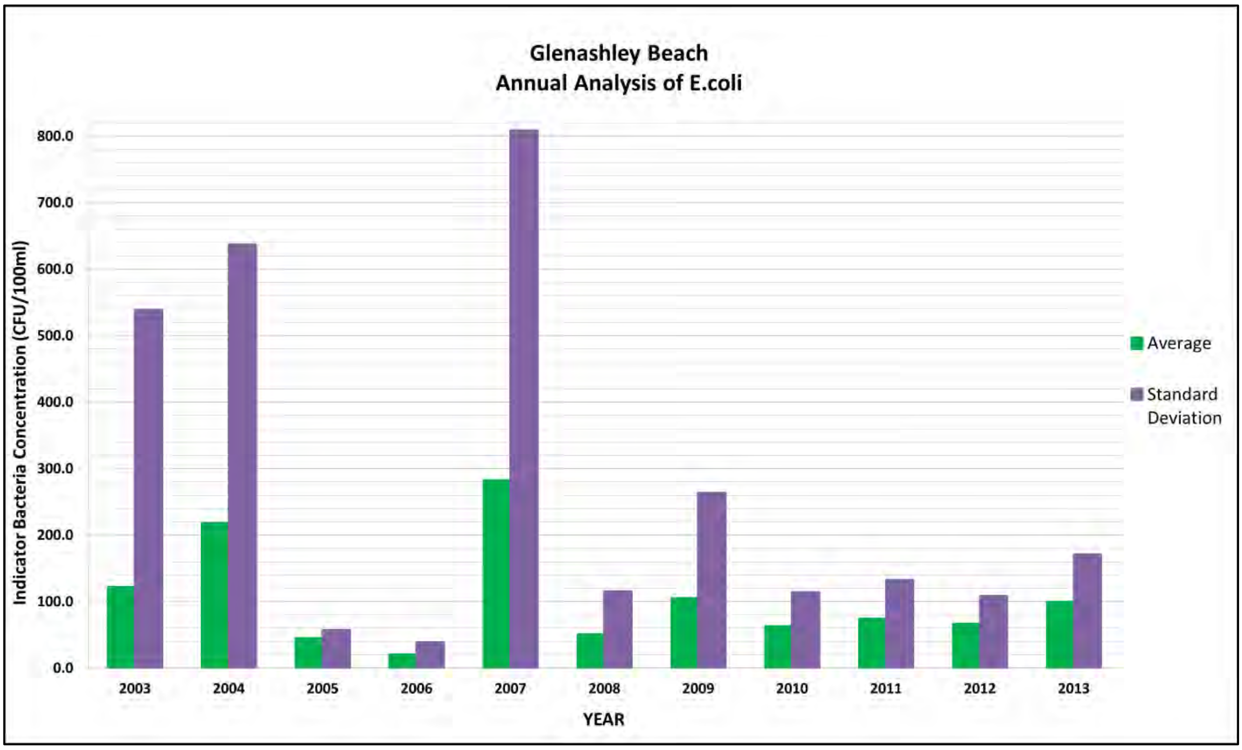

Figure A-31: Annual Analysis of E.coli at Glenashley Beach

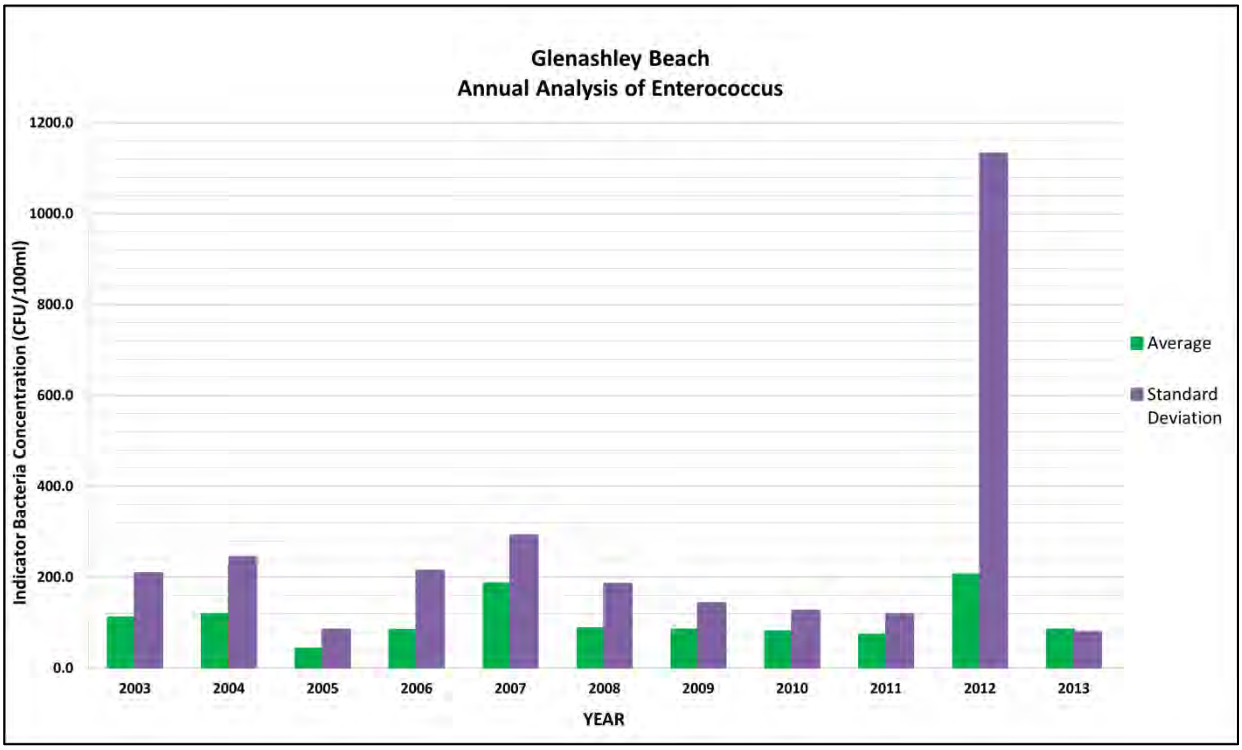

Figure A-32: Annual Analysis of Enterococcus at Glenashley Beach

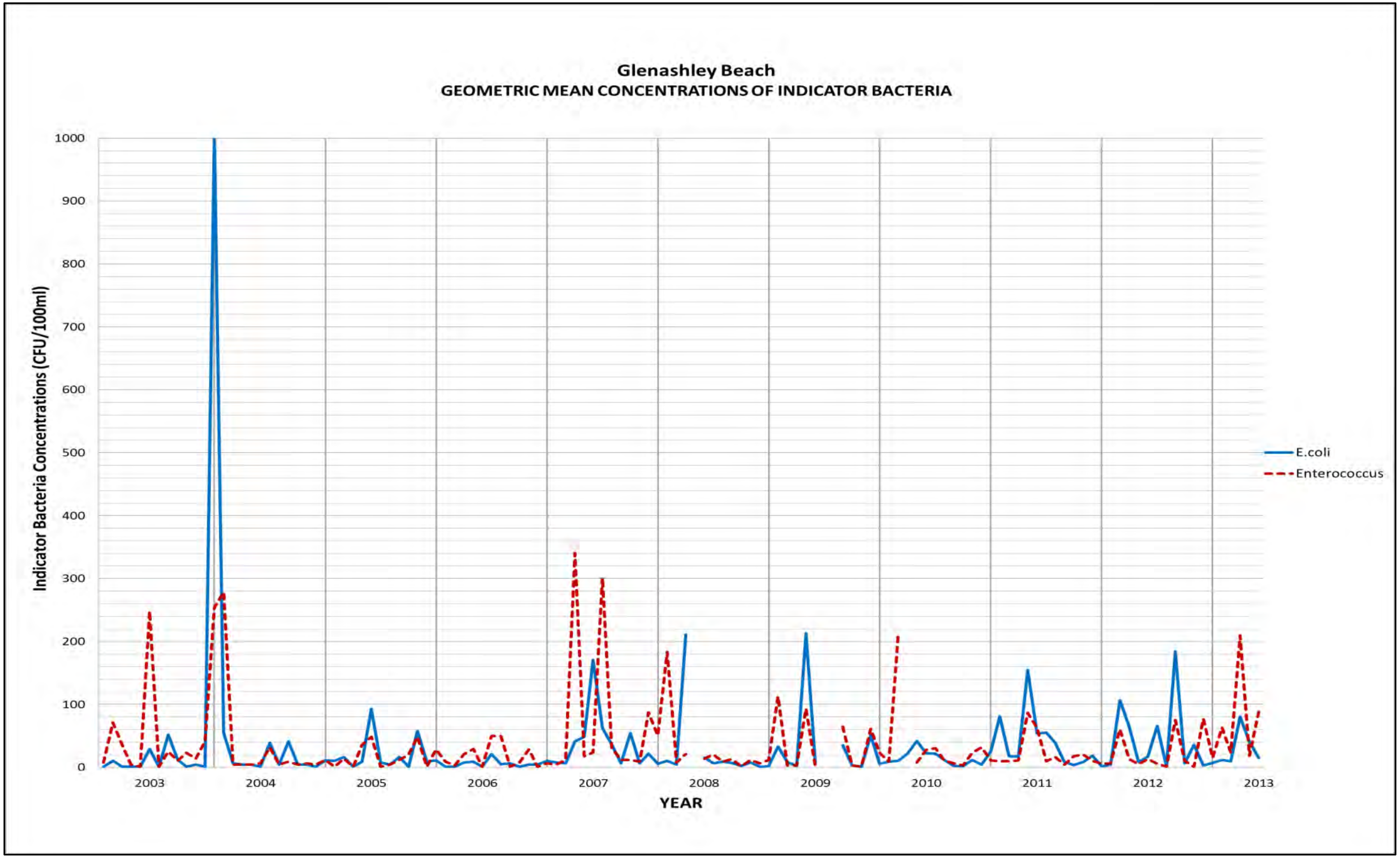

Figure A-33: Glenashley – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-33 illustrates the geometric means of E.coli and Enterococcus at Glenashley beach. The graph shows the patterns of the indicator bacteria have remained the consistent. The lowest counts of both bacteria are shown to be from 2004 to 2006, where counts are less than 100/100ml. Generally, the geometric mean in shown to be below 200CFU/100ml for both indicators.

- **SAWQ Guidelines**

Table A-43 summarises the microbiological rating based on E.coli concentrations. Generally water quality has been good. Occurrences of poor water quality are scattered throughout the study period. Based on E.coli, 2007 is the only year with an annual rating of poor. This is consistent with the Table A-64 which shows the highest counts of E.coli in 2007.

Table A-43: Glenashley – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	E	E	E	E	E	G	E	E
FEB	E	E	E	E	E	E	P	E	P	E	E
MAR	E	E	E	E	E	E	P	E	E	G	E
APR	E	E	E	E	E	-	E	E	G	G	P
MAY	E	E	E	E	E	-	P	G	G	E	E
JUN	E	E	E	E	P	G	E	G	P	E	E
JUL	E	P	E	E	P	G	-	E	G	E	E
AUG	P	E	E	E	P	E	-	G	G	E	E
SEP	E	E	E	E	E	E	E	E	E	G	G
OCT	E	E	E	E	E	E	E	E	E	E	G
NOV	E	E	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	G	E	G	G	E	E	E
Annual	E	G	E	E	P	E	G	G	G	G	G

The microbiological water quality rating based on Enterococcus is shown in Table A-44. Annually water quality at Glenashley has never been rated as excellent, with the ratings split between good and poor. In 2007, 2010 and 2011 the water quality was rated poor for half of each year.

Table A-44: Glenashley – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	G	P	E	G	G	P	E	G	E
FEB	P	P	E	E	E	G	P	E	P	E	G
MAR	E	E	G	E	G	E	E	P	G	P	E
APR	E	P	E	E	P	-	E	-	P	E	P
MAY	E	E	E	E	P	-	P	P	P	E	E
JUN	G	E	E	E	P	P	E	P	P	E	G
JUL	E	P	E	E	P	P	-	G	P	E	-
AUG	P	E	E	G	P	E	-	P	E	E	-
SEP	E	E	E	E	G	G	E	G	G	G	-
OCT	P	E	P	E	G	E	E	E	P	E	-
NOV	G	E	E	P	E	P	E	P	E	G	-
DEC	E	E	E	E	P	E	P	G	G	G	-
Annual	P	P	G	G	P	G	P	P	P	G	P

A.1.12. Virginia

- **Seasonal Trends**

The seasonal averages for E.coli and Enterococcus are ranked in Tables A-45 and A-46 respectively. Winter is shown to produce the highest average counts of E.coli most often, however not consistently. Autumn yielded the highest average for three consecutive years from 2010 to 2012. There are no distinctive patterns based on the seasonal averages for E.coli.

Table A-45: Virginia – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	3.30 (4)	10.0 (3)	33.3 (3)	34.4 (2)	13.3 (4)	15.0 (3)	114 (4)	**108 (1)**	**161 (1)**	**110 (1)**	131 (2)
Winter	**816 (1)**	**425 (1)**	**100 (1)**	7.80 (4)	**988 (1)**	64.8 (2)	**336 (1)**	82.8 (2)	148 (2)	51.8 (3)	18.9 (4)
Spring	603 (2)	10.0 (3)	31.1 (4)	**576 (1)**	210 (2)	12.4 (4)	120 (3)	22.9 (4)	104 (4)	73.9 (2)	**193 (1)**
Summer	266 (3)	43.3 (2)	36.7 (2)	23.3 (3)	83.3 (3)	**88.3 (1)**	236 (2)	78.8 (3)	146 (3)	35.8 (4)	38.3 (3)

No clear seasonal trends are evident based on Enterococcus as the season which produced the highest average concentration of the bacterium varies each year. There is no correlation between the two indicators.

Table A-46: Virginia – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	103 (4)	56.7 (4)	10.0 (1)	88.9 (2)	43.3 (4)	10.0 (4)	149 (2)	**176 (1)**	126 (2)	83.3 (2)	**58.3 (1)**
Winter	**313 (1)**	**193 (1)**	26.7 (3)	64.4 (3)	**245 (1)**	101 (2)	126 (3)	90.0 (3)	**257 (1)**	42.2 (3)	35.0 (2)
Spring	300 (2)	76.7 (3)	**47.8 (1)**	**403 (1)**	170 (2)	98.1 (3)	65.6 (4)	17.9 (4)	55.1 (4)	**96.7 (1)**	-
Summer	140 (3)	153 (2)	43.3 (2)	60.0 (4)	120 (3)	**274 (1)**	**178 (1)**	92.8 (2)	97.6 (3)	25.0 (4)	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for Virginia beach are depicted in Figure A-34. The averages are shown to decrease and increase variably up to 2009. Thereafter the average becomes constant until the end of the study. Ultimately the concentration at the end of the study period is approximately a quarter of that at the start.

The deviations show the same erratic behaviour as the averages from 2003 to 2009. In addition, larger standard deviations appear to be linked to higher averages. As with the averages, the standard deviations are shown to have reduced and become consistent.

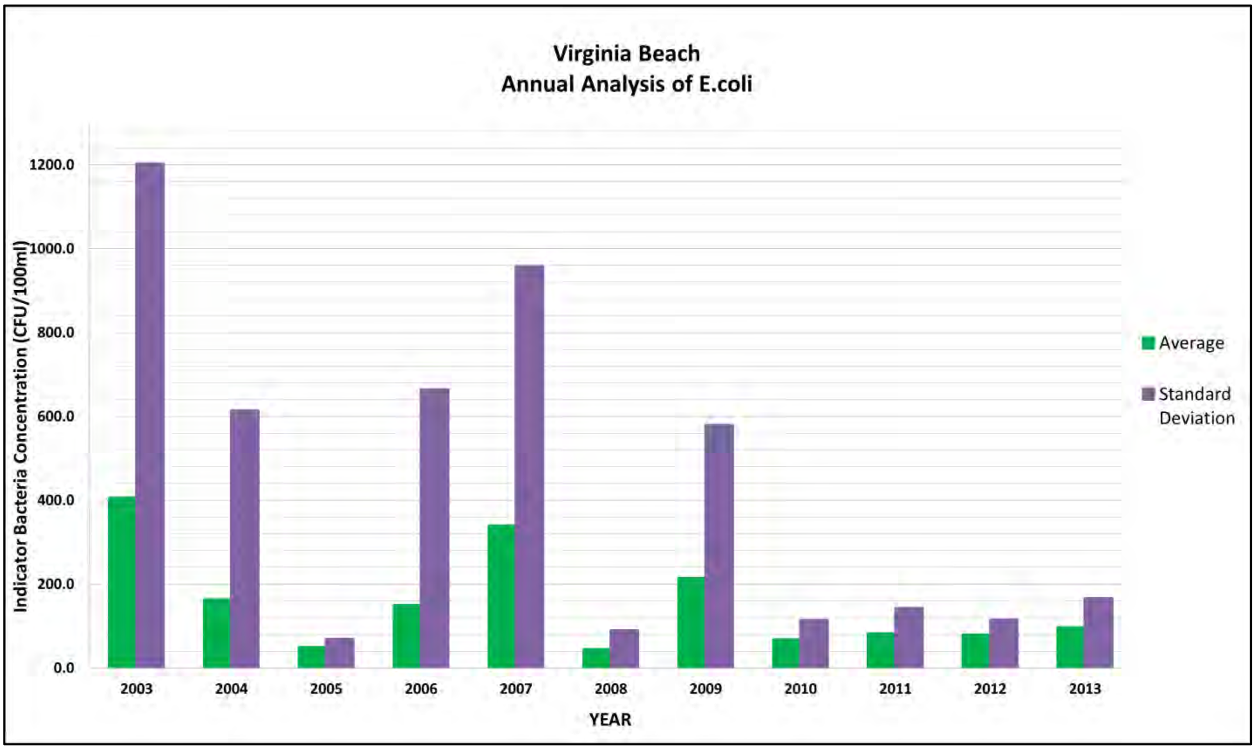

Figure A-34: Annual Analysis of E.coli at Virginia Beach

Figure A-35 shows the annual averages and standard deviations of Enterococcus. From 2003 to 2009 the averages decrease and increase inconsistently. Thereafter the average concentration of Enterococcus decreases gradually. Ultimately the average concentration of Enterococcus in 2013 is only a fifth of the highest in 2003. Generally the standard deviations follow the same pattern as the averages.

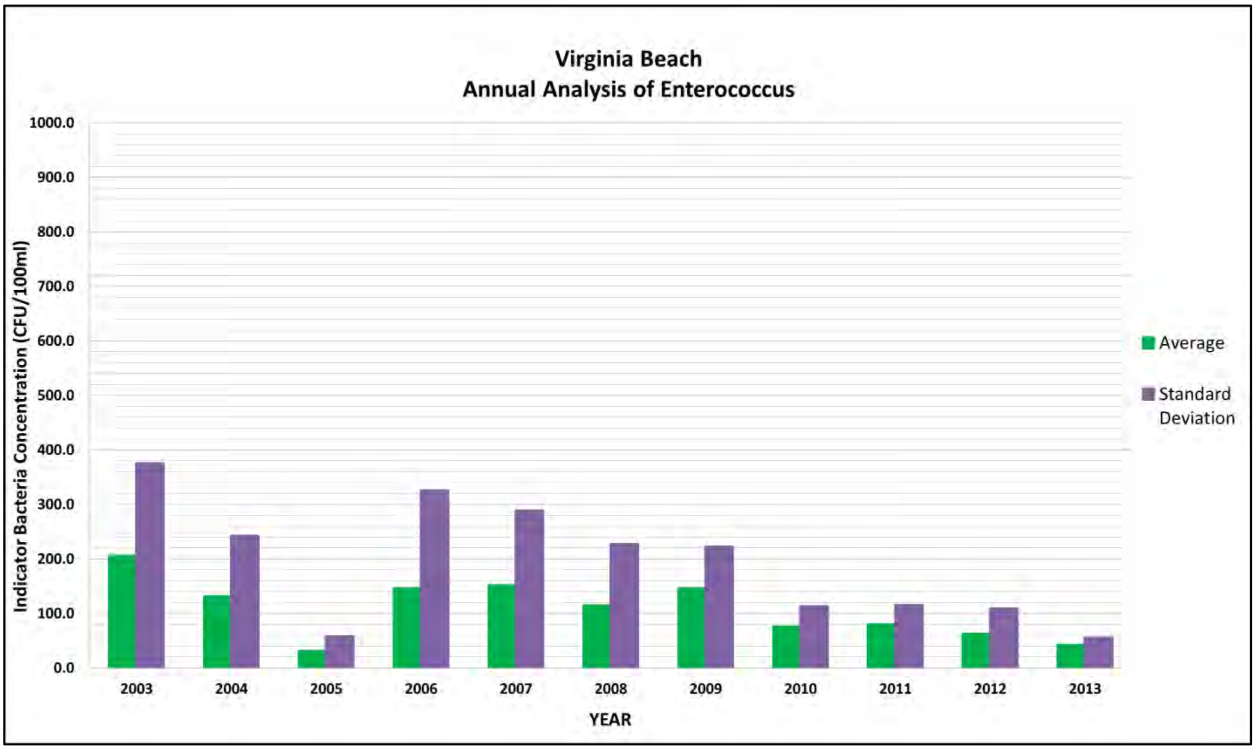

Figure A-35: Annual Analysis of Enterococcus at Virginia Beach

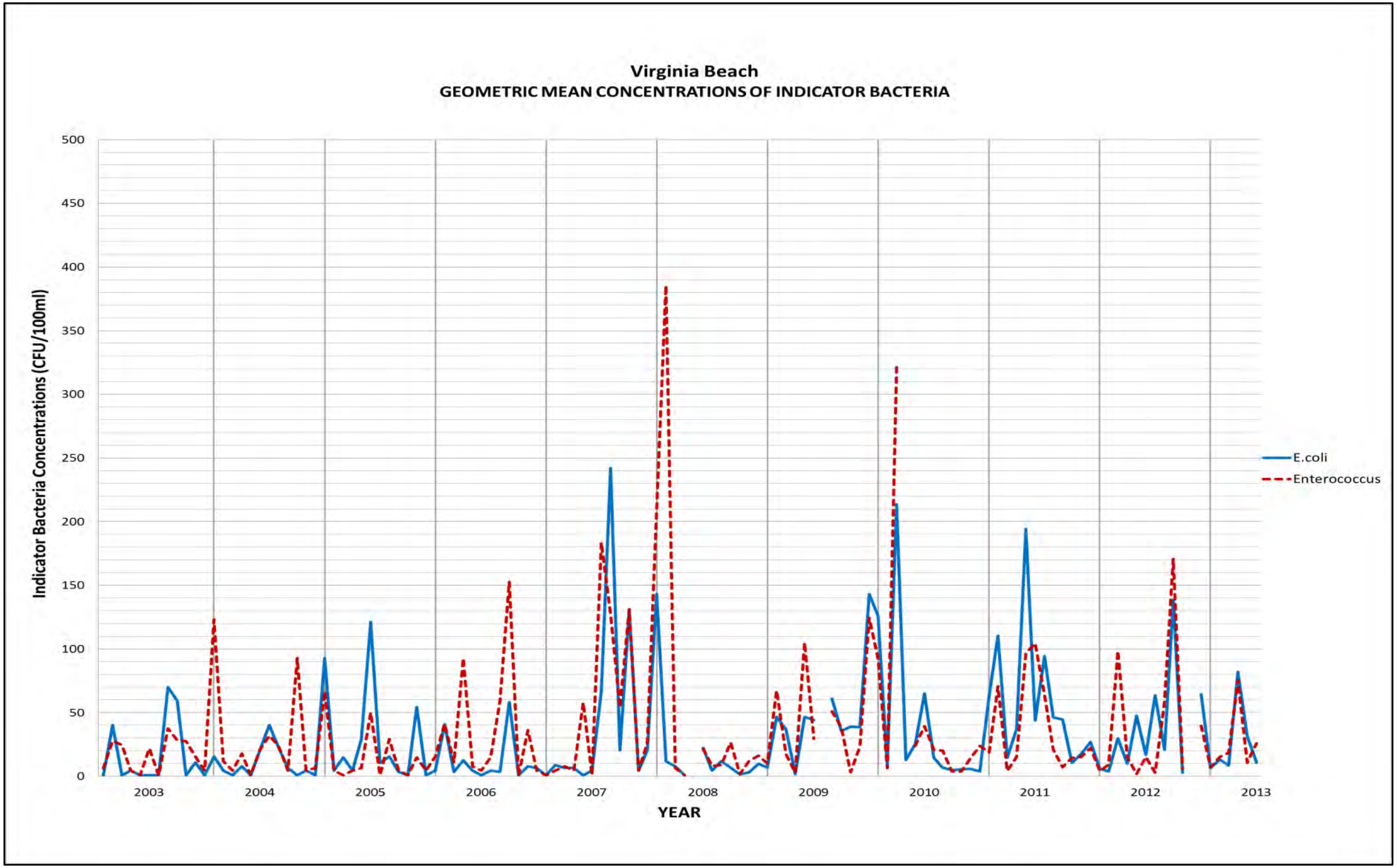

Figure A-36: Virginia – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-36 illustrates the geometric mean concentrations of the two indicator bacteria. Although both indicators have maintained their variable nature, the geometric means have consistently remained below 150 counts throughout most of the study period. E.coli and Enterococcus have also shared the same pattern of variability.

- **SAWQ Guidelines**

Tables A-47 and A-48 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. The last five years of the study show that water quality has been good overall. The occurrence of poor water quality has been random throughout the study period. Two years in the study, namely 2003 and 2007, have a poor annual rating. This correlates to Figure A-34 which shows that the averages and deviations are higher for those years.

Table A-47: Virginia – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	G	E	G	P	G	E
FEB	P	E	E	E	E	E	P	E	G	E	E
MAR	E	E	E	E	E	E	G	G	E	E	E
APR	E	E	E	E	E	E	E	E	G	G	P
MAY	E	E	E	E	E	-	P	E	P	G	E
JUN	E	E	E	E	E	G	P	G	P	E	E
JUL	E	P	E	E	P	E	-	-	G	E	E
AUG	P	E	E	E	P	E	E	G	E	E	E
SEP	P	E	E	P	G	E	E	E	G	E	G
OCT	E	E	E	E	P	E	E	E	P	E	G
NOV	E	E	E	E	P	E	G	E	E	-	E
DEC	E	G	E	E	G	E	G	E	E	G	E
Annual	P	G	E	E	P	E	G	G	G	G	G

Based on Enterococcus the waters at Virginia beach have been poor throughout most of the study period. Annually water quality has never been classified as excellent. Virginia beach had many years where the water quality was classified as poor for approximately a quarter the year, resulting in 8 years with an overall poor quality rating.

Table A-48: Virginia – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	G	P	E	P	E	P	P	G	E
FEB	P	G	E	E	E	P	P	G	P	G	E
MAR	P	E	E	E	E	E	P	P	E	P	E
APR	E	P	E	P	E	E	E	P	P	P	P
MAY	E	E	E	E	G	-	P	E	P	E	E
JUN	G	E	E	E	E	P	G	P	P	E	E
JUL	E	-	E	P	P	G	-	G	P	E	-
AUG	P	E	E	G	P	E	E	P	G	G	-
SEP	P	P	E	P	G	P	E	E	G	P	-
OCT	P	E	E	E	P	E	E	E	P	E	-
NOV	G	E	P	P	P	P	P	E	E	-	-
DEC	E	P	E	E	P	E	P	P	E	G	-
Annual	P	P	G	P	P	P	P	P	P	G	G

A.1.13. Beachwood

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-49. The highest levels of E.coli were found to be in winter most frequently. No clear patterns are evident as the season which produced the highest average concentration of this bacterium varies each year.

Table A-49: Beachwood – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	10.0 (3)	26.7 (3)	15.6 (4)	**51.1 (1)**	60.0 (3)	**70.0 (1)**	93.3 (3)	35.8 (3)	86.6 (3)	**113 (1)**	153 (2)
Winter	**183 (1)**	**435 (1)**	**173 (1)**	36.7 (2)	**827 (1)**	62.9 (3)	50.0 (4)	**91.7 (1)**	139 (2)	83.2 (2)	40.6 (4)
Spring	140 (2)	3.30 (4)	37.8 (2)	13.3 (3)	436 (2)	25.7 (4)	94.7 (2)	10.0 (4)	77.9 (4)	9.40 (4)	**216 (1)**
Summer	3.30 (4)	170 (2)	33.3 (3)	13.3 (3)	6.70 (4)	66.7 (2)	**199 (1)**	46.4 (2)	**157 (1)**	63.9 (3)	95.0 (3)

Table A-50 shows the ranking of seasonal averages for Enterococcus. Summer yielded the highest average count of Enterococcus at Beachwood. This is consistent from 2008 to 2011. There are no clear correlations between the two indicators.

Table A-50: Beachwood – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	26.7 (3)	26.7 (4)	26.7 (4)	87.8 (2)	**233 (1)**	20.0 (4)	155 (2)	61.7 (3)	102 (4)	**92.0 (1)**	**63.3 (1)**
Winter	68.9 (2)	121 (3)	**50.0 (1)**	43.3 (4)	216 (2)	44.3 (3)	85.0 (3)	96.7 (2)	121 (2)	82.8 (2)	30.0 (2)
Spring	**250 (1)**	146 (2)	38.9 (2)	**140 (1)**	120 (3)	68.6 (2)	82.5 (4)	2.90 (4)	118 (3)	37.2 (3)	-
Summer	23.3 (4)	**323 (1)**	30.0 (3)	70.0 (3)	63.3 (4)	**254 (1)**	**202 (1)**	**120 (1)**	**123 (1)**	31.4 (4)	-

- **Annual Trends**

Figures A-37 and A-38 show the annual averages and standard deviation for E.coli and Enterococcus at Beachwood respectively. The average concentrations of E.coli vary randomly. Generally, the average is shown to be consistent during the latter half of the study. The largest average is shown to be in 2007 with extremely high corresponding standard deviation.

Although the average concentration of Enterococcus varied throughout the study period, ultimately it remains within the range of 50 – 150CFU/100ml in most cases.

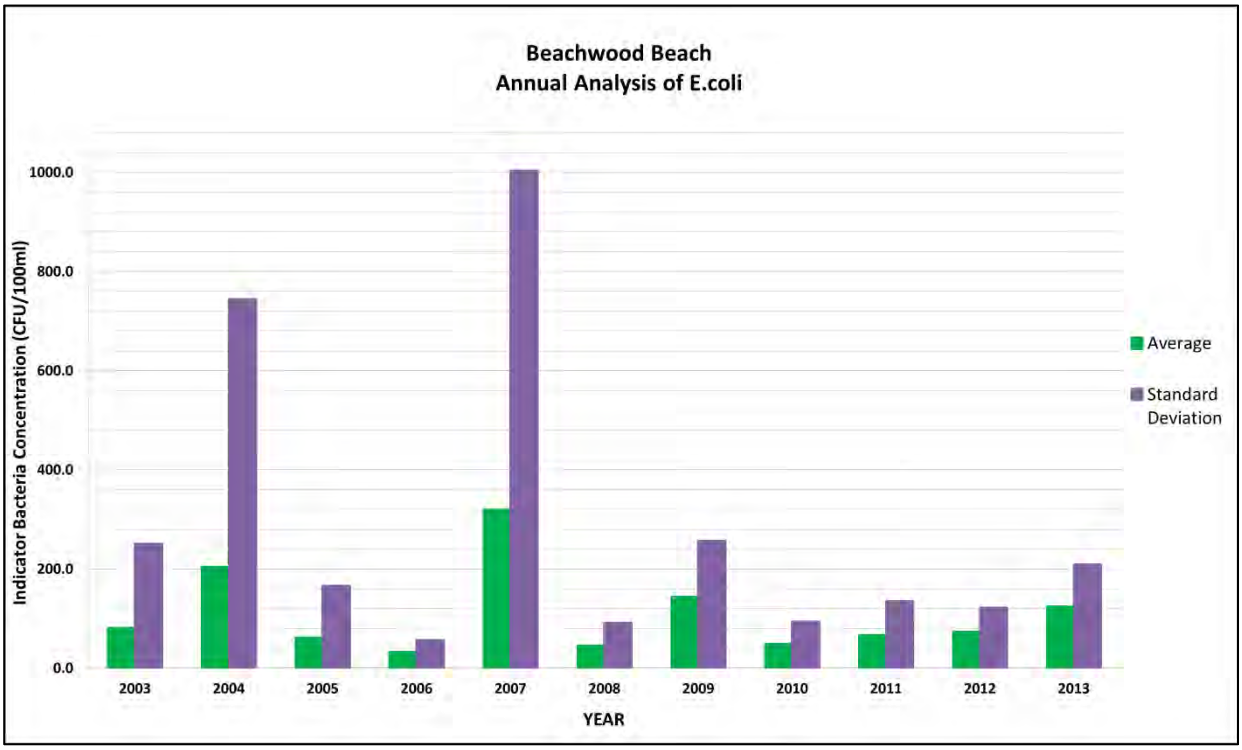

Figure A-37: Annual Analysis of E.coli at Beachwood Beach

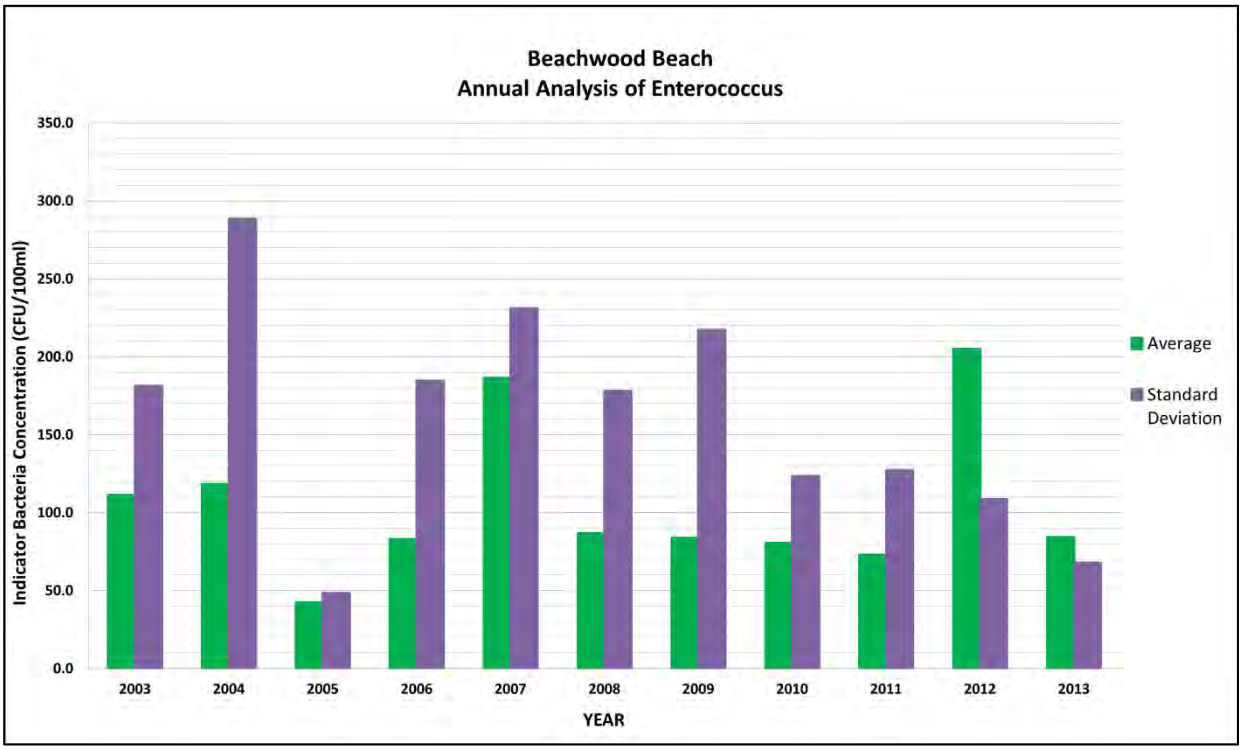

Figure A-38: Annual Analysis of Enterococcus at Beachwood Beach

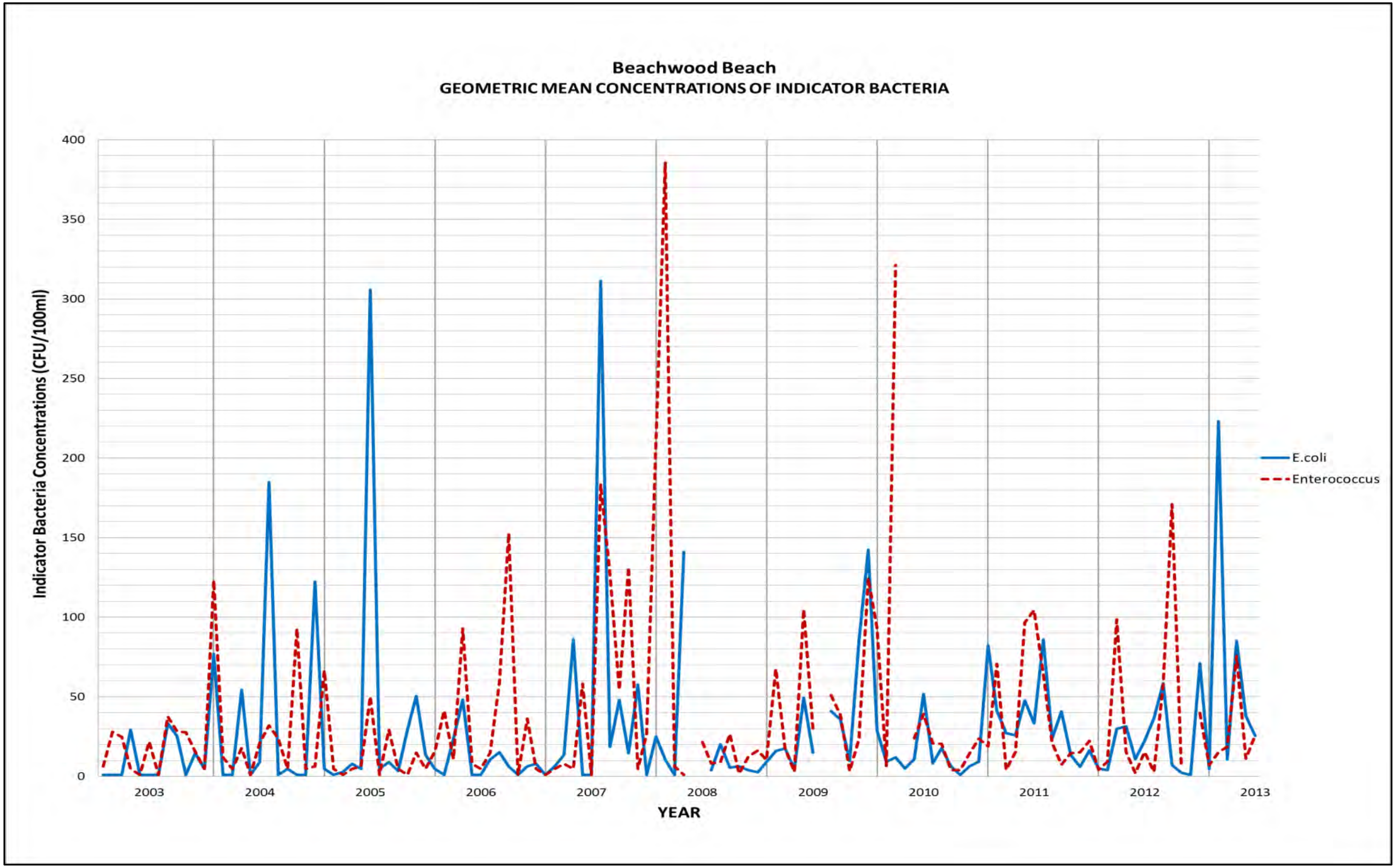

Figure A-39: Beachwood – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of the two indicator bacteria are illustrated in Figure A-39. Both bacteria have remained variable throughout the study period.

- **SAWQ Guidelines**

Table A-51 shows that the waters at Beachwood have an overall good rating. Annually water quality has been rated as excellent to good. Few occurrences of poor water quality are scattered randomly throughout the study period.

Table A-51: Beachwood – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	E	E	E	G	E	E	G	G	E
FEB	E	E	E	E	E	E	P	E	G	E	G
MAR	E	E	E	G	E	E	G	E	E	E	E
APR	E	E	E	E	E	E	E	E	G	G	P
MAY	E	E	E	E	E	-	G	E	G	G	E
JUN	E	E	P	E	E	-	E	G	G	E	E
JUL	E	P	E	E	P	E	-	E	G	E	E
AUG	P	E	E	E	G	G	E	G	E	G	E
SEP	P	E	E	E	P	E	E	E	G	E	E
OCT	E	E	E	E	E	E	E	E	G	E	G
NOV	E	E	E	E	E	E	G	E	E	E	E
DEC	E	G	E	E	E	E	G	E	G	E	E
Annual	G	G	E	E	G	E	G	E	G	G	G

Table A-52 summarises the microbiological rating based on Enterococcus concentrations. Based on Enterococcus the waters have been mostly poor, annually water quality has never been classified as excellent. Many years experienced poor water quality conditions for more than half the year, resulting in 7 years receiving an overall poor rating.

Table 3-52: Beachwood – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	P	E	P	G	P	P	G	E
FEB	E	E	E	E	E	P	P	E	P	E	E
MAR	E	E	G	G	G	E	P	G	G	P	E
APR	E	G	E	P	P	E	G	-	P	G	P
MAY	E	E	E	E	P	-	P	E	P	E	E
JUN	G	E	G	E	E	-	P	P	P	E	E
JUL	E	P	E	E	P	G	-	P	P	E	-
AUG	P	G	E	G	P	G	E	P	G	P	-
SEP	P	E	G	E	P	G	E	G	P	G	-
OCT	P	P	E	P	P	E	P	E	P	E	-
NOV	P	E	E	P	E	G	P	E	G	E	-
DEC	E	P	E	E	P	E	P	P	P	E	-
Annual	P	P	G	P	P	G	P	P	P	G	G

A.2. Section B – City Beaches

A.2.1. Blue Lagoon (Umgeni South)

Sample data for both indicators was not provided from July 2012 up to and including April 2013.

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-53. Summer yielded the highest average of E.coli most frequently and consistently in the last three years of the study. No other seasonal trends are evident.

Table A-53: Blue Lagoon – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	176 (3)	170 (2)	**230 (1)**	241 (3)	40.0 (4)	245 (4)	416 (2)	**594 (1)**	330 (3)	109 (2)	**800 (1)**
Winter	98.9 (4)	**690 (1)**	147 (4)	177 (4)	63.3 (3)	**1289 (1)**	**1310 (1)**	117 (4)	115 (4)	100 (3)	108 (2)
Spring	336 (2)	137 (4)	182 (2)	**2647 (1)**	**907 (1)**	450 (3)	103 (4)	157 (3)	430 (2)	-	80.0 (3)
Summer	**570 (1)**	167 (3)	153 (3)	2293 (2)	172 (2)	551 (2)	192 (3)	203 (2)	**701 (1)**	**192 (1)**	**800 (1)**

Seasonal averages for Enterococcus at Blue Lagoon beach are shown in Table A-54. Summer yielded the highest average count of Enterococcus every alternate year. No clear patterns are evident as the season which produced the highest average concentration of Enterococcus is not consistent each year. There are no clear correlations between the two indicators.

Table A-54: Blue Lagoon – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	83.3 (4)	187 (2)	82.2 (4)	110 (4)	183 (4)	85.0 (4)	286 (3)	250 (2)	218 (3)	52.8 (2)	**300 (1)**
Winter	157 (3)	139 (3)	**207 (1)**	183 (3)	426 (2)	418 (3)	**557 (1)**	124 (4)	**282 (1)**	30.0 (3)	60.0 (2)
Spring	**386 (1)**	66.7 (4)	176 (2)	323 (2)	**567 (1)**	468 (2)	191 (4)	125 (3)	201 (4)	-	-
Summer	235 (2)	**203 (1)**	93.3 (3)	**463 (1)**	207 (3)	**533 (1)**	352 (2)	**260 (1)**	250 (2)	**169 (1)**	-

- **Annual Trends**

The annual averages and standard deviations for E.coli and Enterococcus are depicted in Figures A-40 and A-41 respectively.

It is evident that the average concentration of E.coli has varied significantly over the study period. Averages have decreased and increased inconsistently but remained below 500CFU/100ml every year with exception to 2006 and 2008. The significant increase in average E.coli counts in 2006 is almost 8 times that of the previous year. It is clear that there is significant variation in E.coli concentrations. However, there is no trend in the variation. The standard deviations were found to be relatively large in many cases thus highlighting that levels of E.coli vary greatly throughout those years.

Enterococcus levels have varied slightly with average counts ranging from just over 100/100ml to just below 450ml. The highest averages are shown to be during the middle of the study period from 2006 to 2009. Thereafter the average concentration of Enterococcus decreased with a slight peak again in 2011. At the end of the study period the average level of Enterococcus is approximately half that at the beginning in 2003. Standard deviations were not found to be significantly large which indicates that concentrations of Enterococcus have not varied greatly throughout each year. Both of the indicator bacteria show inconsistent variations throughout the study period, however, there is no correlation between E.coli and Enterococcus.

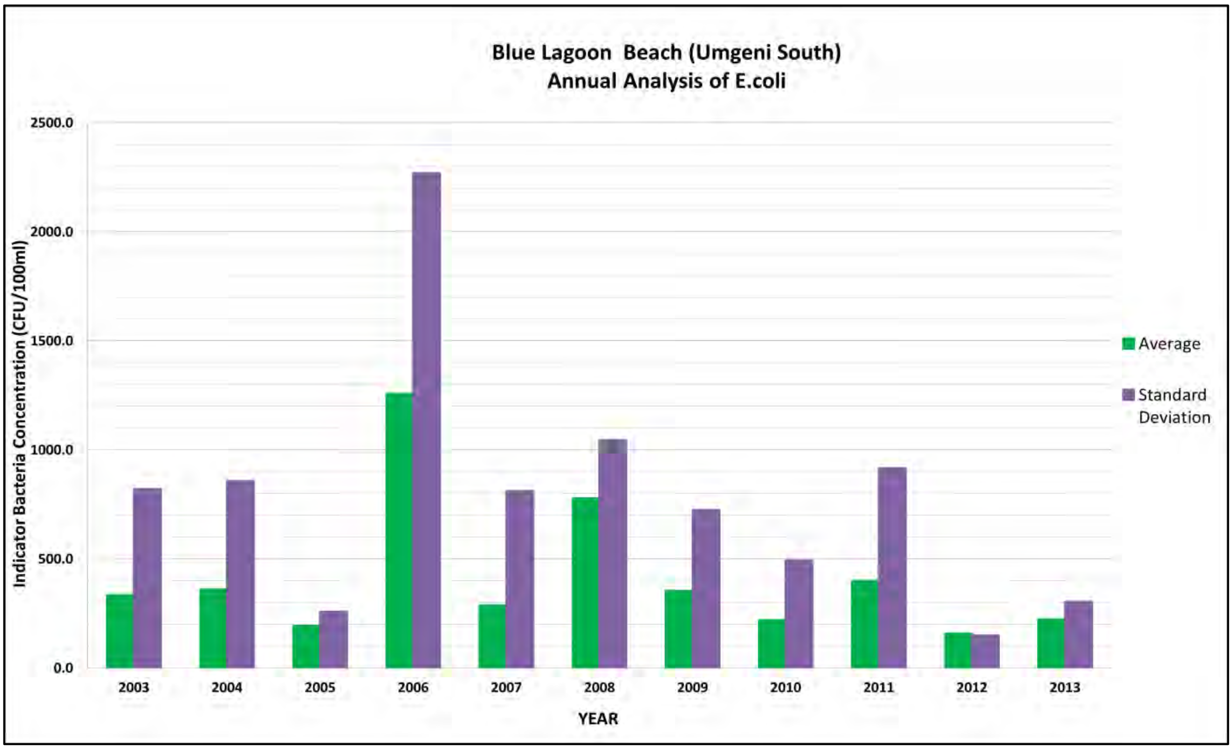

Figure A-40: Annual Analysis of E.coli at Blue Lagoon Beach

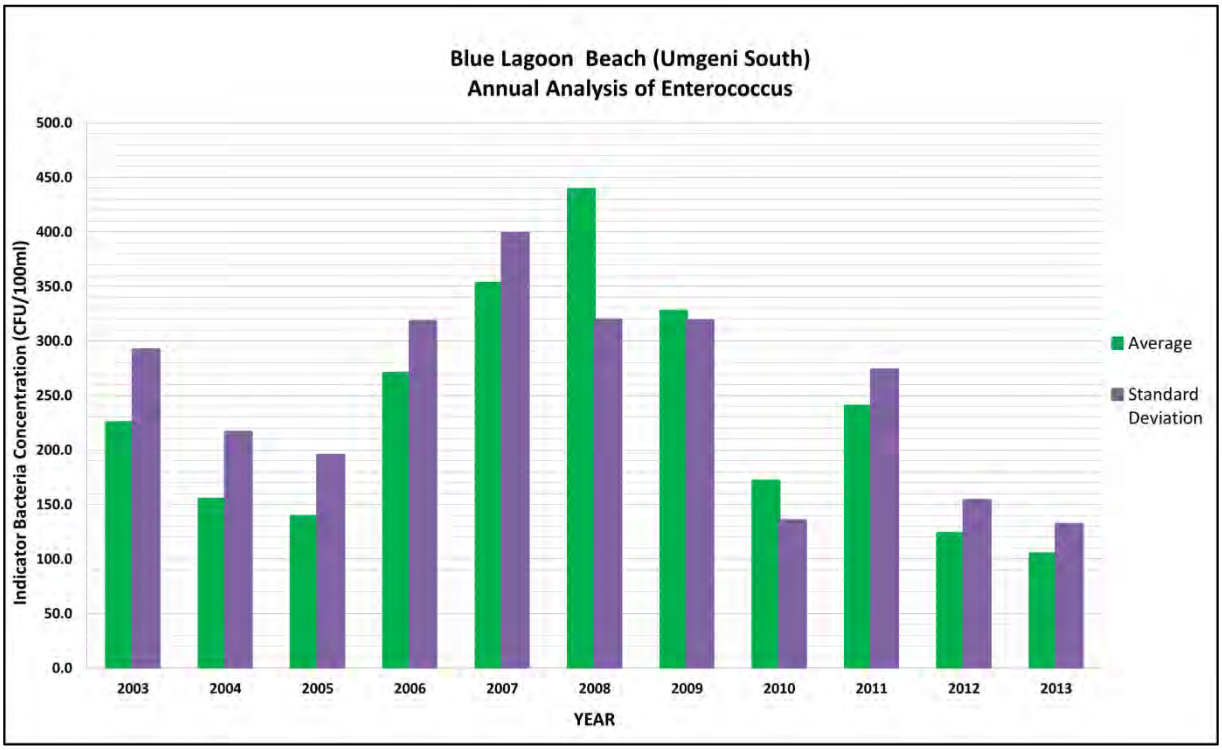

Figure A-41: Annual Analysis of Enterococcus at Blue Lagoon Beach

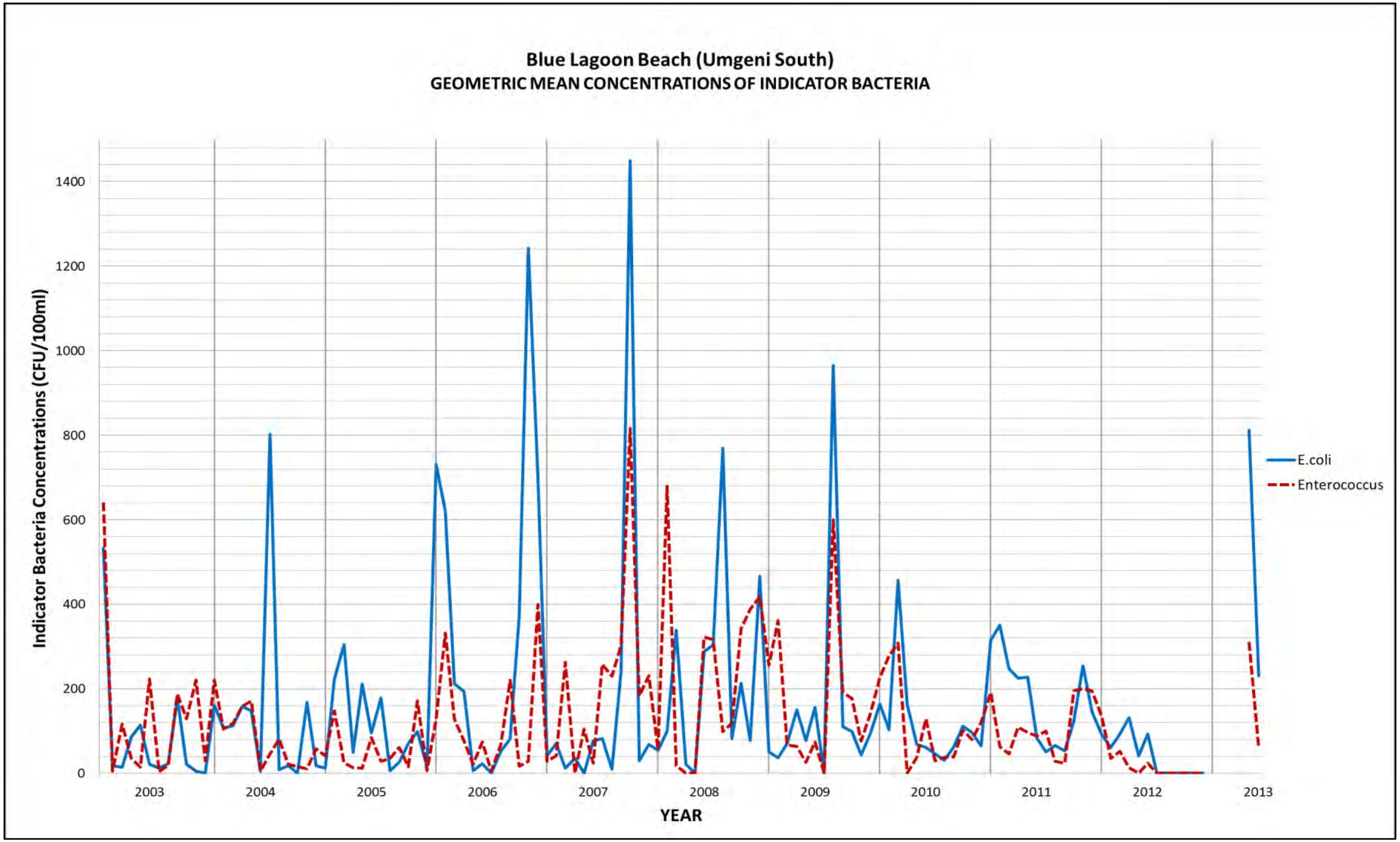

Figure A-42: Blue Lagoon – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-42 compares the geometric means of E.coli and Enterococcus at Blue Lagoon beach. It is clear that both bacteria have been variable throughout the study period. E.coli exceeded Enterococcus in most cases however, the two bacteria increased and decreased in unison.

- **SAWQ Guidelines**

Table A-55 summarises the microbiological water quality rating based on E.coli. Poor water quality is evident throughout the study period. Annually the quality of the waters at Blue Lagoon has never been classified as excellent, with the ratings split between good and poor. The most frequent occurrences of poor water quality occurred in 2006, 2008, 2009, and again in 2011. This corresponds with the larger averages observed in Figure A-45.

Table A-55: Blue Lagoon – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	G	E	P	P	P	G	G	P	G	-
FEB	G	E	G	P	E	E	P	G	P	G	-
MAR	E	G	P	G	E	P	P	P	P	E	-
APR	E	G	E	P	E	E	P	G	P	G	-
MAY	P	E	E	E	E	-	P	G	G	G	P
JUN	E	E	E	G	E	P	P	G	G	E	E
JUL	E	P	G	E	E	P	-	E	E	-	E
AUG	G	E	E	P	E	P	P	G	G	-	E
SEP	P	G	P	P	P	P	E	G	P	-	E
OCT	G	E	E	P	P	G	G	G	G	-	G
NOV	E	G	E	P	E	G	E	G	P	-	E
DEC	E	G	E	P	E	P	G	E	G	-	P
Annual	P	G	G	P	P	P	P	G	P	G	P

Table A-56 shows the microbiological rating for Enterococcus. Annually the water quality has been rated as poor every year of the study with exception to 2010. From 2006 to 2009 and again in 2011 at least 10 months of each year had poor water quality ratings. This corresponds with the larger averages observed in Figure A-46.

Table A-56: Blue Lagoon – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	P	E	P	P	P	P	G	P	P	P
FEB	E	G	P	P	E	P	P	G	P	P	E
MAR	G	G	G	P	P	P	P	G	P	P	G
APR	E	G	G	P	E	E	P	-	P	E	E
MAY	G	G	G	E	P	-	P	G	P	E	G
JUN	P	E	P	P	P	P	P	G	P	E	P
JUL	E	P	P	E	P	P	-	G	P	-	-
AUG	P	G	E	P	P	P	P	G	P	-	-
SEP	P	E	P	P	P	P	P	E	E	-	-
OCT	P	G	P	P	P	P	P	G	P	-	-
NOV	P	G	P	P	P	P	P	G	P	-	-
DEC	E	E	E	P	P	P	P	G	P	-	-
Annual	P	P	P	P	P	P	P	G	P	P	P

A.2.2. .Laguna

Sample data for both indicators was not provided from August 2012 up to and including May 2013.

- **Seasonal Trends**

Table A-57 shows the ranking of seasonal averages for E.coli. Autumn and summer produced the highest averages most frequently. Furthermore, autumn produced the highest for three consecutive years from 2009 to 2011.

Table A-57: Laguna – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	30.0 (4)	60.0 (3)	**210 (1)**	168 (2)	23.3 (3)	50.0 (4)	**151 (1)**	**173 (1)**	**246 (1)**	132 (2)	-
Winter	73.3 (3)	84.4 (2)	86.7 (2)	107 (3)	33.3 (2)	**609 (1)**	116 (2)	67.2 (3)	117 (3)	34.5 (3)	37.8 (2)
Spring	86.7 (2)	46.7 (4)	28.9 (4)	3.30 (4)	**70.0 (1)**	91.0 (3)	114 (3)	57.8 (4)	99.2 (4)	-	**91.7 (1)**
Summer	**554 (1)**	**360 (1)**	30.0 (3)	**390 (1)**	18.9 (4)	176 (2)	**151 (1)**	123 (2)	198 (2)	**151 (1)**	35.0 (3)

Table A-58 shows the ranking of seasonal averages for Enterococcus. No clear patterns are evident as the season which produced the highest average concentration of Enterococcus varies each year.

Table A-58: Laguna – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	20.0 (4)	46.7 (3)	15.6 (2)	85.6 (3)	43.3 (3)	40.0 (4)	186 (3)	**252 (1)**	**146 (1)**	104 (2)	-
Winter	120 (3)	**179 (1)**	10.0 (3)	77.8 (4)	**247 (1)**	211 (2)	**313 (1)**	78.9 (4)	111 (4)	18.0 (3)	**10.0 (1)**
Spring	**283 (1)**	43.3 (4)	10.0 (3)	113 (2)	163 (2)	147 (3)	180 (4)	111 (3)	112 (3)	-	-
Summer	215 (2)	170 (2)	**70.0 (1)**	**127 (1)**	8.90 (4)	**346 (1)**	253 (2)	233 (2)	120 (2)	**137 (1)**	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for Laguna beach are depicted in Figure A-43. Average levels of E.coli fluctuated slightly. Ultimately the average at the end of the study is shown to have reduced to a quarter of that at the beginning. The deviations were extremely large and variable during the first half of the study period. During the second half of the study period the deviations are shown to have reduced and become less erratic.

Table A-44 shows the annual averages and standard deviations of Enterococcus. Average concentrations of Enterococcus varied slightly but remained within the range of 100-200CFU/100ml in most cases. The average in 2013 is shown to be extremely low; this is due to lack of data for this year. The standard deviations were found to be large in many cases. This highlights the variable nature of Enterococcus at Laguna beach over the duration of the study.

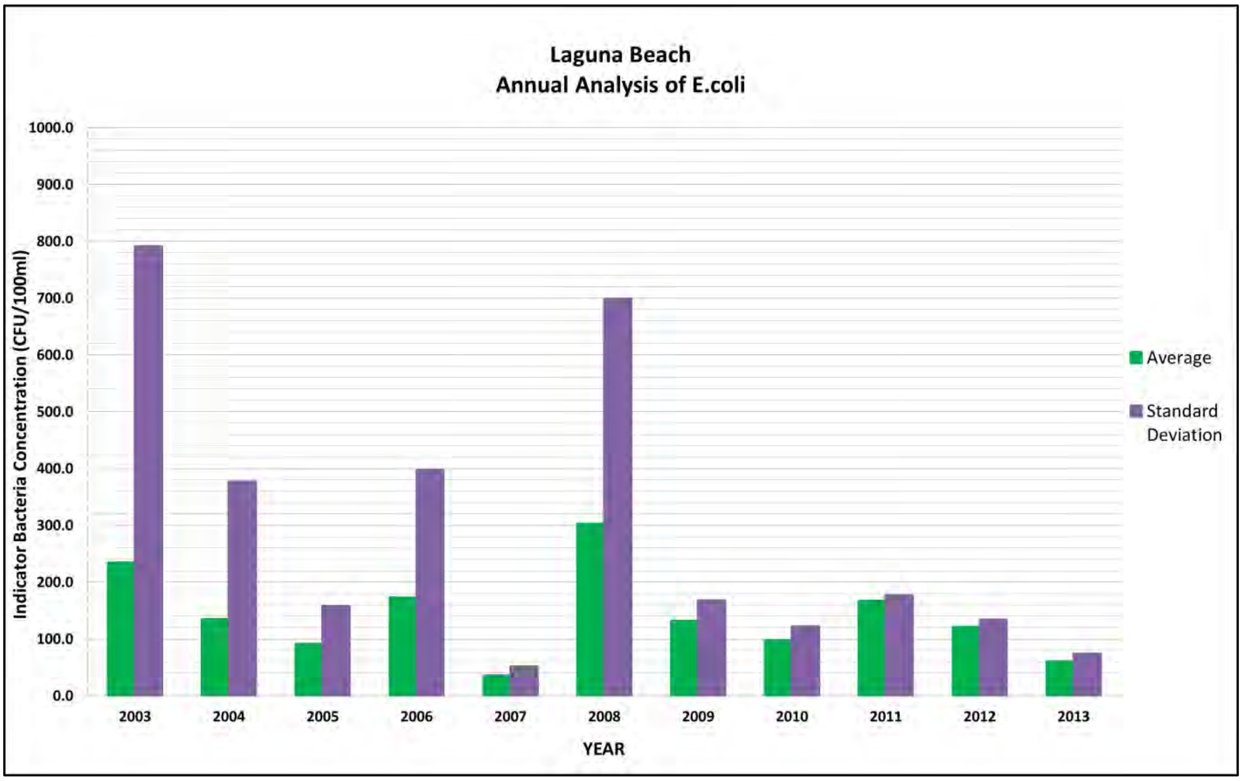

Figure A-43: Annual Analysis of E.coli at Laguna Beach

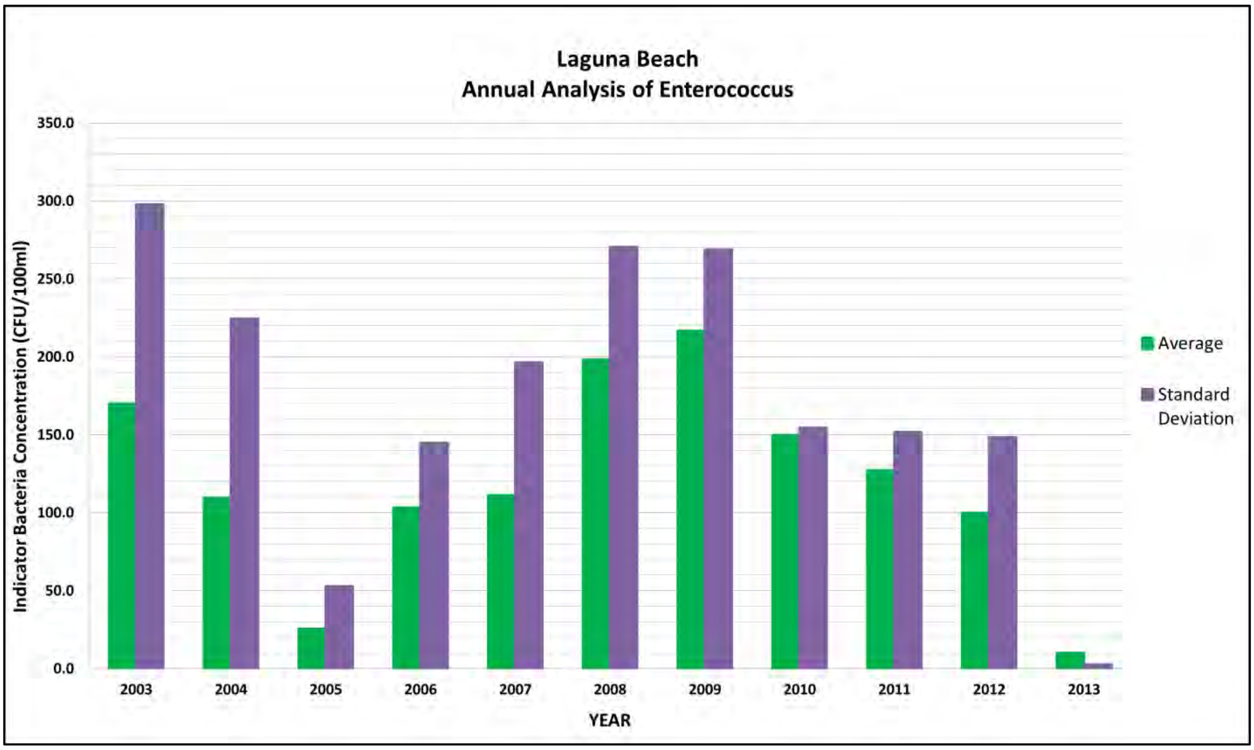

Figure A-44: Annual Analysis of Enterococcus at Laguna Beach

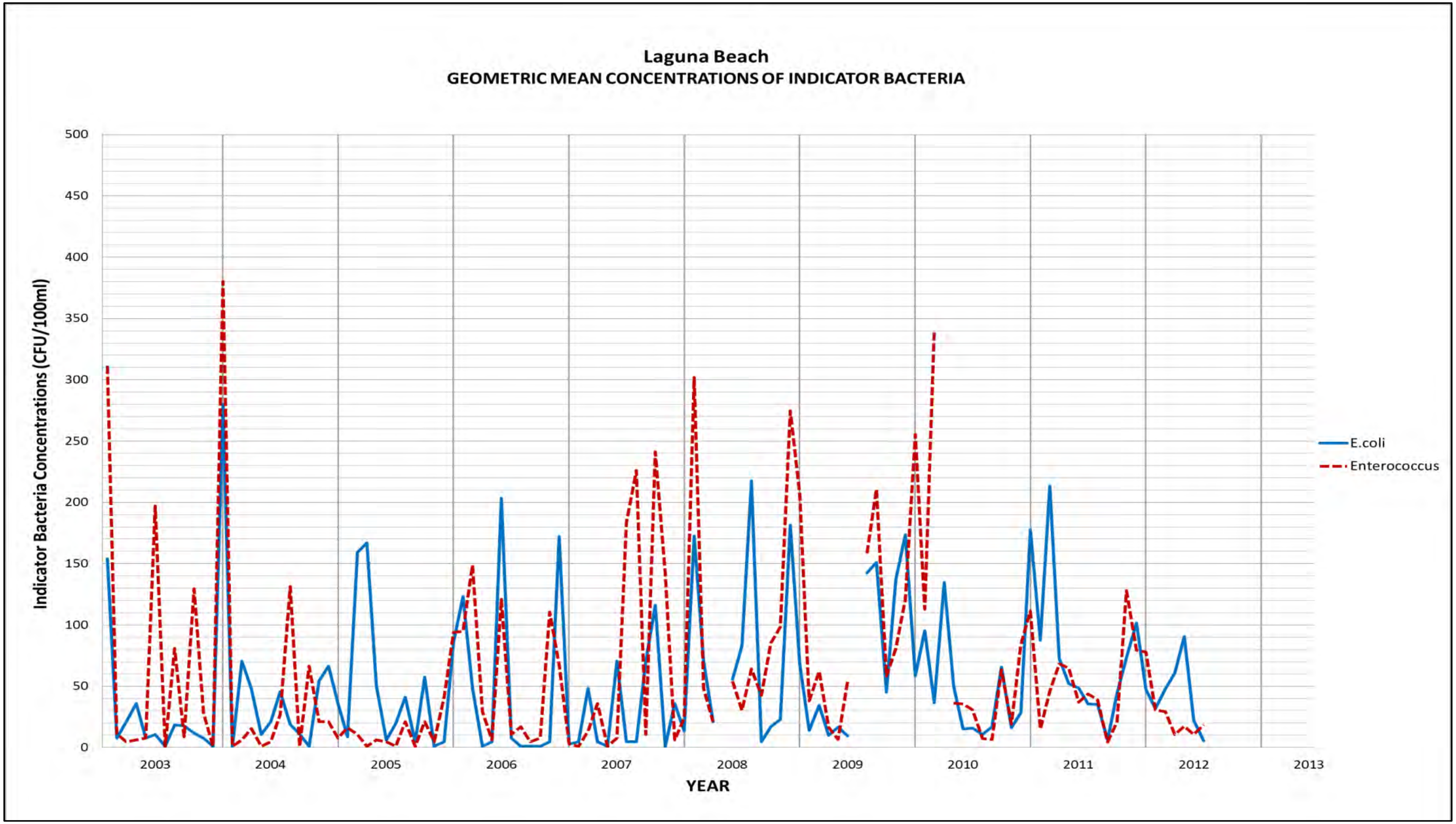

Figure A-45: Laguna – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-45 illustrates the geometric mean concentrations of the two indicator bacteria. Both E.coli and Enterococcus maintained their erratic behaviour for the entire duration of the study. Although the geometric mean concentrations differ, the two indicators fluctuate in unison.

- **SAWQ Guidelines**

Tables A-59 and A-60 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. Annually the waters at Laguna have been classified as mostly good. Poor water quality is experienced more in 2008 and 2009 than any other years. The incidences of poor water quality are shown to be random.

Table A-59: Laguna – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	P	E	E	E	E	G	G	P	G	-
FEB	E	E	E	P	E	E	G	G	P	G	-
MAR	E	E	G	P	E	E	P	G	G	E	-
APR	E	E	P	E	E	E	P	G	G	G	-
MAY	E	E	E	E	E	-	P	G	G	G	P
JUN	E	E	E	G	E	P	P	G	G	E	E
JUL	E	E	G	E	E	P	-	E	G	-	E
AUG	G	G	E	E	E	P	E	E	G	-	E
SEP	G	E	E	E	E	G	E	E	E	-	E
OCT	E	E	E	E	E	G	E	E	E	-	G
NOV	E	E	E	E	E	E	E	E	G	-	E
DEC	E	E	E	P	E	P	G	E	G	-	E
Annual	G	G	G	P	E	P	P	G	G	G	E

Table A-60: Laguna – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	P	E	P	E	P	P	P	P	P	-
FEB	G	E	P	E	E	P	P	P	G	G	-
MAR	E	E	E	P	G	E	P	P	G	P	-
APR	E	P	E	E	E	E	P	-	P	E	-
MAY	E	E	E	E	E	-	P	P	P	P	P
JUN	P	E	E	G	E	P	P	G	P	E	E
JUL	E	P	E	E	P	P	-	P	P	-	-
AUG	P	P	E	G	P	P	P	P	G	-	-
SEP	P	E	E	E	E	P	P	G	G	-	-
OCT	P	G	E	E	P	P	P	P	G	-	-
NOV	P	E	E	P	G	P	P	P	P	-	-
DEC	E	E	E	E	E	P	P	G	P	-	-
Annual	P	P	E	P	P	P	P	P	P	P	P

Based on Enterococcus the waters at Laguna beach have been poor throughout most of the study period, with just one year not rated as poor. The frequency of poor water quality incidents increased drastically during the second half of the study period, with the waters at Laguna beach experiencing poor water quality conditions for approximately three quarters of each year from 2009 to 2011. In addition, the summer months are shown to have poorer ratings consistently from 2008 onward. Based on the requirements of the SAWQ guidelines, the quality of Laguna"s waters has been classified as poor more frequently based on Enterococcus levels as compared to E.coli.

A.2.3. Thekwini

Sample data for both indicator bacteria at Thekwini Beach was only provided for 2008 to 2013. Data for E.coli was from June 2008 to December 2013 and data for Enterococcus was from June 2008 to June 2013. In addition, data for August 2008, July 2009, August to December 2012, and February and March 2013 was not provided.

- **Seasonal Trends**

Seasonal averages of E.coli at Thekwini beach are ranked in Table A-61. From 2008 to 2011 summer produced the second highest average count of E.coli, thereafter it produced the highest for two consecutive years. After 2008 winter consistently yielded the lowest average.

Table A-61: Thekwini – Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	100 (3)	**130** **(1)**	**752** **(1)**	138 (2)	48.3 (3)
Winter	**357** **(1)**	65 (4)	27.6 (4)	92.7 (4)	67.0 (3)	30.0 (4)
Spring	68.9 (3)	**140** **(1)**	46.0 (3)	176 (3)	-	86.7 (2)
Summer	130 (2)	126 (2)	94.3 (2)	236 (2)	**151** **(1)**	**215** **(1)**

Table A-62 shows that autumn yielded the highest counts of Enterococcus at Thekwini beach most frequently. No other seasonal trends are evident based on Enterococcus at this beach. The ranking for E.coli and Enterococcus correlate from 2010 to 2012.

Table A-62: Thekwini – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	123 (4)	**399** **(1)**	**156** **(1)**	77.2 (2)	**405** **(1)**
Winter	228 (2)	**315** **(1)**	29.7 (4)	83.4 (4)	17.0 (3)	10.0 (2)
Spring	124 (3)	177 (2)	67.3 (3)	98.8 (3)	-	-
Summer	**245** **(1)**	152 (3)	169 (2)	99.1 (2)	**116** **(1)**	-

- **Annual Trends**

The annual averages and standard deviations for E.coli are summarised in Figure A-46.Average counts of E.coli have remained consistent throughout the study period, with exception to 2011 where a slight increase is evident. At the end of the study period the average concentration of E.coli is shown to be slightly less than at the start. The standard deviations in 2008 and 2011 were found to be extremely large thus indicating that the concentrations of E.coli varied significantly during those two years.

Figure A-47 depicts the annual averages and standard deviations for Enterococcus. A general decrease in the average concentration of this bacterium is evident from 2008 to 2012. However, in 2013 the concentrations increased by more than double that of the previous year. The standard deviations remained significant for the duration of the study period. This indicates that Enterococcus concentrations have remained variable throughout each year. Although both indicator bacteria concentrations fluctuated, there was no link between their variations over the years.

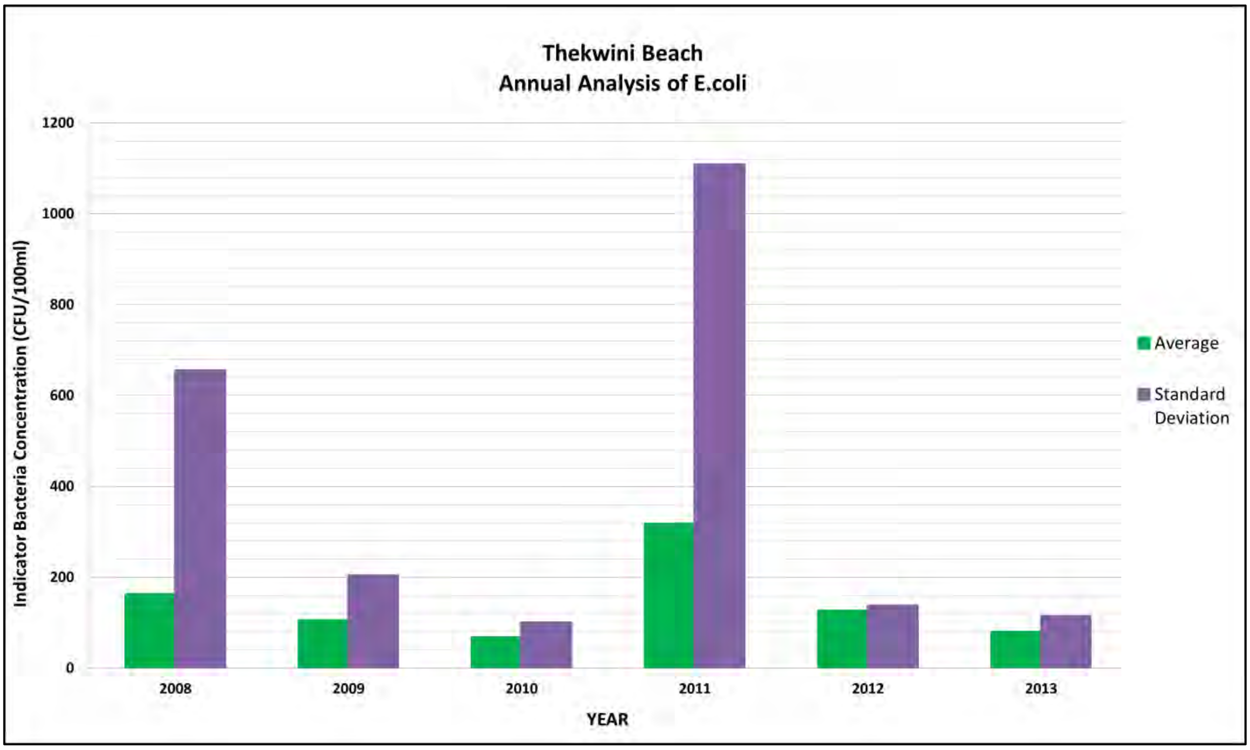

Figure A-46: Annual Analysis of E.coli at Thekwini Beach

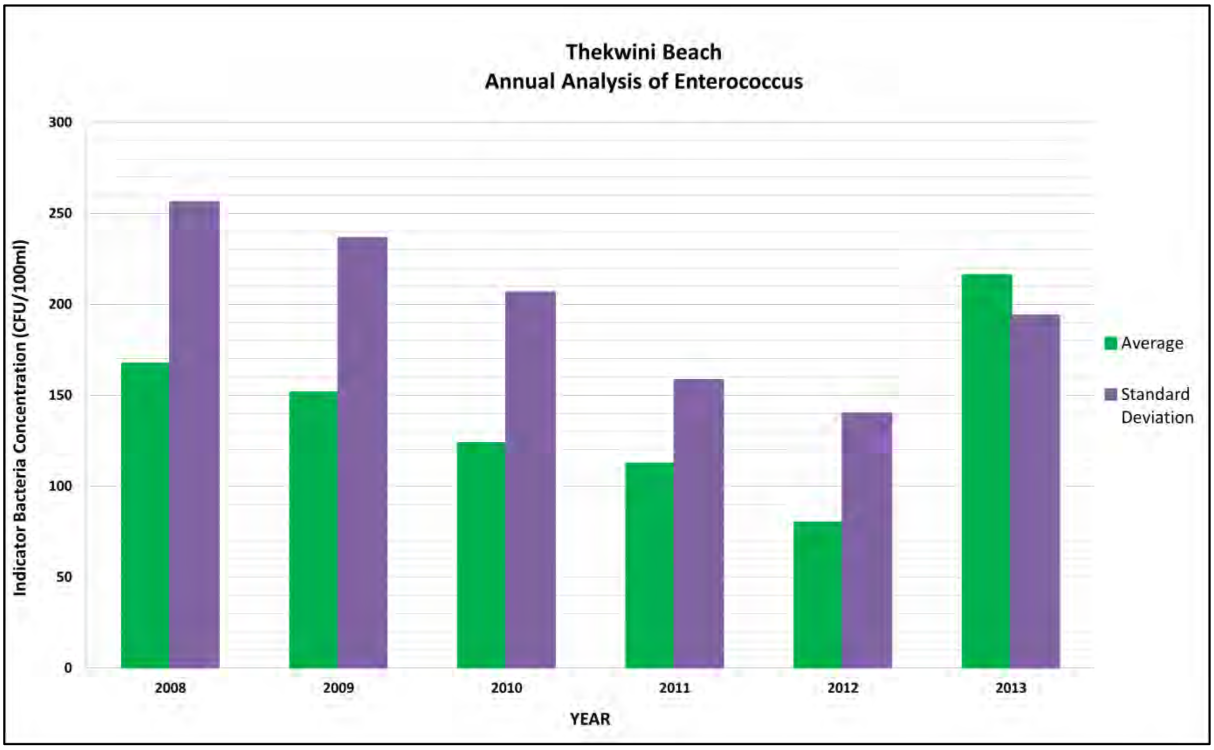

Figure A-47: Annual Analysis of Enterococcus at Thekwini Beach

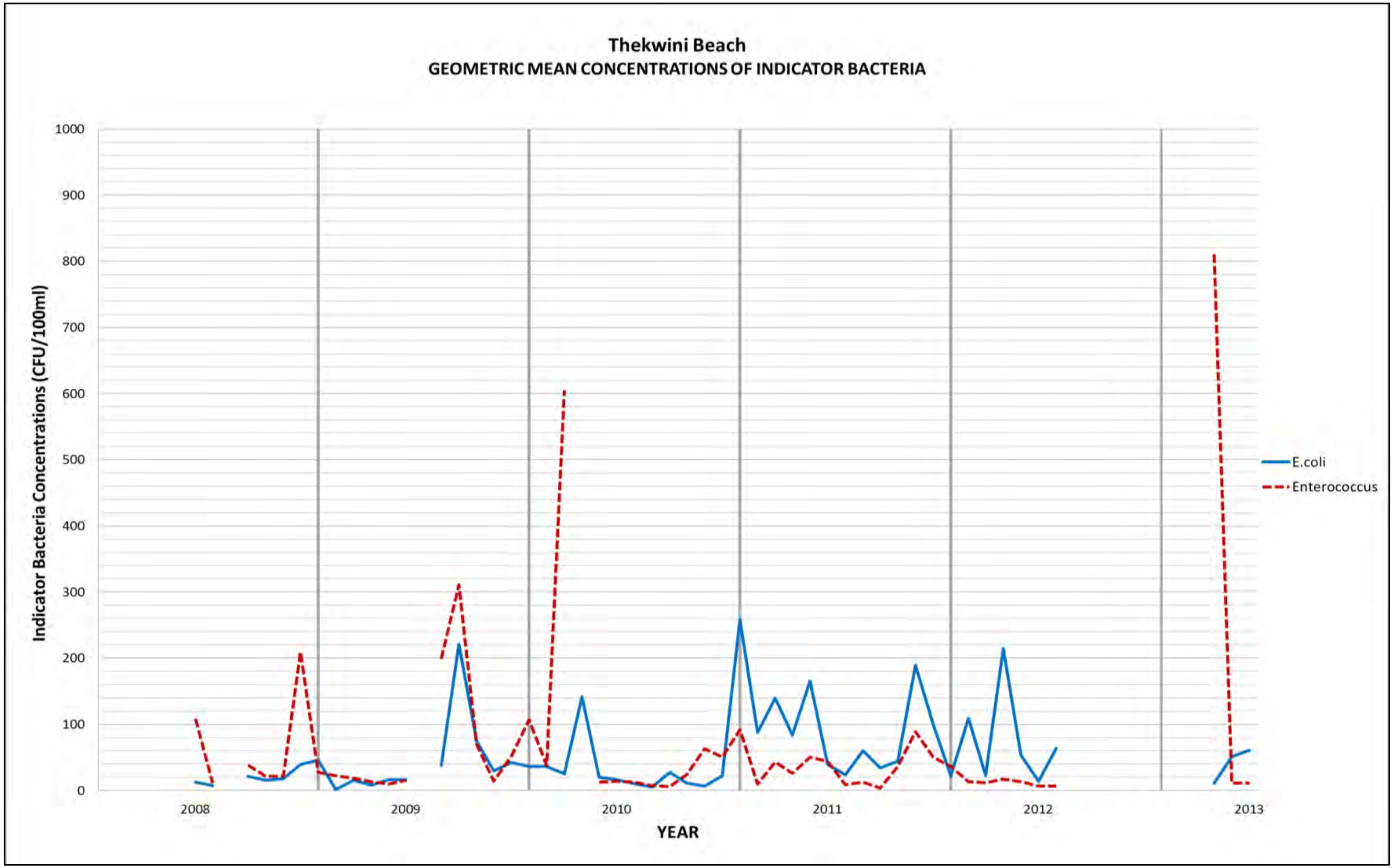

Figure A-48: Thekwini – Geometric Mean Concentrations of Indicator Bacteria (2008-2013)

Figure A-48 compares the geometric means of E.coli and Enterococcus at Thekwini beach from June 2008 to June 2013. Although the geometric means differ, the two indicators follow the same pattern of variability.

- **SAWQ Guidelines**

Tables A-63 and A-64 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. Based on the analysis of the available data for E.coli, generally the water quality has an overall good rating with just one year been rated poor.

Table A-63: Thekwini – E.coli Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	G	G	P	G	G
FEB	-	E	G	G	G	-
MAR	-	G	G	P	E	-
APR	-	G	G	G	G	E
MAY	-	G	E	P	G	E
JUN	G	E	E	G	E	E
JUL	E	-	E	E	E	E
AUG	-	E	E	G	-	E
SEP	G	E	E	E	-	E
OCT	E	E	E	G	-	G
NOV	E	E	E	P	-	E
DEC	G	E	E	G	-	E
Annual	G	G	G	P	G	G

Based on Enterococcus concentrations however, it is clear that water quality at Thekwini Beach has been poor throughout the study period. At least half of each year has a poor rating due to high concentrations of Enterococcus. Incidences of excellent water quality are infrequent and inconsistent.

Table A-64: Thekwini – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	P	P	P	P	P
FEB	-	P	P	E	P	-
MAR	-	P	P	P	G	-
APR	-	P	-	P	E	P
MAY	-	P	P	P	P	E
JUN	P	P	E	P	E	E
JUL	E	-	G	P	E	-
AUG	-	P	E	G	-	-
SEP	P	P	E	E	-	-
OCT	P	P	P	E	-	-
NOV	G	G	P	P	-	-
DEC	P	P	P	P	-	-
Annual	P	P	P	P	P	P

A.2.4. Country Club

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-65. Autumn produced the highest most often. Summer consistently produced the second highest average counts of E.coli for the last 4 years of the study. During the first half of the study period winter is ranked highly and after 2009 it is ranked consistently on the lower end. No other significant trends are evident as the season which yielded the highest concentration of E.coli differs each year.

Table A-65: Country Club – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	23.3 (3)	73.3 (3)	**118 (1)**	15.6 (4)	35.6 (3)	63.3 (4)	97.8 (3)	**130 (1)**	**262 (1)**	110 (4)	**127 (1)**
Winter	64.4 (2)	**116 (1)**	90.0 (2)	90.0 (2)	**76.7 (1)**	**323 (1)**	80.8 (4)	85.3 (3)	78.1 (4)	136 (3)	48.9 (4)
Spring	16.7 (4)	20.0 (4)	21.1 (3)	43.3 (3)	**76.7 (1)**	132 (2)	107 (2)	51.7 (4)	134 (3)	**203 (1)**	83.3 (3)
Summer	**96.7 (1)**	95.6 (2)	20.0 (4)	**267 (1)**	57.8 (2)	106 (3)	**266 (1)**	94.0 (2)	196 (2)	162 (2)	113 (2)

Table A-66 shows the ranking of the Enterococcus seasonal averages. As with E.coli, autumn produced the highest most often and summer yielded the second highest consistently for the last four years. No other significant trends and no other correlations with E.coli are evident.

Table A-66: Country Club – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	13.3 (4)	70.0 (4)	**26.7 (1)**	20.0 (4)	**214 (1)**	53.3 (4)	92.2 (4)	**261 (1)**	166 (3)	81.9 (3)	**277 (1)**
Winter	209 (2)	**178 (1)**	6.70 (4)	61.1 (3)	164 (2)	150 (3)	**314 (1)**	103 (3)	145 (4)	73.3 (4)	15.0 (2)
Spring	**240 (1)**	123 (3)	18.9 (30	173 (2)	107 (3)	165 (2)	139 (3)	49.4 (4)	**344 (1)**	**111 (1)**	-
Summer	26.7 (3)	173 (2)	23.3 (2)	**177 (1)**	18.9 (4)	**255 (1)**	149 (2)	173 (2)	203 (2)	104 (2)	-

- **Annual Trends**

Figures A-49 and A-50 portray the annual averages and standard deviations for E.coli and Enterococcus respectively.

It is shown that average counts of E.coli varied slightly throughout the study period but remained below 100CFU/100ml for most years. The highest average counts occurred in 2008, 2009 and 2011. The average levels of E.coli in 2013 are approximately double that of 2003. Generally the deviations were significant however; in 2008, 2009 the deviations were found to be extremely large which indicate that the data set is widely spread during those years.

With exception to the drastic decrease in 2005, generally the average counts of Enterococcus varied marginally. Ultimately the average concentration of Enterococcus at the end of the study period was determined to be approximately 1.5 times greater than at the start of the study period. Large standard deviations are evident throughout most of the study period. Exceptionally large deviations in 2011 indicate that the data set for Enterococcus for that year was spread over an extremely large set.

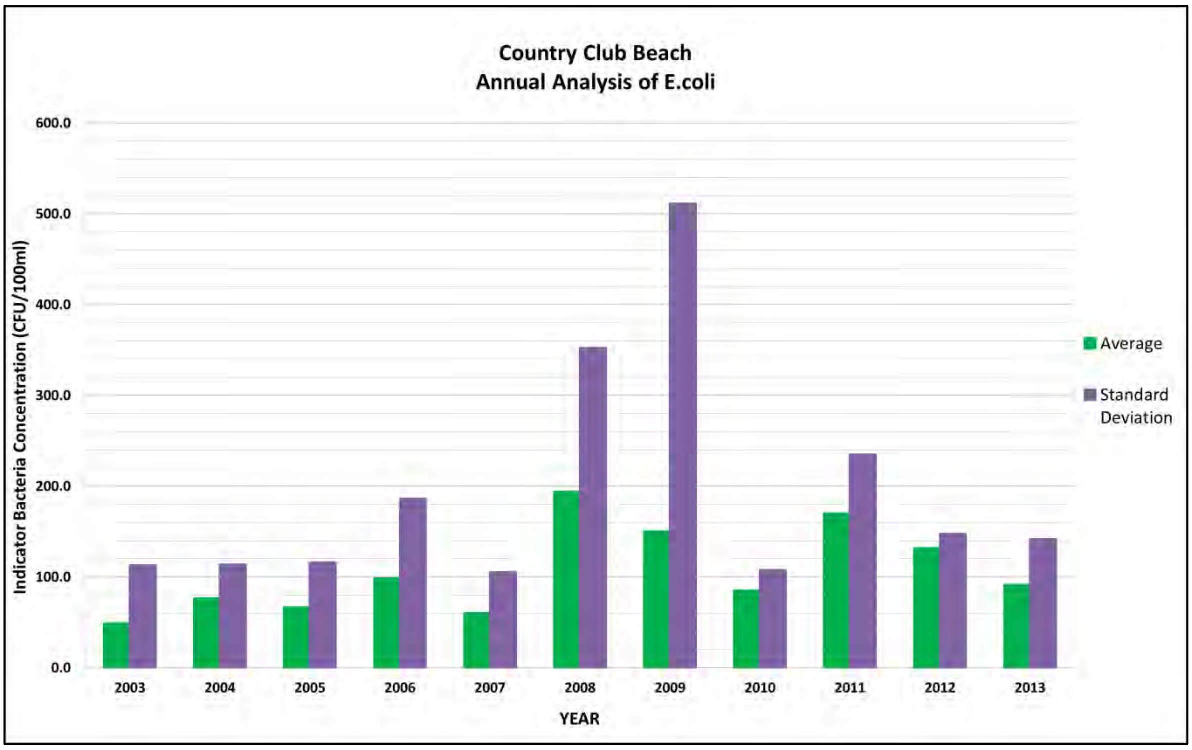

Figure A-49: Annual Analysis of E.coli at Country Club Beach

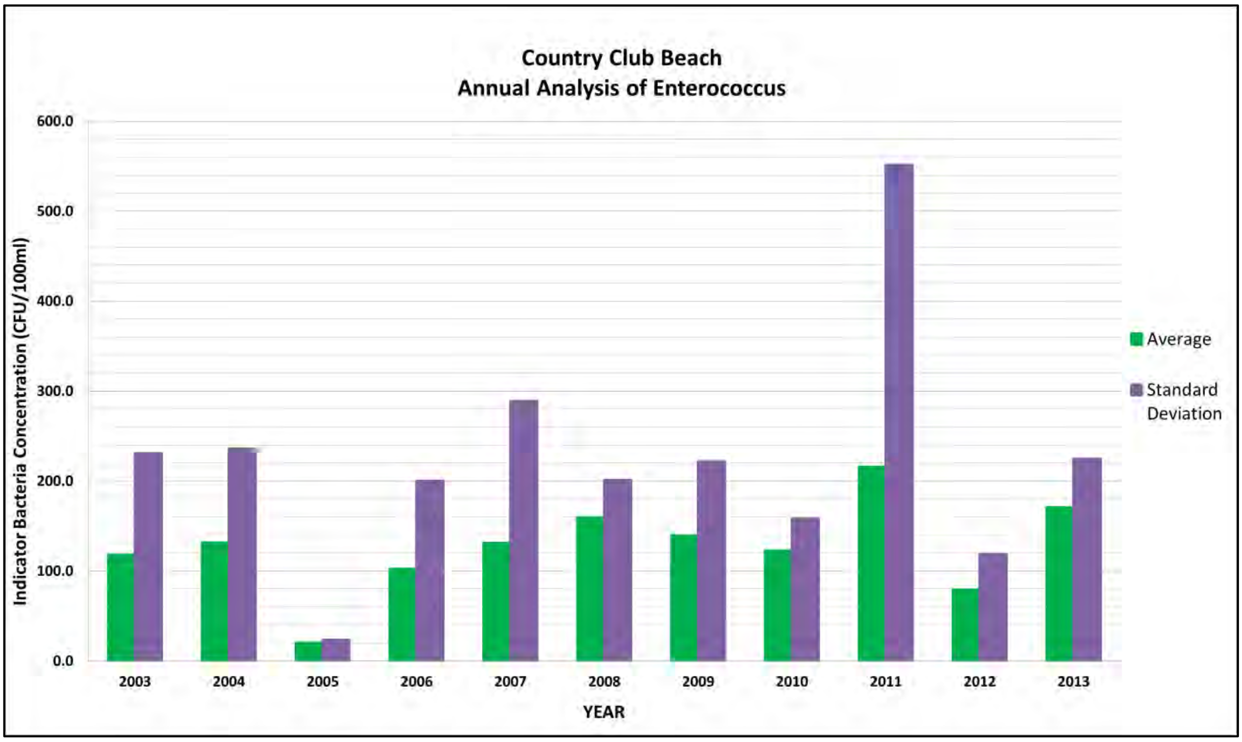

Figure A-50: Annual Analysis of Enterococcus at Country Club Beach

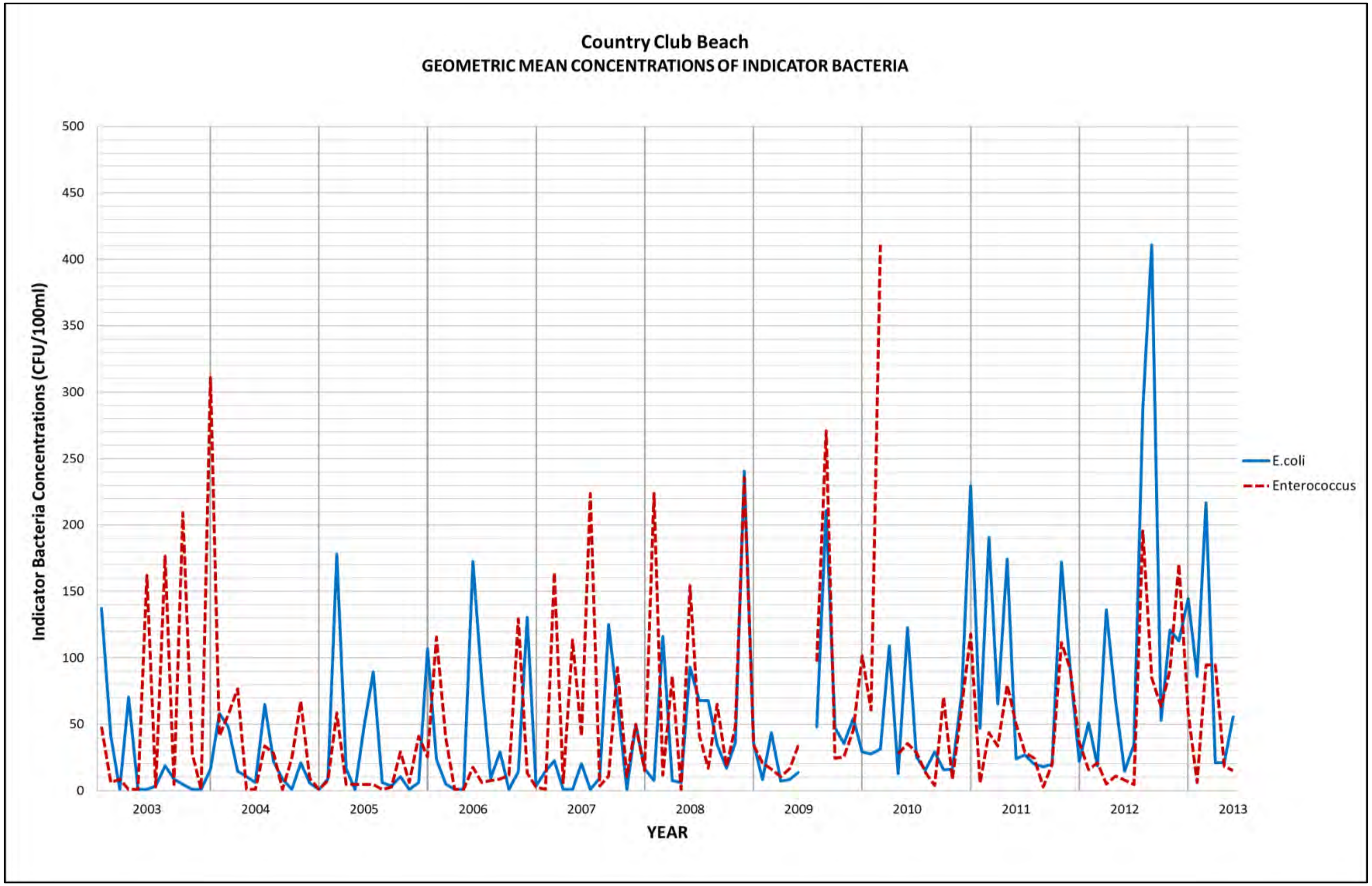

Figure A-51: Country Club – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are compared in Figure A-51. Throughout the entire study period both indicator organisms have remained erratic. From 2003 up to 2010 Enterococcus counts are shown to be higher than E.coli in most cases, thereafter this trend is reversed.

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- **SAWQ Guidelines**

Table A-67 depicts the microbiological water quality rating based on E.coli. Generally the levels of E.coli indicate good annual water quality conditions, with only seven occurrences of poor water quality throughout the entire study period. Based on E.coli Country Club‟s waters have only received one excellent annual classification in 2004 and one overall rating of poor in 2009.

Table A-67: Country Club – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	E	E	E	E	E	P	E	G	G	-
FEB	E	E	E	P	E	E	E	G	E	G	-
MAR	E	E	G	E	G	E	G	G	G	E	-
APR	E	E	G	E	E	E	G	G	G	G	-
MAY	E	E	E	E	E	E	P	E	G	G	E
JUN	E	E	E	E	G	P	P	G	G	E	E
JUL	E	E	G	E	E	P	-	E	G	E	E
AUG	G	G	E	E	E	G	E	E	E	G	E
SEP	E	E	E	E	E	G	E	E	E	G	E
OCT	E	E	E	E	E	G	E	E	E	E	G
NOV	E	E	E	E	E	G	E	E	G	E	E
DEC	E	E	E	P	E	G	G	E	G	G	E
Annual	G	E	G	G	G	G	P	G	G	G	G

Table A-68: Country Club – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	P	E	G	P	P	P	E	P
FEB	E	E	E	G	E	P	P	P	E	E	E
MAR	E	E	E	G	P	G	G	P	P	P	P
APR	E	P	E	E	E	G	G	-	P	E	P
MAY	E	E	E	E	P	E	P	P	P	P	E
JUN	P	E	E	P	E	P	P	P	P	E	E
JUL	E	P	E	E	P	P	-	P	P	E	-
AUG	P	P	E	E	E	G	P	P	P	P	-
SEP	E	E	E	E	G	P	P	G	E	G	-
OCT	P	P	E	G	P	P	P	P	P	E	-
NOV	P	E	E	P	E	P	E	E	P	E	-
DEC	E	E	E	E	E	P	P	P	P	P	-
Annual	P	P	E	P	P	P	P	P	P	P	P

Table A-68 summarises the microbiological water quality rating based on Enterococcus. Annually water quality has been predominantly poor based on counts of Enterococcus, with every year except 2005 being classified as poor. From 2008 to 2011 most months of each year experienced poor water quality. Water quality been classified as poor more frequently based on Enterococcus levels as compared to E.coli.

A.2.5. Dunes (Suncoast)

Sample data for both indicator bacteria at Dunes Beach was only provided for 2008 to 2013. Data for E.coli was from September 2008 to December 2013 and data for Enterococcus was from September 2008 to June 2013. In addition, data for July 2009 was not provided.

- **Seasonal Trends**

Table A-69 ranks the seasonal averages of E.coli. Summer either produced the highest or second highest average. Winter produced the lowest average from 2009 to 2011, thereafter it produced the highest for two consecutive years. Spring never produced the highest average of E.coli.

Table A-69: Dunes – Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	85.6 (3)	**290 (1)**	195 (2)	133 (3)	81.7 (3)
Winter	-	77.5 (4)	84.8 (4)	120 (4)	**184 (1)**	**178 (1)**
Spring	89.6 (2)	137 (2)	86.8 (3)	188 (3)	-	68.3 (4)
Summer	**225 (1)**	**204 (1)**	158 (2)	**328 (1)**	151 (2)	83.3 (2)

The seasonal averages of Enterococcus are ranked in Table A-70. As with E.coli spring never yielded the highest average. It is evident that summer consistently produced the second highest average from 2009 to 2012. There is no correlation between E.coli and Enterococcus seasonal averages.

Table A-70: Dunes – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	83.9 (4)	**167 (1)**	**123 (1)**	61.8 (3)	**280 (1)**
Winter	-	**223 (1)**	69.9 (3)	81.3 (3)	**134 (1)**	10.0 (2)
Spring	73.2 (2)	112 (3)	38.2 (4)	75.1 (4)	-	-
Summer	**270 (1)**	156 (2)	127 (2)	111 (2)	96.7 (2)	-

- **Annual Trends**

Figures A-52 and A-53 represent the annual averages and standard deviation for E.coli and Enterococcus respectively. With exception to the slight increase in 2011, the average levels of E.coli have remained consistently within the range of 100-150CFU/100ml from 2008 to 2013. Exceptionally large standard deviations in 2009 and 2011 are clear and thus highlight variation of E.coli levels during those years.

Average counts of Enterococcus at Dunes beach have been consistent and remained below 150CFU/100ml. Generally the standard deviations were found to be approximately 1.5 times that of their corresponding averages.

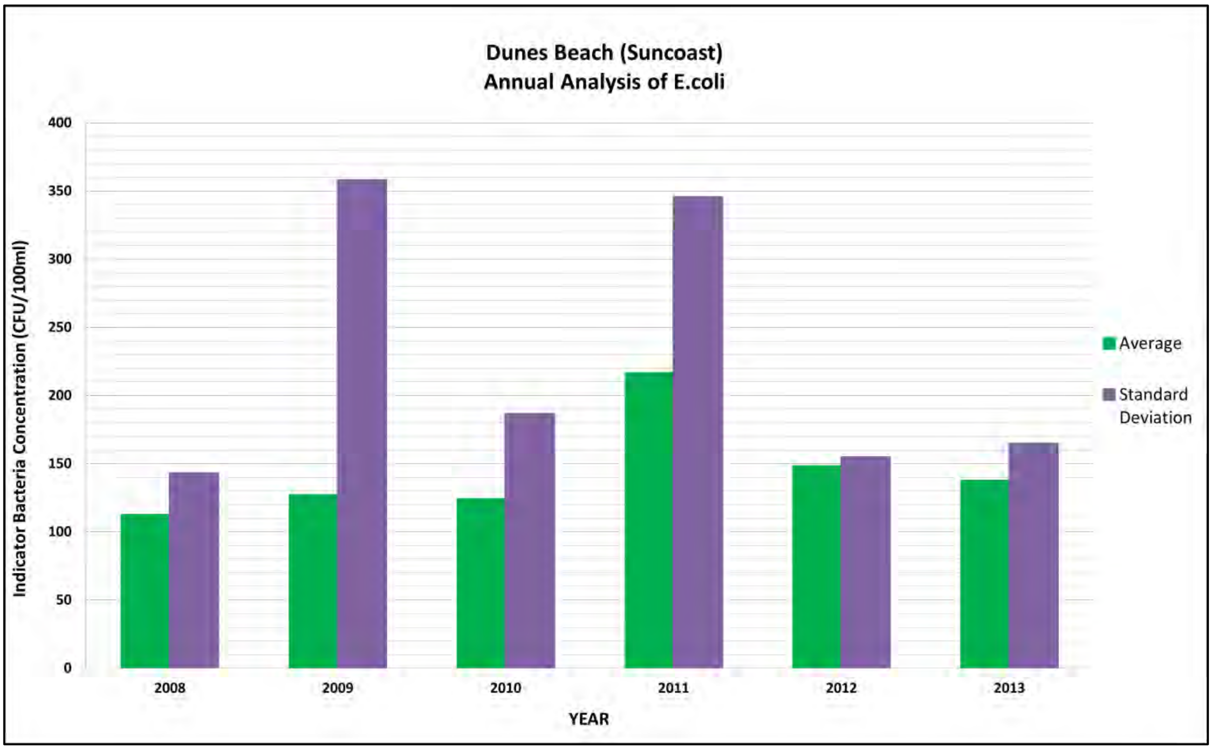


Figure A-52: Annual Analysis of E.coli at Dunes Beach

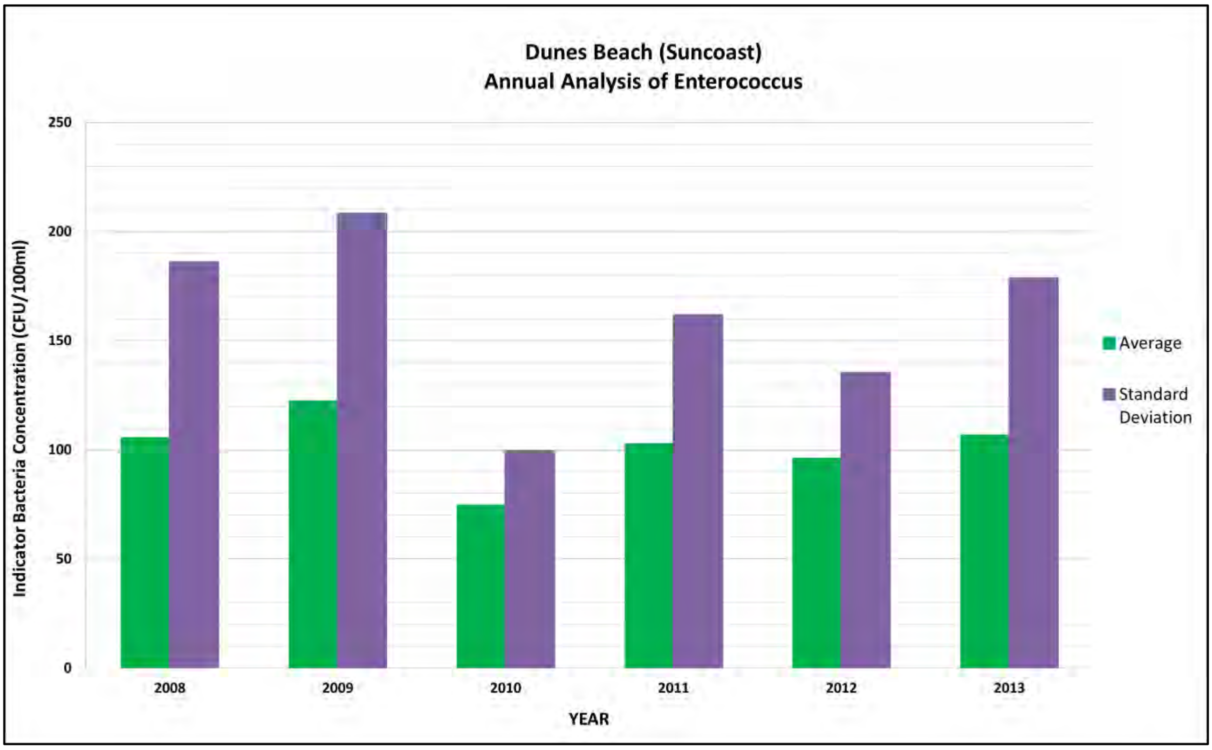


Figure A-53: Annual Analysis of Enterococcus at Dunes Beach

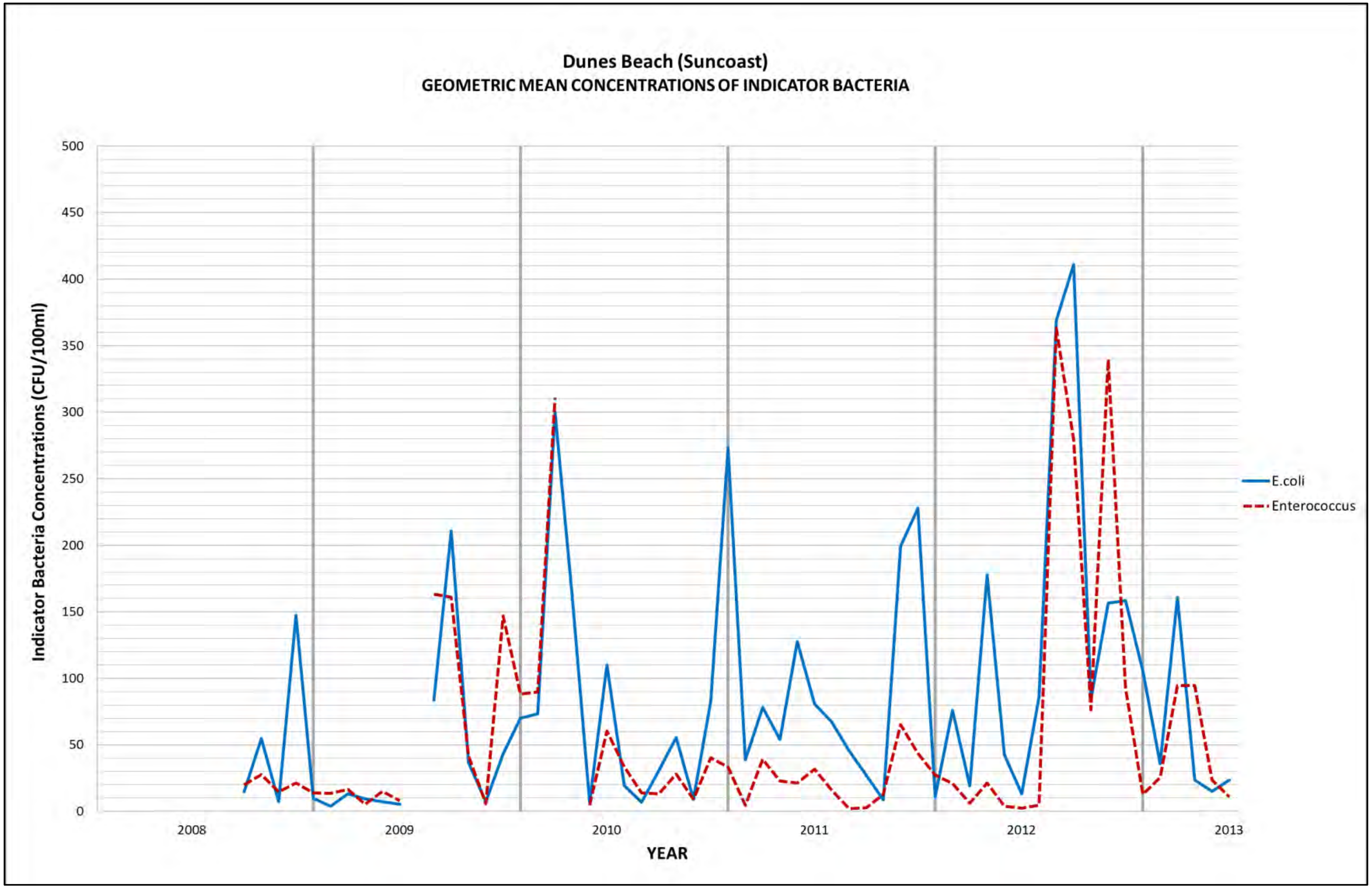


Figure A-54: Dunes – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-54 illustrates the geometric means of E.coli and Enterococcus. Concentrations of E.coli exceeded Enterococcus during most of the study period. Both indicator bacteria have remained variable however; they share the same pattern of variability.

- **SAWQ Guidelines**

Table A-71 summarises the microbiological rating based on E.coli concentrations. Based on the analysis of the available data for E.coli, generally the water quality has an overall good rating with just one year been rated poor overall.

Table A-71: Dunes – E.coli Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	G	G	P	E	G
FEB	-	E	G	E	G	E
MAR	-	E	P	G	E	G
APR	-	E	G	G	G	E
MAY	-	G	E	P	G	E
JUN	-	E	G	P	G	E
JUL	-	-	E	E	E	E
AUG	-	E	E	E	E	P
SEP	G	E	G	E	G	E
OCT	G	E	E	E	G	G
NOV	E	G	E	P	G	E
DEC	G	E	E	P	E	E
Annual	G	G	G	P	G	G

The microbiological water quality rating based on Enterococcus is shown in Table A-72. General the annual water quality classification has been poor. Just one year out of the study has produced an annual rating of good.

Table A-72: Dunes – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	P	G	P	E	G
FEB	-	P	P	E	E	E
MAR	-	G	P	P	P	P
APR	-	E	-	P	P	P
MAY	-	P	E	P	E	E
JUN	-	P	P	P	G	E
JUL	-	-	E	P	E	-
AUG	-	P	G	E	P	-
SEP	G	G	G	E	P	-
OCT	P	P	E	G	P	-
NOV	E	G	E	P	P	-
DEC	P	P	G	G	P	-
Annual	P	P	G	P	P	P

A.2.6. Battery

- **Seasonal Trends**

The ranking of the seasonal averages for E.coli and Enterococcus are depicted in Tables A-73 and A-74 respectively. At Battery beach autumn yielded the highest average concentration of E.coli most frequently but not consistently. The highest average has decreased since the start of the study. No clear trends are evident.

Table A-73: Battery – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	73.3 (4)	**2010 (1)**	**941 (1)**	85.6 (3)	167 (2)	**557 (1)**	81.1 (2)	**315 (1)**	**255 (1)**	140 (4)	61.7 (4)
Winter	**861 (1)**	1473 (2)	23.3 (4)	58.9 (4)	**533 (1)**	156 (3)	61.7 (4)	44.1 (4)	117 (4)	148 (3)	**190 (1)**
Spring	733 (2)	3.30 (4)	86.7 (3)	**287 (1)**	40.0 (3)	217 (2)	63.3 (3)	80.4 (3)	164 (3)	**253 (1)**	100 (2)
Summer	123 (3)	917 (3)	257 (2)	160 (2)	10.0 (4)	149 (4)	**304 (1)**	145 (2)	192 (2)	166 (2)	83.3 (3)

Based on Enterococcus there are no definitive trends evident as the season which yielded the highest concentration differs each year. There is no correlation between E.coli and Enterococcus seasonal averages.

Table A-74: Battery – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	46.7 (3)	173 (3)	113 (2)	120 (3)	113 (2)	187 (2)	83.9 (4)	**218 (1)**	**131 (1)**	87.7 (4)	**283 (1)**
Winter	289 (2)	267 (2)	20.0 (4)	117 (4)	**253 (1)**	114 (4)	**252 (1)**	69.1 (3)	76.4 (4)	123 (2)	10.0 (2)
Spring	**427 (1)**	93.3 (4)	86.7 (3)	**347 (1)**	46.7 (3)	145 (3)	101 (3)	38.1 (4)	83.3 (3)	**224 (1)**	-
Summer	10.0 (4)	**380 (1)**	**267 (1)**	193 (2)	22.2 (4)	**218 (1)**	117 (2)	103 (2)	119 (2)	99.4 (3)	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for Battery beach are portrayed in Figure A-55. The average concentration of E.coli at Battery Beach has decreased since 2004, where the highest average was experienced. For the last four years the average remained below 200CFU/100ml. Ultimately the average concentration in 2013 is only 10% of that in 2004.

The standard deviations are shown to be large during the first seven years of the study. Thereafter they become less significant and more uniform. This indicates that as the averages have become consistent, there is less variation in counts of E.coli each year.

Figure A-56 shows the annual averages and standard deviations of Enterococcus. It is shown that the average levels of this bacterium varied slightly but no significant changes are evident. Ultimately the average concentration of Enterococcus at the end of the study was only marginally less than at the start. Large deviations are evident throughout the study period. Although the averages have not changed greatly, Enterococcus concentrations still varied significantly throughout each year.

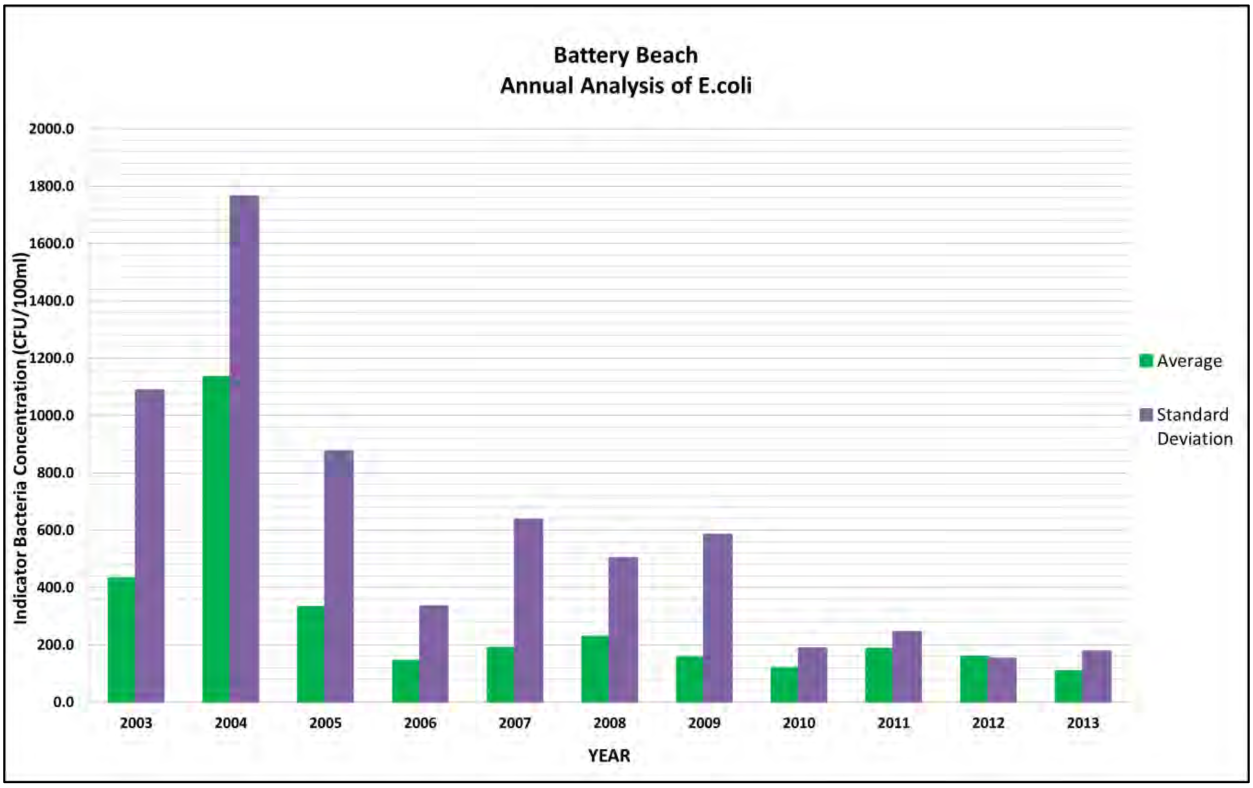


Figure A-55: Annual Analysis of E.coli at Battery Beach

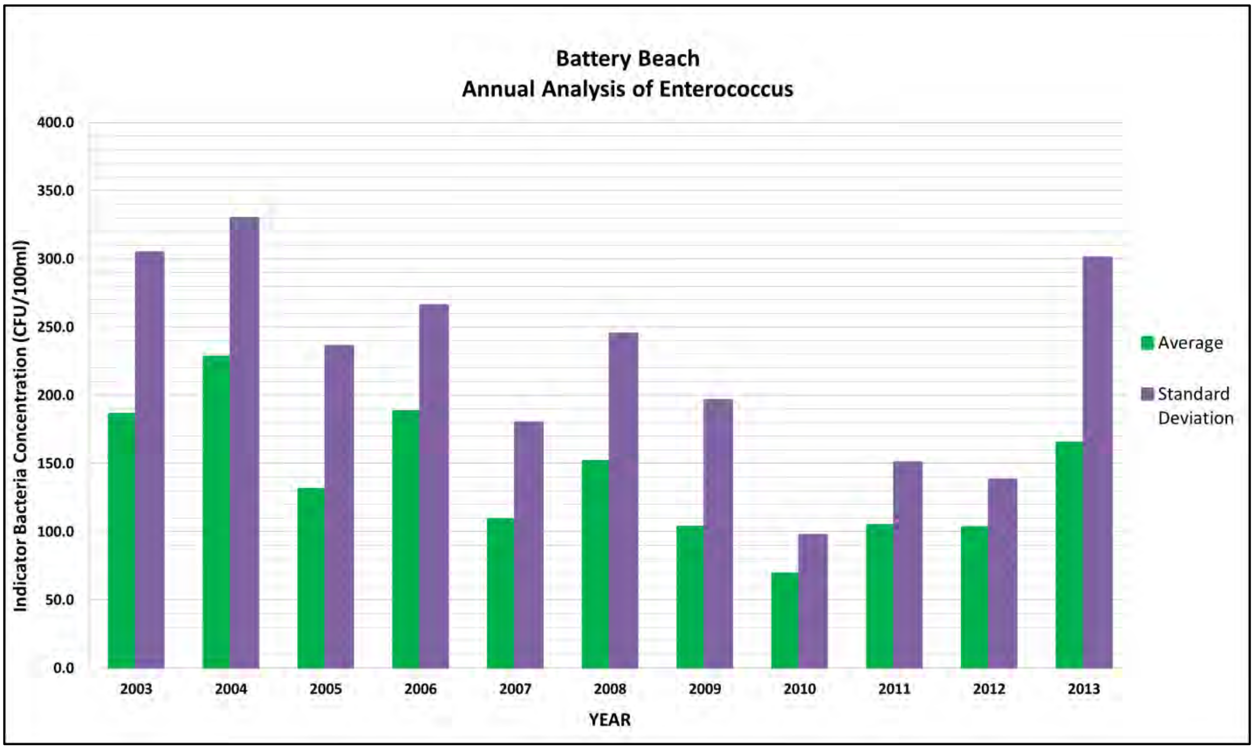


Figure A-56: Annual Analysis of Enterococcus at Battery Beach

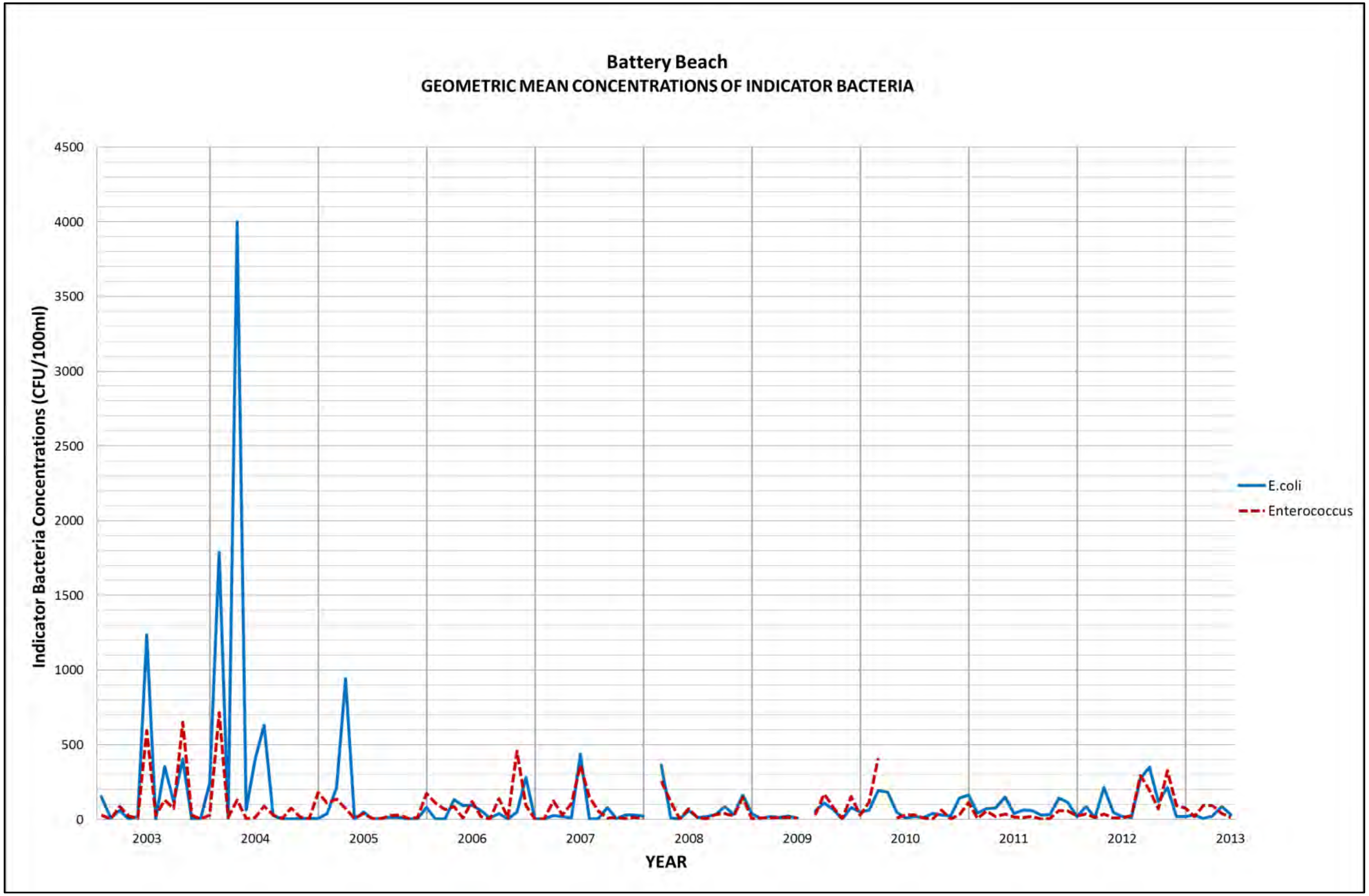


Figure A-57: Battery – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-57 illustrates the geometric mean concentrations of the two indicator bacteria. During the first three years both E.coli and Enterococcus were variable however, E.coli exceeded Enterococcus during this time. From the middle of 2005 both indicators became less erratic and they share the same patterns of fluctuation. The geometric mean concentrations were also nearly identical.

- **SAWQ Guidelines**

Tables A-75 and A-76 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. Poor water quality conditions occurred frequently during the first three years. This trend correlates to the higher geometric means shown in Figure A-62 during the same period. Water quality appears to have improved after 2010 and remained consistently good thereafter.

Table A-75: Battery – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	G	E	E	E	E	P	E	G	G	G
FEB	E	G	P	E	E	P	E	G	E	G	E
MAR	E	E	P	E	P	P	E	G	G	E	E
APR	E	P	P	E	G	E	E	G	G	G	E
MAY	G	P	E	E	E	-	P	E	G	G	E
JUN	P	P	E	E	P	P	E	E	G	G	E
JUL	E	P	E	E	E	G	-	E	G	E	E
AUG	G	P	E	E	E	G	E	E	E	G	P
SEP	G	E	P	P	E	P	E	G	E	G	E
OCT	P	E	E	E	E	P	E	E	E	G	G
NOV	E	E	E	E	E	E	E	E	G	G	E
DEC	E	E	E	P	E	G	G	E	G	G	E
Annual	P	P	P	G	G	G	P	G	G	G	G

Based on Enterococcus the water quality has been classified as poor for the duration of the study period with exception to just one year, 2010, having an overall good rating. Many years experienced poor water quality conditions for about half the year. The waters at Battery beach have been classified as poor more frequently based on Enterococcus levels as compared to E.coli.

Table A-76: Battery – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	P	P	E	P	P	G	P	E	G
FEB	E	P	P	E	E	P	E	P	E	G	E
MAR	G	G	P	G	P	P	E	P	P	P	P
APR	E	P	P	G	E	G	E	-	P	P	P
MAY	E	E	E	E	P	E	P	E	P	P	E
JUN	P	G	E	G	P	P	G	G	P	G	E
JUL	E	P	E	G	P	G	-	G	G	E	-
AUG	P	P	E	E	E	G	P	P	G	P	-
SEP	P	E	P	G	E	P	G	E	E	P	-
OCT	P	P	E	E	G	P	P	G	G	P	-
NOV	P	P	E	P	E	G	E	E	P	P	-
DEC	E	E	G	E	G	P	P	G	P	P	-
Annual	P	P	P	P	P	P	P	G	P	P	P

A.2.7. Bay of Plenty

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-77. There are no clear seasonal trends based on E.coli as the season which produced the highest average differs each year.

Table A-77: Bay of Plenty – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	3.30 (4)	20.0 (3)	34.4 (3)	41.1 (2)	34.0 (2)	20.0 (4)	**61.3 (1)**	**222 (1)**	67.5 (3)	74.7 (3)	**128 (1)**
Winter	13.3 (3)	**508 (1)**	10.0 (4)	15.6 (4)	3.30 (4)	38.7 (3)	32.0 (2)	56.7 (3)	57.7 (4)	18.3 (4)	56.7 (4)
Spring	**203 (1)**	6.70 (4)	85.6 (2)	33.3 (3)	**56.7 (1)**	**118 (1)**	32.0 (2)	53.7 (4)	131 (2)	84.4 (2)	88.3 (3)
Summer	23.3 (2)	52.2 (2)	**183 (1)**	**50.0 (1)**	12.2 (3)	107 (2)	23.1 (3)	72.7 (2)	**248 (1)**	**112 (1)**	90.0 (2)

Table A-78 shows the ranking of seasonal averages for Enterococcus. Summer produced the highest average level of Enterococcus most frequently and consistently for the last three years for which data was provided. There is no relationship between the two indicators.

Table A-78: Bay of Plenty – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	10.0 (4)	10.0 (4)	66.7 (2)	44.4 (3)	**161 (1)**	16.7 (4)	9.30 (4)	41.0 (2)	62.8 (2)	39.9 (3)	**278 (1)**
Winter	18.9 (2)	**207 (1)**	50.0 (4)	17.8 (4)	80.0 (3)	72.4 (2)	**267 (1)**	42.4 (3)	56.4 (3)	13.3 (4)	20.0 (2)
Spring	**303 (1)**	157 (3)	57.8 (3)	175 (2)	83.3 (2)	66.7 (3)	51.3 (2)	24.2 (4)	51.8 (4)	64.4 (2)	-
Summer	13.3 (3)	162 (2)	**293 (1)**	**197 (1)**	32.2 (4)	**284 (1)**	42.7 (3)	**120 (1)**	**93.3 (1)**	**104 (1)**	-

- **Annual Trends**

Figures A-58 and A-59 show the annual averages and standard deviation for E.coli and Enterococcus at Bay of Plenty respectively.

The average concentrations of E.coli have varied slightly; however, average counts exceeded 100/100ml only twice. Although the averages appear low, there have been large deviations throughout the years. The most significant standard deviation is noted in 2004.

A general decrease in the average concentration of Enterococcus is evident from 2004 to 2012. However, in 2013 the concentration increases by more than triple that of the previous year as well as at the start of the study. Large deviations are consistent throughout the study period, indicating the data set is spread over a large range throughout the study period. There is no link between E.coli and Enterococcus annual averages or standard deviations.

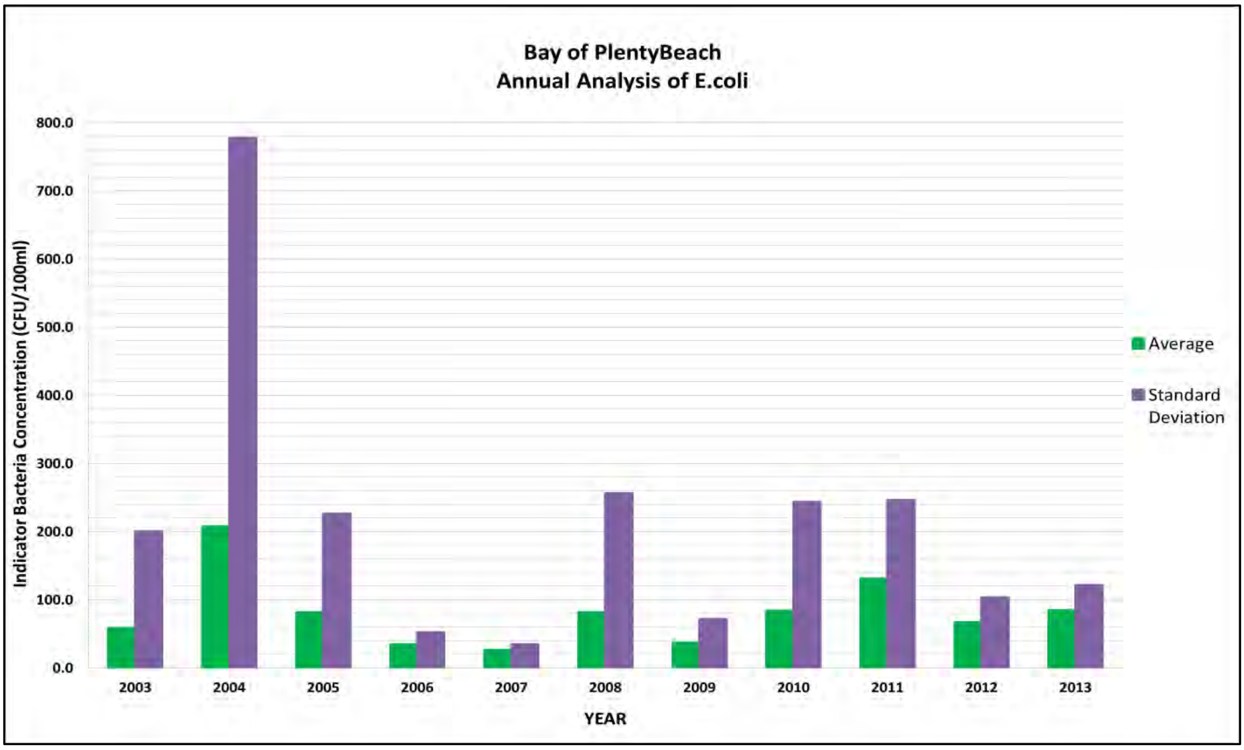


Figure A-58: Annual Analysis of E.coli at Bay of Plenty Beach

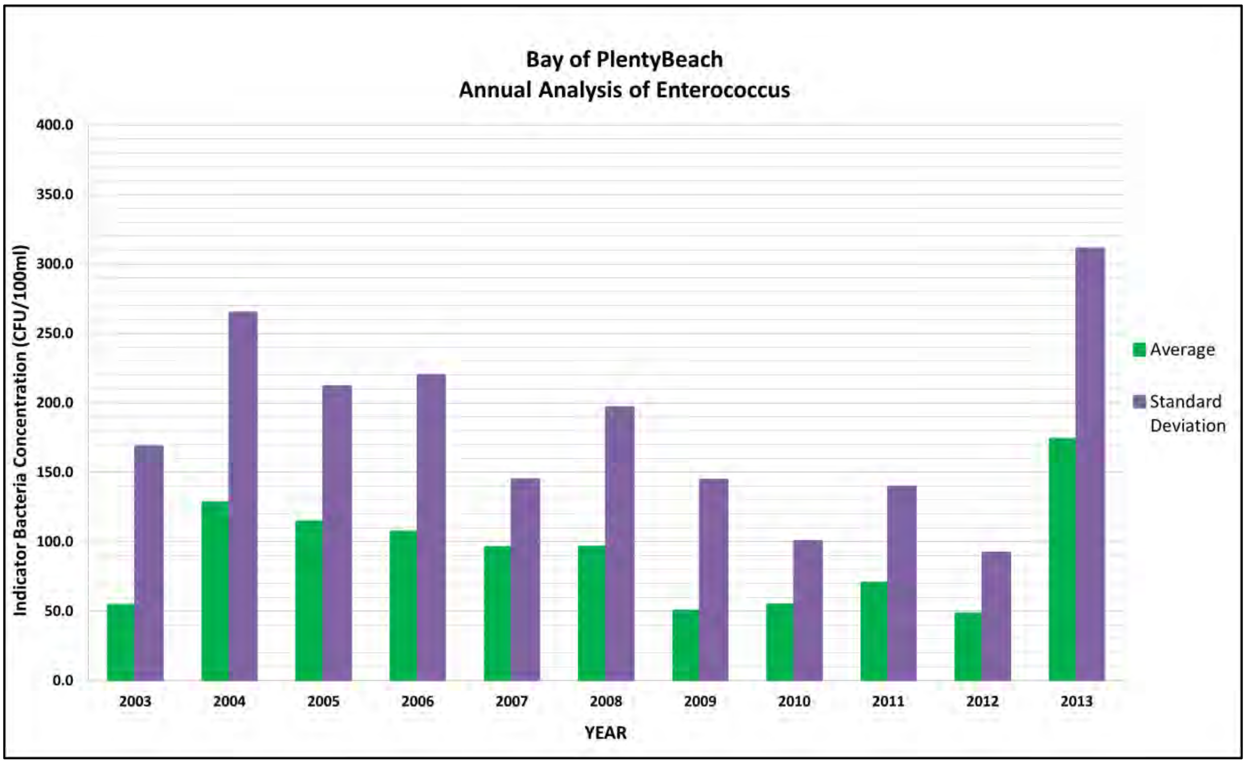


Figure A-59: Annual Analysis of Enterococcus at Bay of Plenty Beach

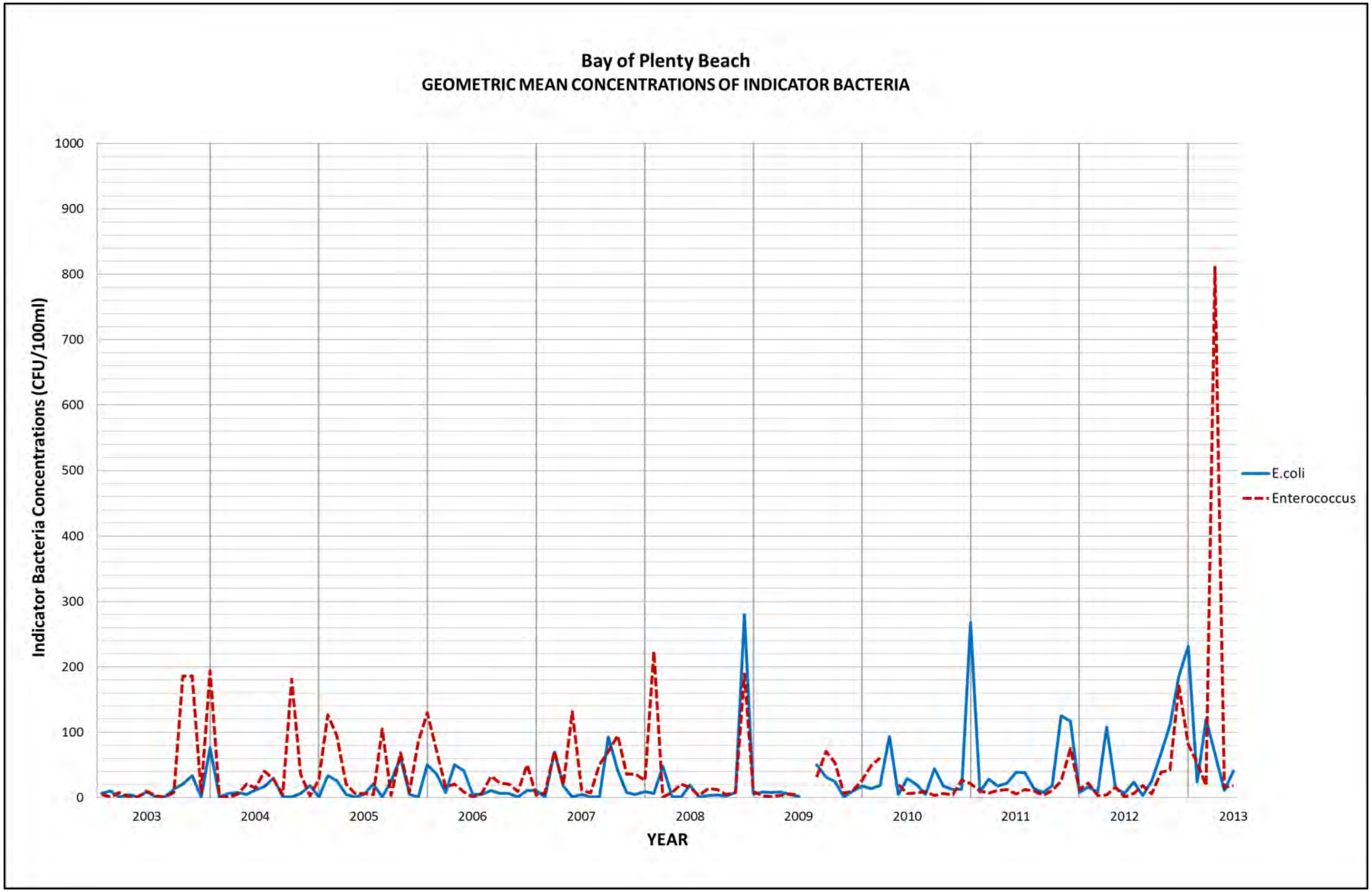


Figure A-60: Bay of Plenty – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of the two indicator bacteria are illustrated in Figure A-60. Enterococcus exceeded E.coli in most instances during the first half of the study period. The two indicator bacteria do follow the same patterns of fluctuation consistently although the concentrations differ.

- **SAWQ Guidelines**

Table A-79 shows that the waters at Bay of Plenty have an overall excellent to good rating. There have only been five occurrences of poor water quality during the entire study period. Occurrences of poor water quality appear to be random. Poor water quality has not been experienced at all in the last three years of the study and the overall annual water quality has consistently been classified as good for those years.

Table A-80 summarises the microbiological rating based on Enterococcus concentrations. The annual water quality rating was determined to be mostly poor. Poor water quality is experienced at some point every year in the study. The overall water quality rating has been poor consistently for the last four years.

Table A-79: Bay of Plenty – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	G	E	E
FEB	E	E	P	E	E	E	E	G	E	G	E
MAR	E	E	E	E	E	E	E	E	G	E	G
APR	E	E	E	E	E	E	G	P	E	E	G
MAY	E	E	E	E	E	E	E	E	G	G	E
JUN	E	E	E	E	E	G	E	G	G	E	E
JUL	E	P	E	E	E	E	-	E	E	E	E
AUG	E	P	E	E	E	E	E	E	E	E	E
SEP	E	E	G	E	E	G	E	E	E	E	E
OCT	E	E	E	E	E	E	E	E	E	E	E
NOV	G	E	E	E	E	P	E	E	G	E	G
DEC	E	E	E	E	E	G	E	G	G	G	E
Annual	E	G	G	E	E	G	E	G	G	G	G

Table A-80: Bay of Plenty – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	P	P	E	E	G	G	P	E	E
FEB	E	E	P	P	E	P	E	P	E	E	E
MAR	E	E	P	G	G	E	E	E	E	E	E
APR	E	E	E	E	P	E	E	-	P	E	P
MAY	E	E	E	E	P	E	E	E	P	P	E
JUN	E	G	E	E	G	P	G	P	P	E	E
JUL	E	P	E	E	P	G	-	E	G	E	-
AUG	E	P	G	E	G	P	P	E	E	E	-
SEP	E	E	E	P	G	E	E	E	E	E	-
OCT	P	P	E	E	P	G	G	G	E	P	-
NOV	G	E	E	P	E	P	E	E	P	G	-
DEC	E	E	G	E	E	P	G	P	P	P	-
Annual	G	P	P	P	P	P	G	P	P	P	P

A.2.8. North

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-81. Spring produced the highest average most frequently and consistently from 2005 to 2008. The highest concentration is shown to vary significantly each year. No clear seasonal trends are observed based on E.coli.

Table A-81: North – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	3.30 (3)	13.3 (3)	14.4 (3)	24.4 (3)	12.0 (3)	16.7 (4)	**259 (1)**	**49.2 (1)**	76.7 (2)	71.1 (2)	**217 (1)**
Winter	**14.4 (1)**	27.8 (2)	20.0 (2)	11.1 (4)	3.30 (4)	30.3 (3)	51.7 (2)	28.9 (4)	56.1 (4)	10.7 (3)	22.2 (4)
Spring	6.70 (2)	3.30 (4)	**50.0 (1)**	**470 (1)**	**33.3 (1)**	**206 (1)**	24.2 (4)	37.9 (2)	69.8 (3)	**137 (1)**	120 (2)
Summer	3.30 (3)	**300 (1)**	0.00 (4)	56.7 (2)	15.6 (2)	62.2 (2)	30.0 (3)	35.9 (3)	**199 (1)**	10.4 (4)	48.3 (3)

Table A-82 shows the ranking of the Enterococcus seasonal averages at North beach. Summer produced the highest average every alternate year. No trends are clear as season which yielded the highest counts of Enterococcus varies each year. There is no correlation between the two indicator bacteria.

Table A-82: North – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	23.3 (3)	23.3 (4)	13.3 (4)	18.9 (3)	**142 (1)**	36.7 (4)	29.4 (4)	76.0 (2)	27.8 (4)	13.8 (4)	**270 (1)**
Winter	55.6 (2)	64.4 (2)	**43.3 (1)**	17.8 (4)	90.0 (4)	92.1 (3)	**271 (1)**	36.3 (3)	**62.8 (1)**	14.0 (3)	10.0 (2)
Spring	**163 (1)**	30.0 (3)	25.6 (2)	112 (2)	113 (3)	93.8 (2)	55.6 (2)	22.1 (4)	28.9 (3)	**106 (1)**	-
Summer	23.3 (3)	**277 (1)**	23.3 (3)	**177 (1)**	127 (2)	**245 (1)**	50.6 (3)	**101 (1)**	48.8 (2)	65.8 (2)	-

- **Annual Trends**

Figure A-61 shows a clear variation in both the annual averages and standard deviations of E.coli concentrations at North beach. E.coli has fluctuated slightly over the study period. It increased and decreased randomly with average counts exceeding 150/100ml just once. In 2013 the average increased more than tenfold when compared to the start of the study.

It is clear larger standard deviations are associated with higher averages. Noteworthy deviations in 2004, 2006, 2008 and 2009 highlight significant variation in E.coli levels throughout each of those years.

The annual averages and standard deviations for Enterococcus are depicted in Figure A-62. Like E.coli, average Enterococcus counts showed some variation but remained below 150CFU/100ml throughout most of the study. A significant increase in 2013 shows average levels approximately 3 times that at the start of the study period. As with E.coli, larger standard deviations are linked to higher averages.

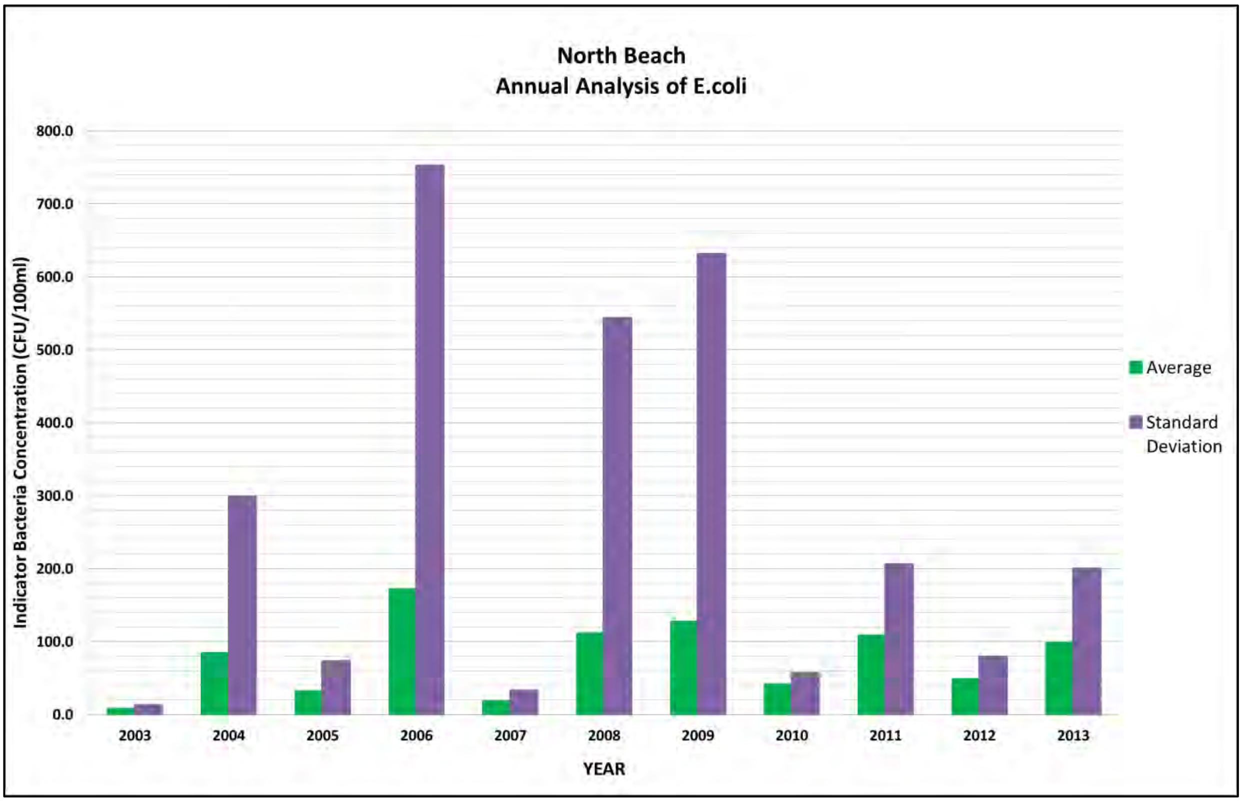


Figure A-61: Annual Analysis of E.coli at North Beach

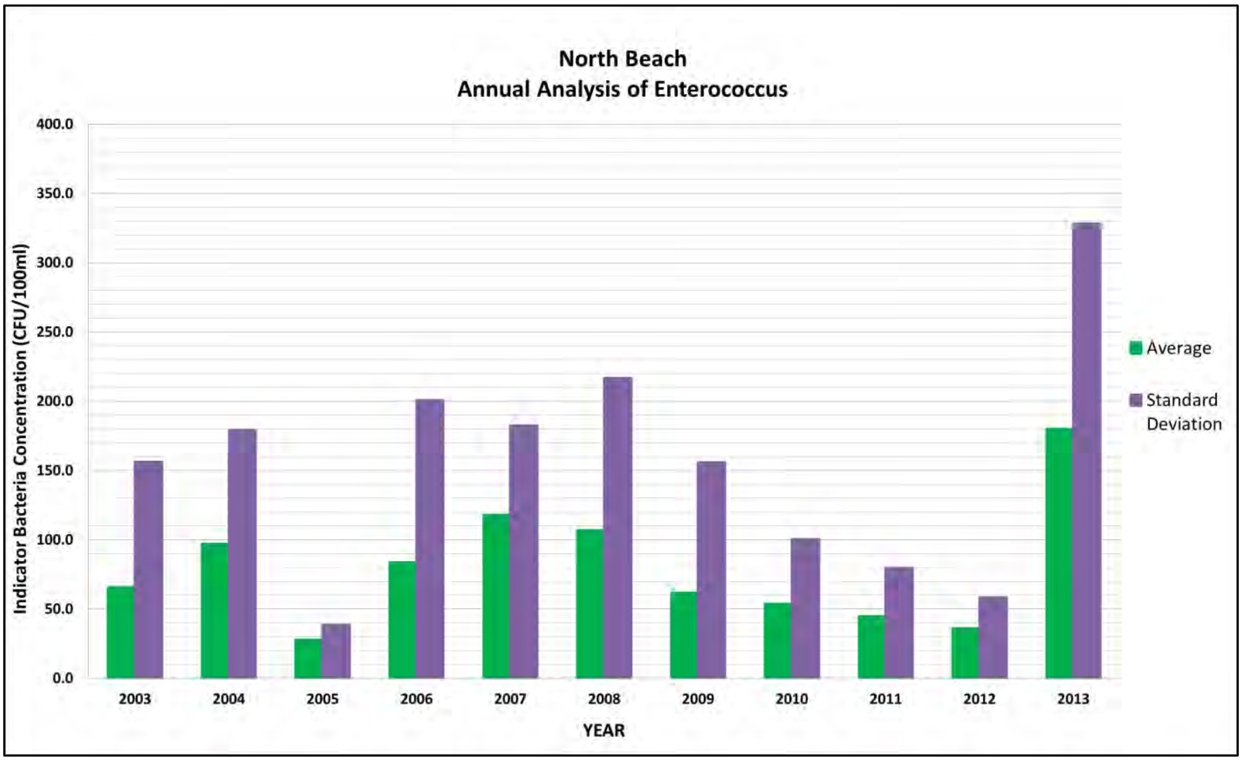


Figure A-62: Annual Analysis of Enterococcus at North Beach

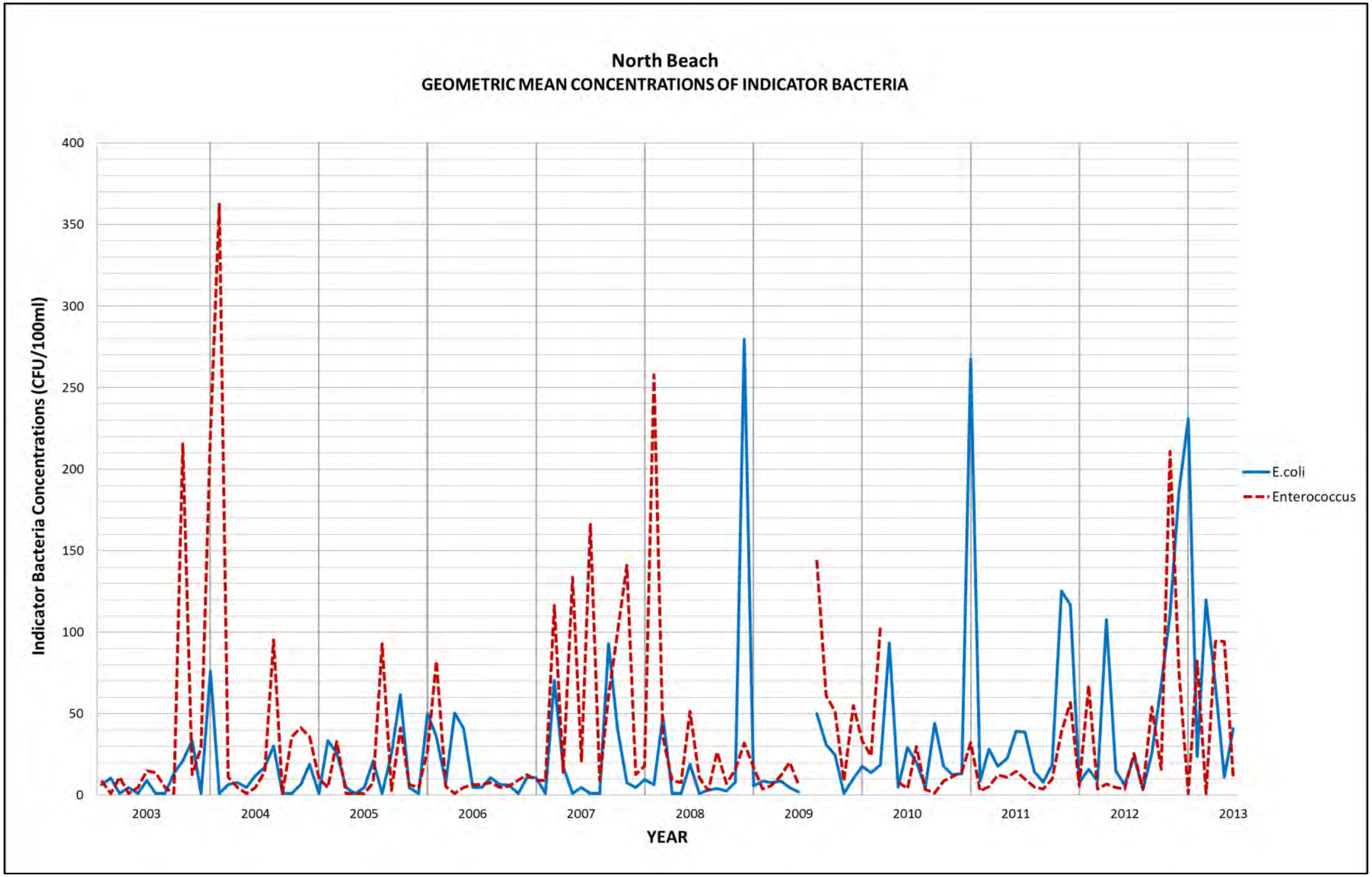


Figure A-63: North – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-63 shows the geometric mean concentrations of Enterococcus exceeded E.coli in most instances during the first half of the study period. Although the concentrations differ for each bacterium, they follow the same patterns of fluctuation.

- **SAWQ Guidelines**

Tables A-83 and A-84 summarise the microbiological water quality ratings for E.coli and Enterococcus respectively.

At North beach the annual rating has been mostly excellent. Infrequent occurrences of poor water quality conditions in 2011 and 2013 resulted in a drop in the annual rating from excellent to good.

Table A-83: North – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	E	E	E	E	E	E	G	E	E
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	E	E	E	G	E	E
APR	E	E	E	E	E	E	G	E	E	E	P
MAY	E	E	E	E	E	-	E	E	E	G	E
JUN	E	E	E	E	E	E	E	E	P	E	E
JUL	E	E	E	E	E	E	-	E	P	E	E
AUG	E	E	E	E	E	E	E	E	E	E	E
SEP	E	E	G	E	E	E	E	E	E	E	E
OCT	E	E	E	E	E	G	E	E	E	E	E
NOV	E	E	E	G	E	E	E	E	E	E	G
DEC	E	E	E	E	E	E	E	E	G	E	E
Annual	E	E	E	E	E	E	E	E	G	E	G

Based on Enterococcus North beach‟s waters have only earned one excellent annual rating early in the study period and generally the annual water quality rating is split between good and poor. Poor water quality conditions occur at least twice every year except 2005. From 2008 to 2011 poorer water quality conditions are clear in the summer months. The quality of North beach‟s waters has been classified as poor more frequently based on Enterococcus levels as compared to E.coli.

Table A-84: North – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	P	G	G	G	P	G	G	E
FEB	E	P	E	E	E	P	E	P	E	G	E
MAR	G	G	E	G	P	E	E	P	E	E	E
APR	E	E	E	E	E	E	E	-	E	E	P
MAY	E	E	E	E	P	-	E	E	G	E	P
JUN	P	E	E	E	E	P	G	E	P	E	E
JUL	G	G	E	E	P	G	-	P	P	E	-
AUG	E	P	G	E	E	E	P	E	E	E	-
SEP	E	E	E	E	E	P	E	E	E	E	-
OCT	P	E	E	G	P	P	P	G	E	P	-
NOV	G	E	E	P	G	P	E	E	E	P	-
DEC	E	E	E	E	G	P	P	P	P	E	-
Annual	G	P	E	G	P	P	G	P	G	G	P

A.2.9. Wedge

- **Seasonal Trends**

The E.coli seasonal averages for Wedge beach are ranked in Table A-85. The highest levels of E.coli were determined to be in spring most frequently and consistently from 2005 to 2008. The highest concentration fluctuated greatly each year. No clear seasonal trends are observed based on E.coli.

Table A-85: Wedge – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	20.0 (2)	15.6 (3)	16.7 (2)	13.3 (3)	0.00 (4)	41.1 (3)	**1465 (1)**	112 (2)	66.8 (4)	**147 (1)**
Winter	**23.3 (1)**	14.4 (3)	26.7 (2)	8.90 (3)	6.70 (4)	59.7 (3)	**130 (1)**	104 (2)	71.4 (4)	86.3 (3)	37.8 (4)
Spring	16.7 (2)	10.0 (4)	**42.2 (1)**	**53.3 (1)**	**40.0 (1)**	**133 (1)**	10.0 (4)	76.9 (3)	72.3 (3)	**144 (1)**	83.3 (2)
Summer	0.00 (3)	**627 (1)**	3.30 (4)	53.3 (1)	26.7 (2)	85.0 (2)	48.1 (2)	33.8 (4)	**348 (1)**	95.8 (2)	48.3 (3)

Table A-86 shows the ranking of seasonal averages for Enterococcus. There are no clear seasonal trends based on Enterococcus at Wedge beach. There is also no correlation between E.coli and Enterococcus in this regard.

Table A-86: Wedge – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	13.3 (4)	33.3 (4)	23.3 (4)	38.9 (4)	56.7 (3)	35.0 (4)	106 (3)	**157 (1)**	67.8 (3)	31.1 (4)	**142 (1)**
Winter	81.1 (2)	35.6 (3)	**100 (1)**	62.2 (3)	41.1 (4)	116 (3)	**3320 (1)**	101 (3)	**87.3 (1)**	90.3 (2)	15.0 (2)
Spring	**237 (1)**	43.3 (2)	28.9 (3)	153 (2)	**160 (1)**	130 (2)	32.1 (4)	76.8 (4)	33.6 (4)	66.1 (3)	-
Summer	20.0 (3)	**283 (1)**	43.3 (2)	**243 (1)**	141 (2)	**358 (1)**	178 (2)	108 (2)	84.6 (2)	**96.6 (1)**	-

- **Annual Trends**

The annual averages and standard deviations for E.coli are summarised in Figure A-64. The averages for E.coli remained low but did vary marginally. Average counts only exceeded 200/100ml one time during the study period. Although the average levels of E.coli remained low, ultimately in 2013 the concentration of this bacterium increased nearly ten times from the start of the study period. Significantly large deviations experienced in 2004, 2010 and 2011 indicate that E.coli concentrations fluctuated greatly throughout each of those years.

Figure A-65 depicts the annual averages and standard deviations for Enterococcus. With the exception of 2009, average levels of Enterococcus remained below 200/100ml for the duration of the study. Enterococcus is shown to be consistent. Standard deviations were found to be small in most cases except 2009. Data clustered closely around the averages every year except 2009 where the data set spread widely.

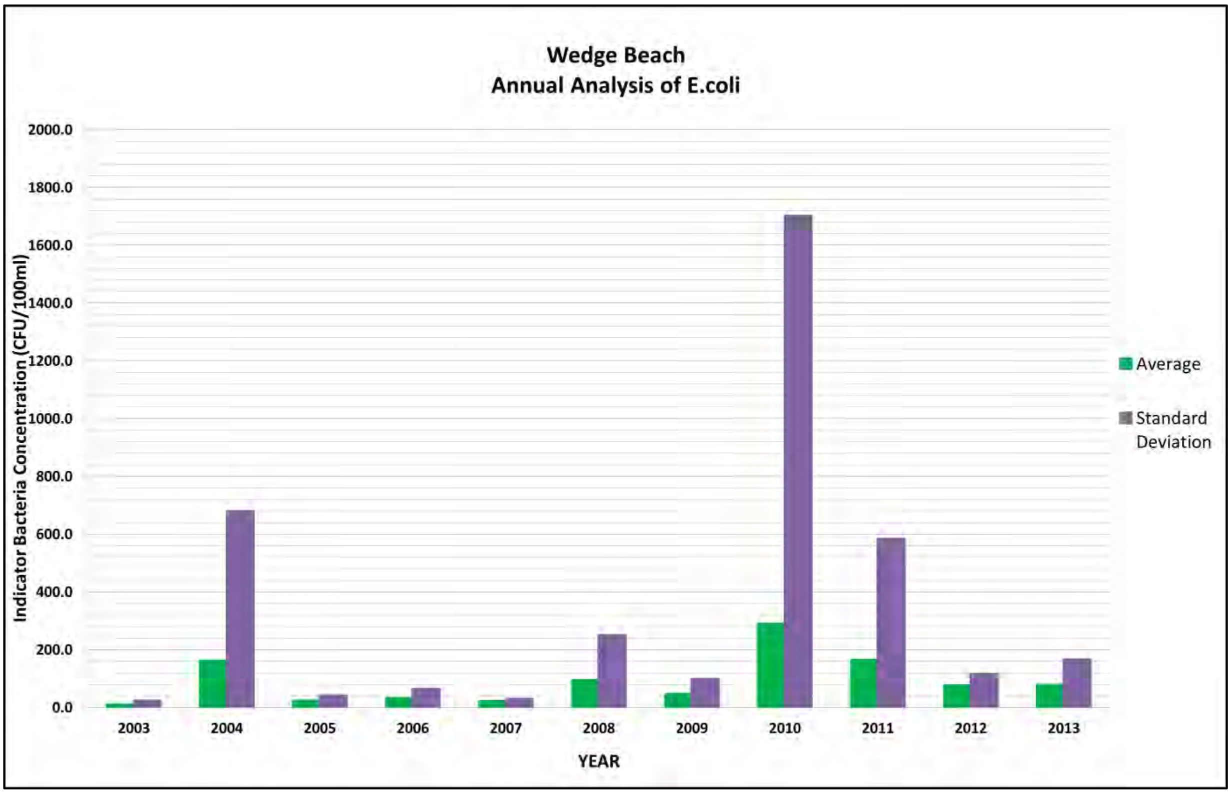


Figure A-64: Annual Analysis of E.coli at Wedge Beach

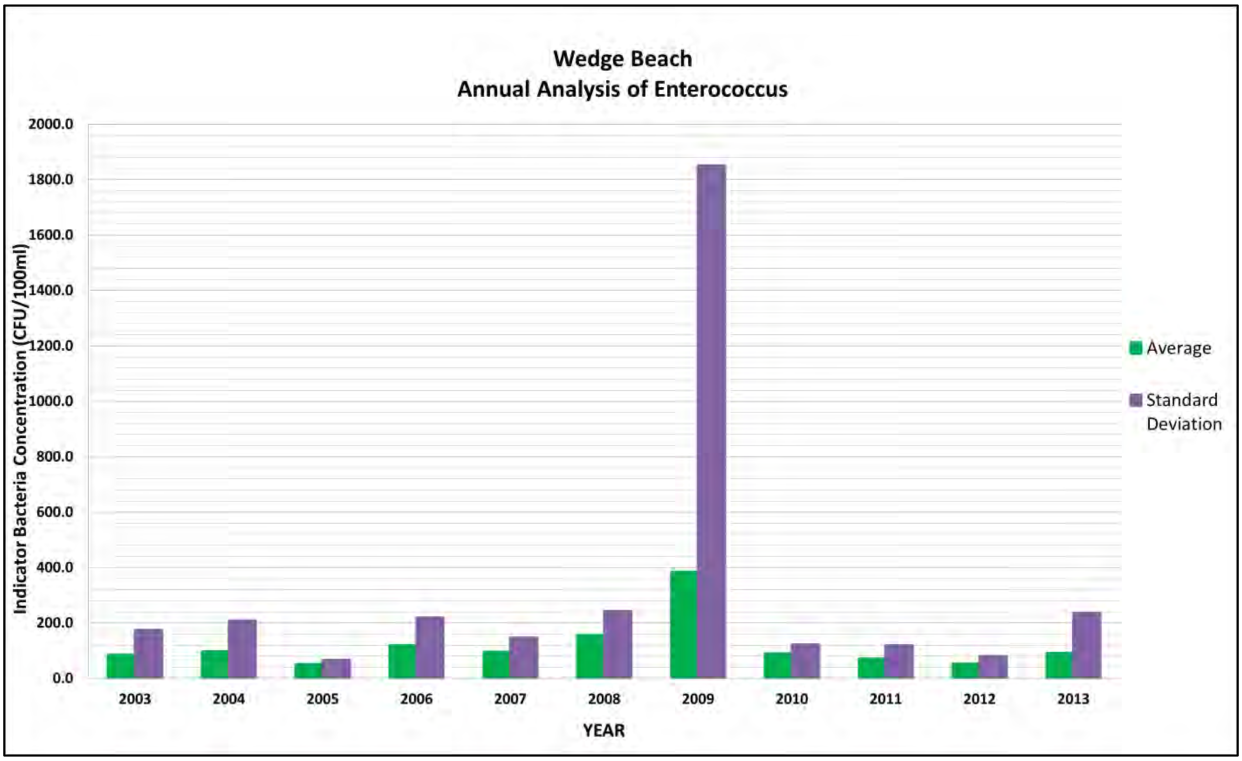


Figure A-65: Annual Analysis of Enterococcus at Wedge Beach

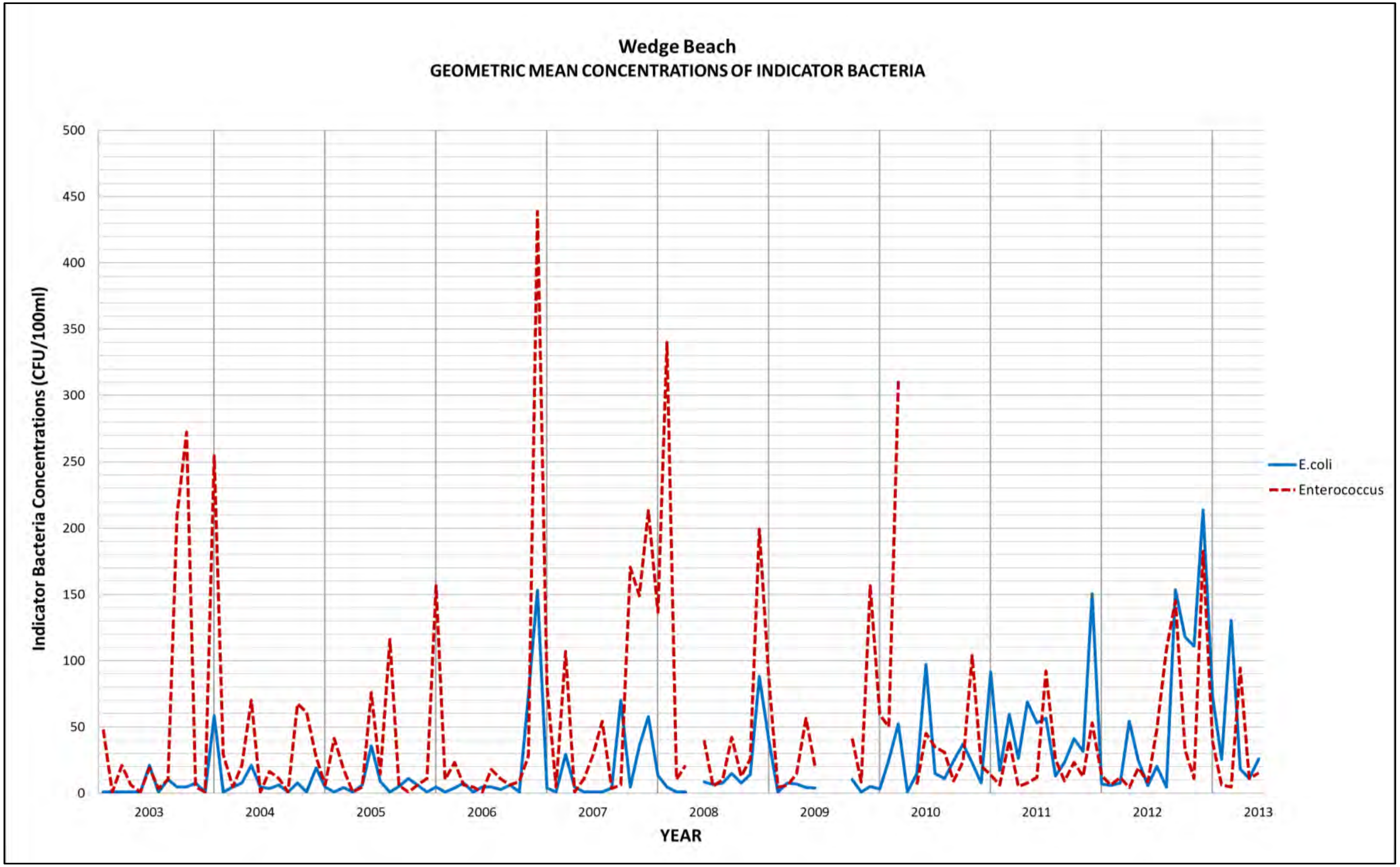


Figure A-66: Wedge – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-66 compares the geometric means of E.coli and Enterococcus at Wedge beach. Enterococcus is shown to be significantly higher than E.coli throughout most of the study period. In addition, Enterococcus has been variable throughout the study. E.coli was slightly less variable than its counterpart and became more erratic in the latter years.

- **SAWQ Guidelines**

Tables A-87 and A-88 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. Annually the water quality rating based on E.coli has been consistently good for last six years of study. Only two incidences of poor water quality are evident.

Table A-87: Wedge – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	E	E	E	E	G	E	G	E	E
FEB	E	E	E	E	E	E	E	E	G	E	E
MAR	E	E	E	E	E	E	E	P	G	E	G
APR	E	E	E	E	E	E	E	E	E	E	E
MAY	E	E	E	E	E	-	E	E	E	G	E
JUN	E	E	E	E	E	G	E	G	E	E	E
JUL	E	E	E	E	E	E	-	E	P	G	E
AUG	E	E	E	E	E	E	G	G	E	E	E
SEP	E	E	E	E	E	G	-	E	G	G	E
OCT	E	E	E	E	E	E	E	G	E	E	E
NOV	E	E	E	E	E	G	E	E	E	E	G
DEC	E	G	E	E	E	G	E	E	G	G	E
Annual	E	G	E	E	E	G	G	G	G	G	G

Generally, based on the presence of Enterococcus at wedge beach, the annual water quality rating is split between good and poor. Poor water quality occurred at some point every year except 2005 and 2012. The summer months from 2007 to 2011 experienced poor water quality conditions consistently. Poor classifications are more frequent based on Enterococcus than E.coli.

Table A-88: Wedge – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	P	G	P	P	P	P	E	E
FEB	E	E	E	E	E	P	E	G	P	E	E
MAR	E	E	G	G	G	E	E	P	P	G	E
APR	E	E	E	E	E	E	G	-	E	E	P
MAY	E	E	E	E	G	-	P	E	G	E	E
JUN	P	E	G	E	E	P	P	P	E	E	E
JUL	E	G	G	P	G	E	-	P	P	G	-
AUG	E	E	G	E	E	G	P	G	G	G	-
SEP	P	E	G	E	E	P	-	E	E	G	-
OCT	P	E	E	E	G	G	E	G	E	E	-
NOV	E	P	E	P	P	P	E	P	E	E	-
DEC	E	G	G	E	P	P	P	G	P	G	-
Annual	G	G	G	P	G	P	P	P	P	G	G

A.2.10. South

- **Seasonal Trends**

Seasonal averages for E.coli at South beach are shown in Table A-89. The rankings for last two years of the study follow the same pattern. There are no other definitive patterns based on E.coli.

Table A-89: South – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (4)	76.7 (2)	8.90 (4)	0.00 (4)	6.70 (3)	40.0 (3)	84.4 (3)	26.7 (4)	88.5 (3)	**83.9 (1)**	**150 (1)**
Winter	20.0 (2)	46.7 (3)	10.0 (3)	12.2 (3)	5.60 (4)	**78.7 (1)**	**233 (1)**	**95.0 (1)**	104 (2)	21.7 (4)	35.6 (4)
Spring	**103 (1)**	13.3 (4)	**56.7 (1)**	28.9 (2)	**33.3 (1)**	60.5 (2)	33.3 (4)	61.3 (3)	72.7 (4)	71.1 (2)	75.0 (2)
Summer	6.70 (3)	**100 (1)**	33.3 (2)	**30.0 (1)**	13.3 (2)	36.1 (4)	88.3 (2)	93.1 (2)	**106 (1)**	69.4 (3)	68.3 (3)

Table A-90 shows the ranking of the Enterococcus seasonal averages. Summer is produced the highest average counts of this bacterium most often. This trend is consistently observed from 2004 through to 2008. There are no other trends evident.

Table A-90: South – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	20.0 (3)	20.0 (4)	38.9 (2)	12.2 (3)	167 (2)	153 (4)	67.2 (4)	121 (2)	63.3 (2)	23.6 (3)	**272 (1)**
Winter	136 (2)	171 (2)	30.0 (3)	37.8 (2)	81.1 (4)	203 (2)	**1058 (1)**	95.3 (3)	**84.4 (1)**	22.0 (4)	10.0 (2)
Spring	**347 (1)**	23.3 (3)	8.90 (4)	**103 (1)**	110 (3)	183 (3)	76.7 (3)	77.3 (4)	62.3 (3)	50.6 (2)	-
Summer	20.0 (3)	**188 (1)**	**80.0 (1)**	**103 (1)**	**183 (1)**	**338 (1)**	207 (2)	**125 (1)**	56.4 (4)	**124 (1)**	-

- **Annual Trends**

Figures A-67 and A-68 portray the annual averages and standard deviations for E.coli and Enterococcus respectively.

E.coli is varied throughout the study but the average remained below 100CFU/100ml in most cases. During the first half of the study period E.coli decreased gradually. After 2008 averages increased and continued fluctuating. The average level of E.coli at the end of the study is almost three times that in 2003. The standard deviations remained significant which indicates that E.coli levels have varied throughout the study period regardless of the average changes.

Fluctuations in the average concentration of Enterococcus are clear at South beach. Initially the indicator decreased but increased again from 2006 to 2009, where the highest average is noted. Thereafter a gradual decrease is evident until 2012, followed by another increase in 2013. Ultimately the average at the end of the study is only slightly higher than at the start.

The standard deviations are shown to be significant throughout the study. The highest average in 2009 is also linked to the largest deviation. There is no common pattern between the two indicator bacteria.

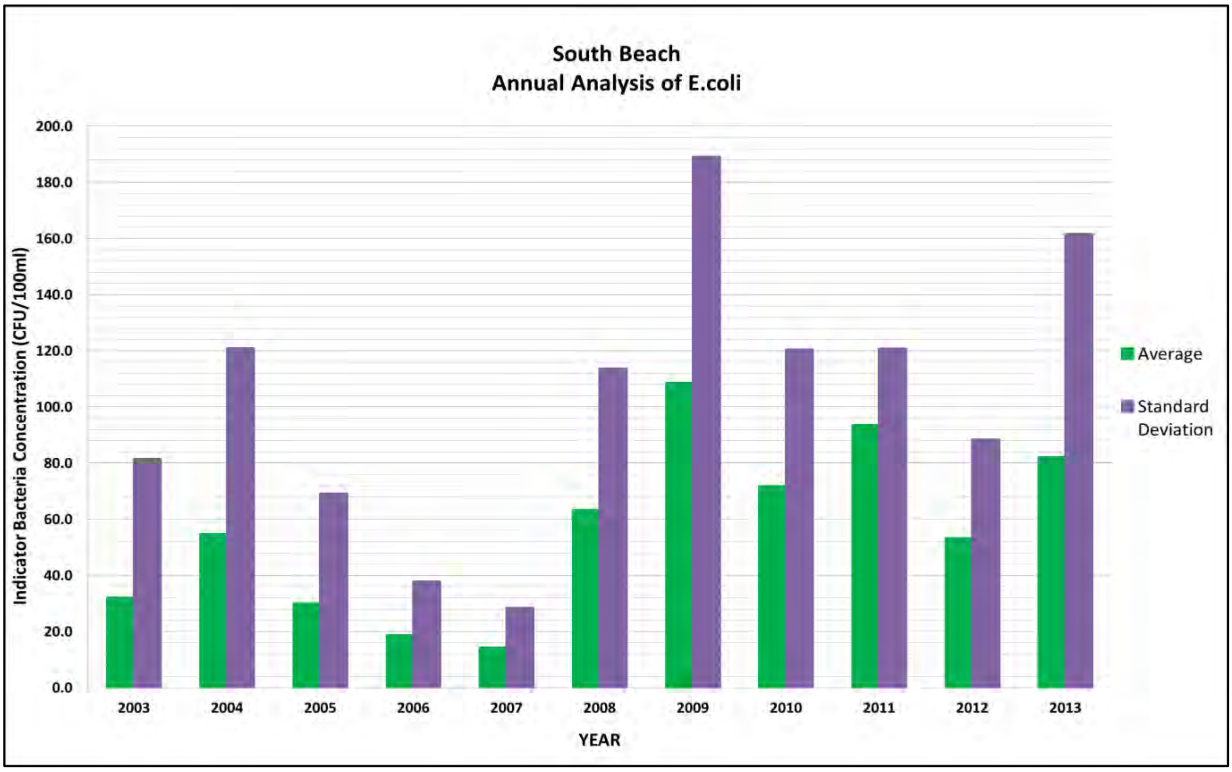


Figure A-67: Annual Analysis of E.coli at South Beach

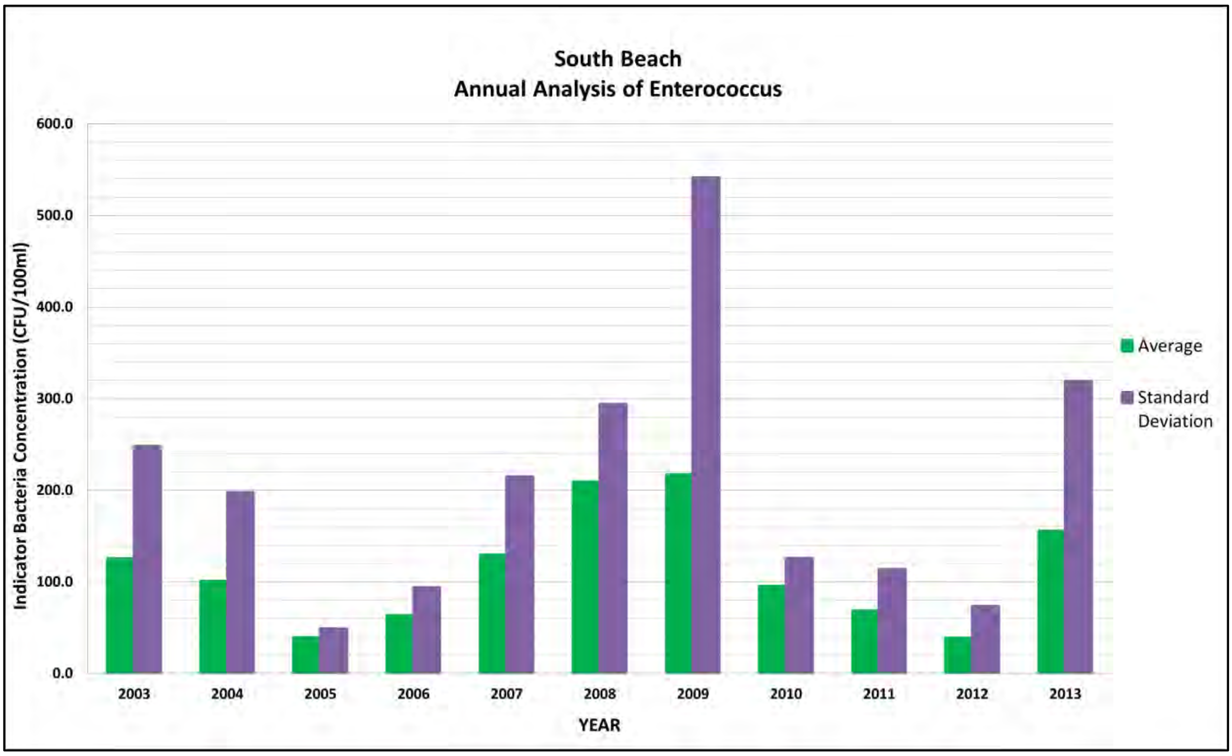


Figure A-68: Annual Analysis of Enterococcus at South Beach

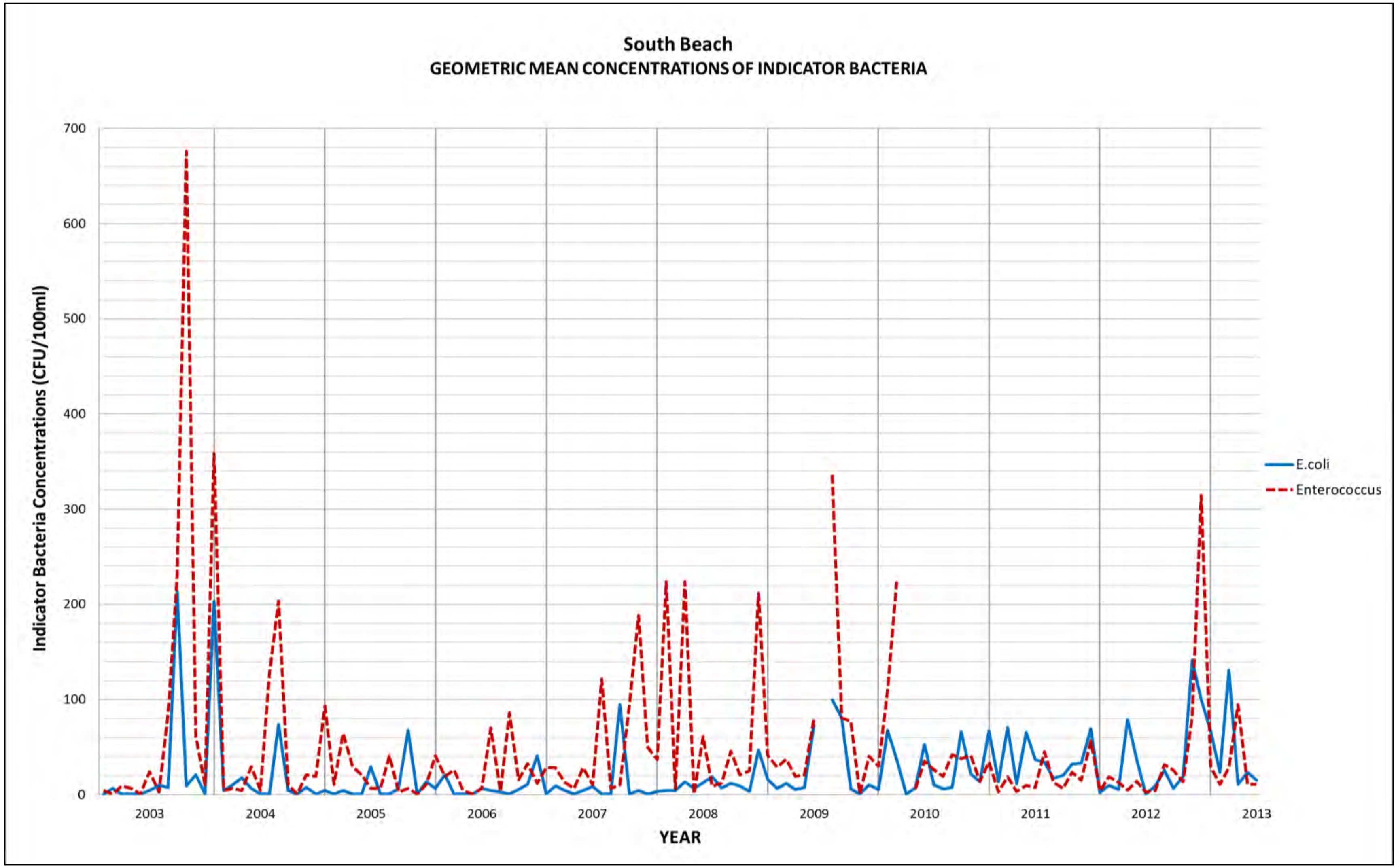


Figure A-69: South – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are compared in Figure A-69. Enterococcus exceeded E.coli throughout most of the study; however, indicator bacteria share the same pattern of fluctuation.

- **SAWQ Guidelines**

Table A-91 depicts the microbiological water quality rating based on E.coli. Generally the levels of E.coli indicate excellent to good water quality conditions, with only one occurrence of poor water quality during the entire study period. In the last two years there have been no occurrences of poor water quality conditions based on E.coli concentrations and the overall water quality has been excellent.

Table A-91: South – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	G	E	E	E	E	G	E	G	E	E
FEB	E	E	E	E	E	E	G	G	E	E	E
MAR	E	G	E	E	E	E	E	E	G	E	G
APR	E	E	E	E	E	E	G	E	E	E	E
MAY	E	E	E	E	E	-	E	E	E	G	E
JUN	E	E	E	E	E	G	G	G	G	E	E
JUL	E	E	E	E	E	G	-	G	P	E	E
AUG	E	E	E	E	E	E	G	G	G	E	E
SEP	G	E	G	E	E	G	E	E	G	E	E
OCT	E	E	E	E	E	G	E	E	E	E	E
NOV	E	E	E	E	E	E	E	E	E	E	E
DEC	E	E	E	E	E	E	E	E	G	G	E
Annual	E	G	E	E	E	G	G	G	G	E	E

Table A-92: South – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	G	E	G	P	G	P	G	E	E
FEB	E	E	G	P	P	P	G	P	E	G	E
MAR	E	E	E	E	G	E	G	P	G	G	P
APR	E	E	E	E	E	P	G	-	E	E	P
MAY	E	E	E	E	P	-	E	E	P	E	E
JUN	P	E	E	E	E	P	G	P	G	E	E
JUL	E	P	E	G	P	P	-	P	P	E	-
AUG	G	P	E	E	E	P	P	G	E	E	-
SEP	P	E	E	G	E	P	E	P	G	E	-
OCT	P	E	E	G	E	P	P	G	P	E	-
NOV	E	E	E	P	P	P	E	G	G	E	-
DEC	E	G	G	E	E	P	P	E	P	G	-
Annual	G	P	G	G	P	P	G	P	P	G	P

Table A-92 summarises the microbiological water quality rating based on Enterococcus concentrations. Annually there have been no occurrences of excellent water quality at South beach. Generally the annual rating is split between good and poor. Poor water quality is evident throughout the study period, with the most frequent incidences from 2007 to 2011. Water quality is classified as poor more frequently based on the presence of Enterococcus than E.coli.

A.2.11. Addington

- **Seasonal Trends**

Table A-93 summarises the seasonal averages of E.coli at Addington beach. Summer yielded the highest average count of this bacterium most frequently; however, this did not occur consistently.

Table A-93: Addington – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	10.0 (3)	6.70 (4)	20.0 (2)	**31.1 (1)**	8.00 (4)	40.0 (4)	37.8 (2)	10.8 (3)	82.4 (4)	80.0 (3)	**140 (1)**
Winter	6.70 (4)	82.2 (2)	20.0 (2)	10.0 (3)	**184 (1)**	80.2 (2)	**60.8 (1)**	**63.3 (1)**	83.2 (3)	32.5 (4)	21.1 (4)
Spring	**50.0 (1)**	16.7 (3)	0.00 (3)	25.6 (2)	63.3 (2)	50.0 (3)	14.2 (3)	40.0 (2)	91.9 (2)	85.0 (2)	70.0 (2)
Summer	23.3 (2)	**783 (1)**	**43.3 (1)**	6.70 (4)	12.2 (3)	**224 (1)**	10.6 (4)	40.0 (2)	**105 (1)**	**105 (1)**	65.0 (3)

The seasonal averages of Enterococcus are ranked in Table A-94. Summer produced the highest average of Enterococcus every alternate year for the duration of the study. No seasonal trends are evident at Addington beach and there is no clear relationship between E.coli and Enterococcus.

Table A-94: Addington – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	43.3 (3)	16.7 (3)	**192 (1)**	41.1 (2)	164 (2)	243 (2)	17.8 (4)	79.2 (3)	79.4 (2)	48.4 (3)	**272 (1)**
Winter	50.0 (2)	68.9 (2)	20.0 (3)	41.1 (2)	**293 (1)**	130 (4)	**776 (1)**	72.6 (4)	**99.6 (1)**	45.8 (4)	32.5 (2)
Spring	**190 (1)**	6.70 (4)	3.30 (4)	34.4 (3)	93.3 (4)	199 (3)	29.2 (3)	80.3 (2)	19.7 (4)	83.9 (2)	-
Summer	16.7 (4)	**194 (1)**	70.0 (2)	**63.3 (1)**	128 (3)	**364 (1)**	81.1 (2)	**105 (1)**	53.9 (3)	**84.4 (1)**	-

- **Annual Trends**

Figures A-70 and A-71 represent the annual averages and standard deviation for E.coli and Enterococcus respectively.

With exception to 2004, E.coli averages have remained consistently below 100CFU/100ml. Average concentrations varied marginally ranging from 20 to 95CFU/100ml. The largest average is accompanied by the highest standard deviation. The standard deviation is approximately four times the average, thus indicating that the data set for E.coli in 2004 was spread over a significantly large range. The deviations for the rest of the years in study are relatively small. This shows that the E.coli concentrations are clustered around the average and the levels did not vary greatly throughout the year.

The average levels of Enterococcus fluctuated randomly over the years. Ultimately at the end of the study the average concentration of the bacterium doubled when compared to 2003. The average remained below 150CFU/100ml with exception to 2008, where the highest average is noted. The standard deviations were found to be significant in most cases. Although the average concentrations were not extremely high, larger deviations indicate that counts of Enterococcus varied significantly from the average on occasion within many of the years in the study period.

Both indicators fluctuated slightly; however, no significant changes in the averages are observed. The larger deviations noted for Enterococcus highlight that Enterococcus has been more variable than E.coli.

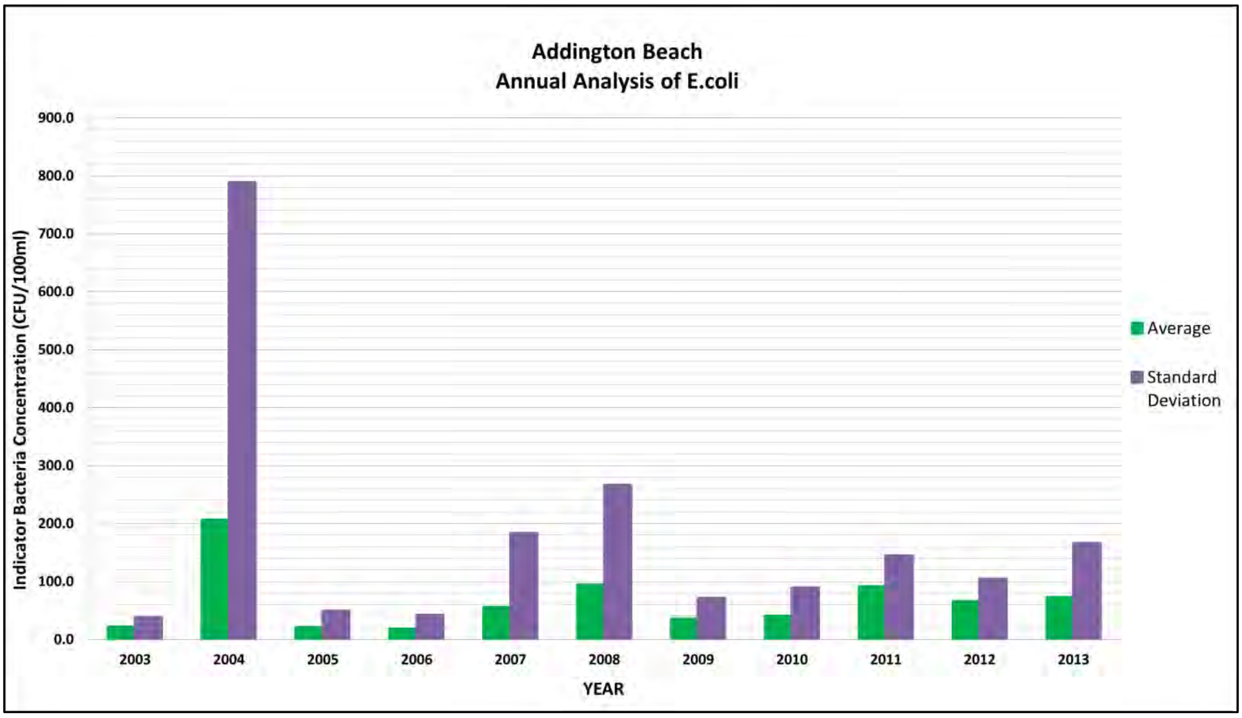


Figure A-70: Annual Analysis of E.coli at Addington Beach

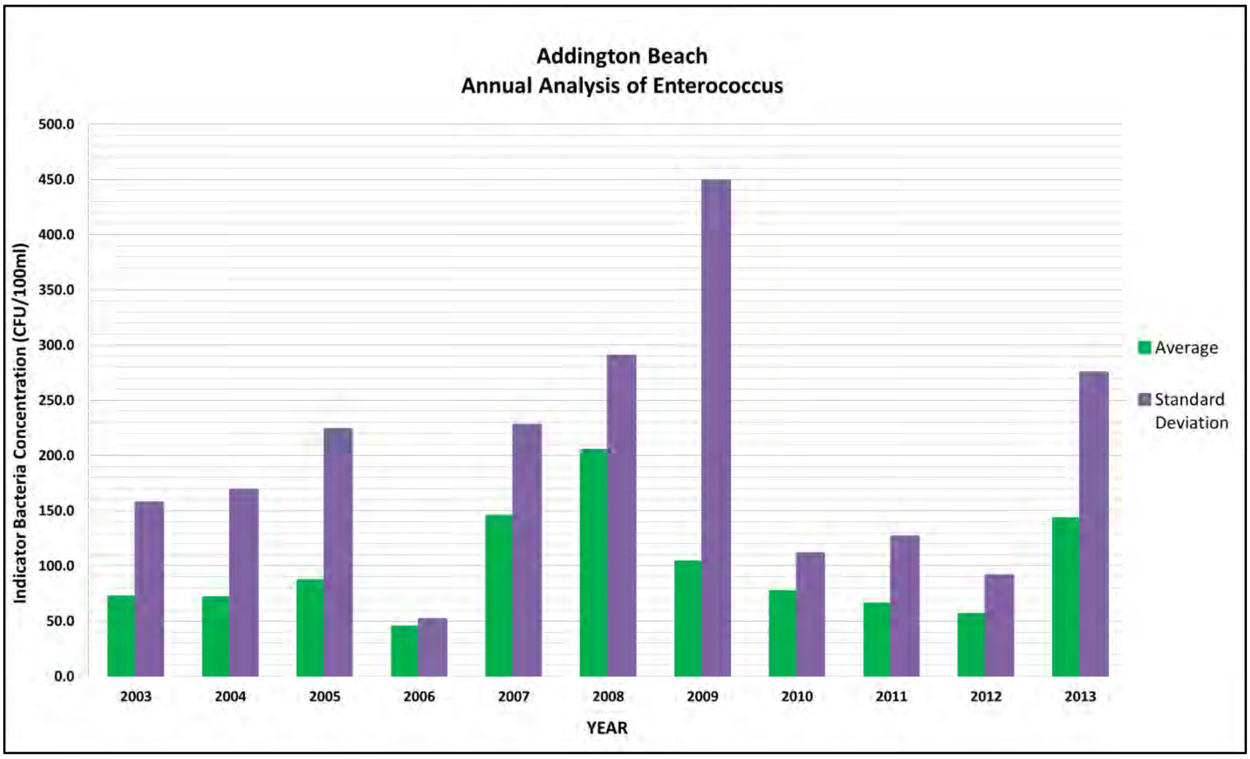


Figure A-71: Annual Analysis of Enterococcus at Addington Beach

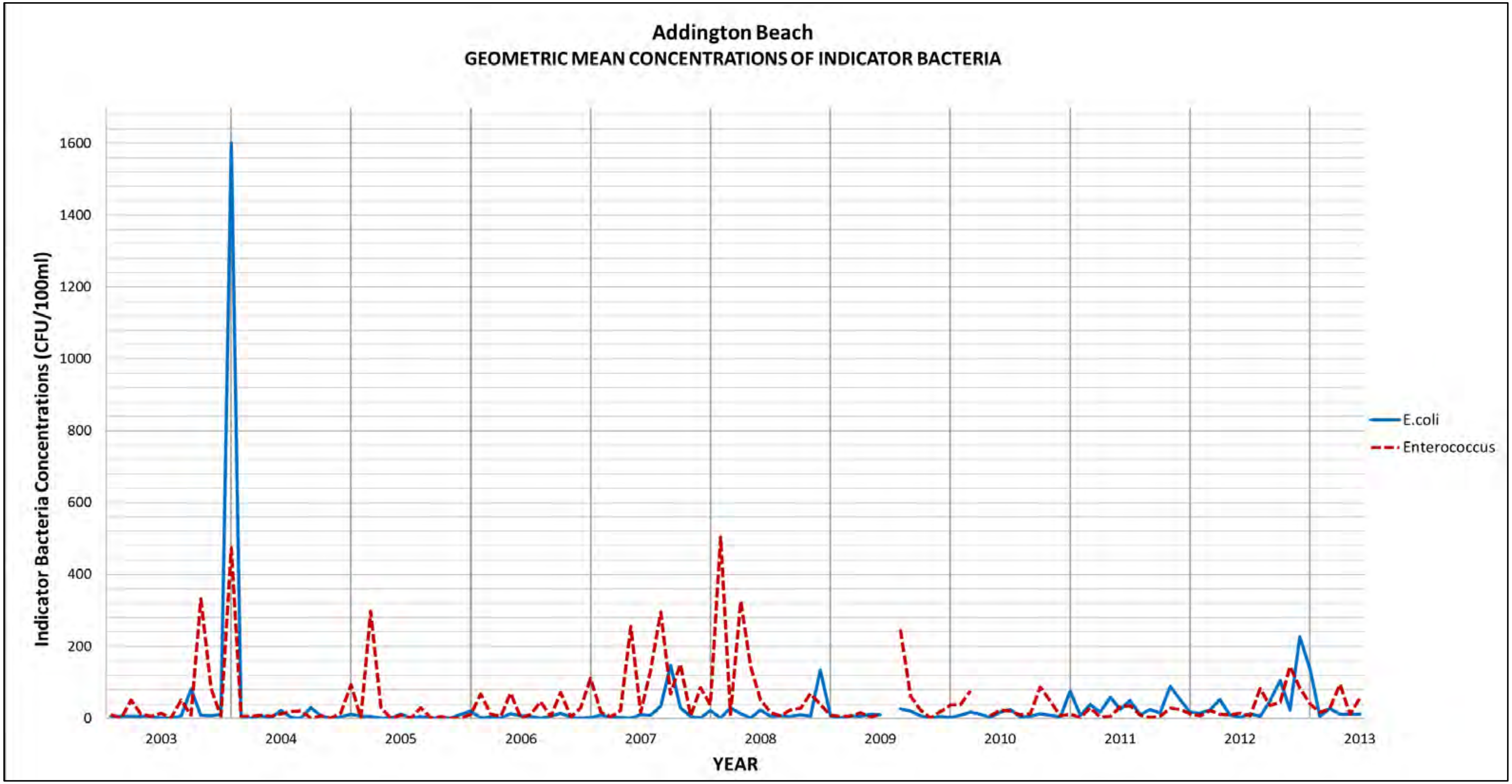


Figure A-72: Addington – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-72 illustrates the geometric means of E.coli and Enterococcus. During the first half of the study Enterococcus exceeded E.coli on most occasions. In addition Enterococcus is also shown to be more erratic than its counterpart.

- **SAWQ Guidelines**

Tables A-95 and A-96 show the microbiological water quality ratings based on E.coli and Enterococcus respectively.

Generally the levels of E.coli indicate excellent to good water quality conditions, with a few random occurrences of poor water quality conditions. In the most recent years there has only been one occurrence of poor water quality conditions based on E.coli concentrations. The water quality has been consistently good for the last three years of the study.

Table A-95: Addington – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	E	E	G	E	E	G	E	G
FEB	E	E	E	E	E	E	E	G	E	E	E
MAR	E	E	E	E	E	E	E	E	E	E	P
APR	E	E	E	E	E	E	E	E	E	G	E
MAY	E	E	E	E	E	E	E	E	G	G	E
JUN	E	G	E	E	E	G	G	E	G	E	E
JUL	E	E	E	E	E	E	-	G	G	E	E
AUG	E	E	E	E	P	E	E	E	E	E	E
SEP	E	E	E	E	E	E	E	E	G	E	E
OCT	E	E	E	E	E	E	E	E	E	E	E
NOV	E	E	E	E	E	E	E	E	G	E	E
DEC	E	E	E	E	E	P	E	E	G	G	E
Annual	E	G	E	E	E	G	E	E	G	G	G

Annually water quality at Addington beach has never been rated as excellent based on the presence of Enterococcus, with the ratings split between good and poor. The frequency of poor water quality conditions increased from 2007. Poor water quality conditions were experienced for at least a third of each year from 2007 to 2011. Water quality ratings are shown to be poor more frequently based on Enterococcus than E.coli.

Table A-96: Addington – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	P	E	G	P	P	G	P	E	E
FEB	E	E	E	G	P	P	E	P	E	G	E
MAR	G	E	P	E	E	E	E	G	P	G	P
APR	E	E	E	E	E	P	E	P	E	E	P
MAY	E	E	E	G	P	P	E	G	P	G	E
JUN	G	G	E	E	E	P	P	P	P	E	E
JUL	E	P	E	G	P	G	P	G	P	E	E
AUG	E	E	E	E	P	G	P	G	E	E	-
SEP	E	E	E	E	G	P	E	E	E	E	-
OCT	P	E	E	E	G	P	E	P	E	G	-
NOV	E	E	E	E	E	P	E	G	E	G	-
DEC	E	E	E	E	G	P	P	E	G	P	-
Annual	G	P	P	G	P	P	P	P	P	G	P

A.2.12. uShaka

Sample data for both indicator bacteria at uShaka Beach was only provided for 2008 to 2013. Data for E.coli was from September 2008 to December 2013 and data for Enterococcus was from September 2008 to June 2013. In addition, data for July 2009, and August to December 2012 was not provided.

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-97. No definite seasonal trends based on this bacterium are evident as the season which gives the highest level of E.coli differs each year.

Table A-97: uShaka – Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	55.6 (2)	12.6 (4)	88.2 (2)	**60.1 (1)**	152 (2)
Winter	-	44.2 (3)	**82.6 (1)**	35.1 (4)	8.30 (3)	23.3 (4)
Spring	15.0 (2)	**148 (1)**	22.0 (2)	49.7 (3)	-	**160 (1)**
Summer	**120 (1)**	10.6 (4)	17.9 (3)	**117 (1)**	42.2 (2)	46.7 (3)

Table A-98 shows the ranking of seasonal averages for Enterococcus. As with E.coli, no clear trends are evident.

Table A-98: uShaka – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	69.4 (2)	17.5 (4)	**82.8 (1)**	49.9 (2)	**275 (1)**
Winter	-	**960 (1)**	**93.4 (1)**	31.6 (2)	28.0 (3)	30.0 (2)
Spring	127 (2)	71.4 (3)	34.2 (3)	16.0 (4)	-	-
Summer	**210 (1)**	57.1 (4)	46.1 (2)	23.3 (3)	**57.2 (1)**	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for uShaka beach are depicted in Figure A-73. At uShaka beach the average E.coli concentrations have remained consistently low, remaining below 80CFU/100ml. The standard deviations are shown to be noteworthy. Values more than double the average show that even though the average levels are not exceptionally high, levels of E.coli have varied from the average on occasion each year.

Figure A-74 shows the annual averages and standard deviations of Enterococcus. Average levels of Enterococcus have dropped and remained consistently below 100 counts/100ml. Furthermore, the standard deviations have also dropped thus indicating that Enterococcus has become more consistent at uShaka beach.

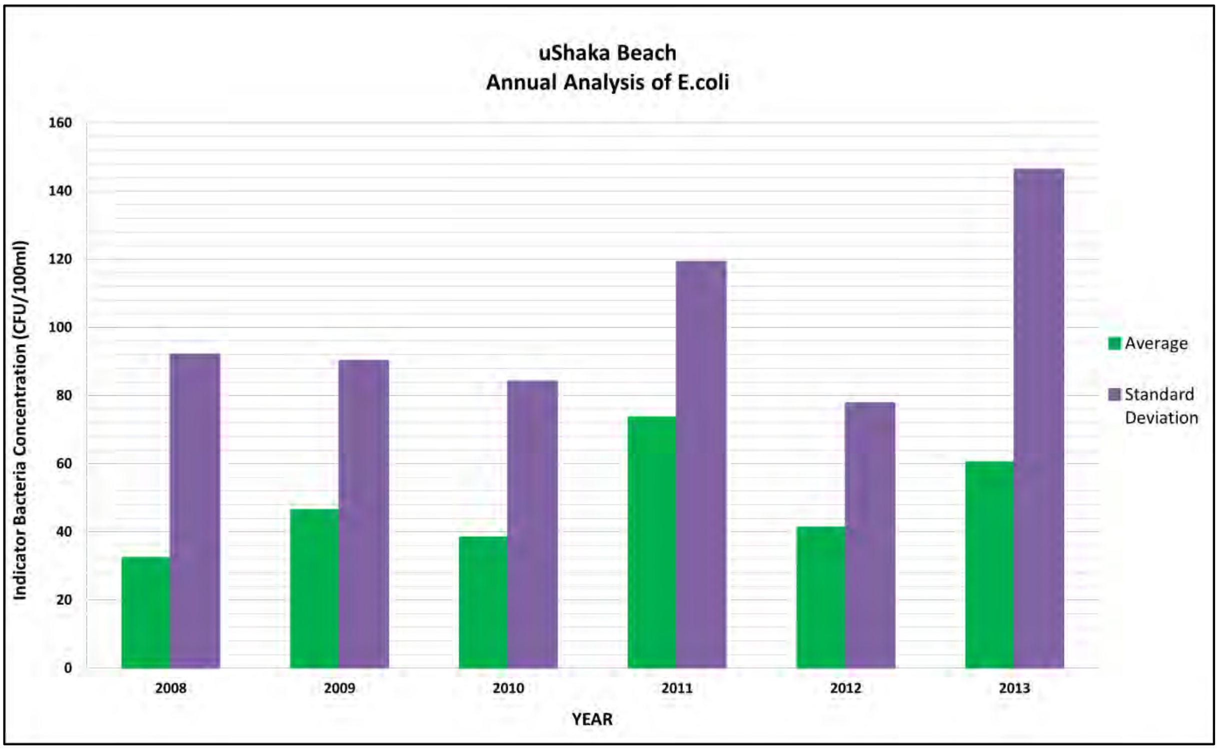


Figure A-73: Annual Analysis of E.coli at uShaka Beach

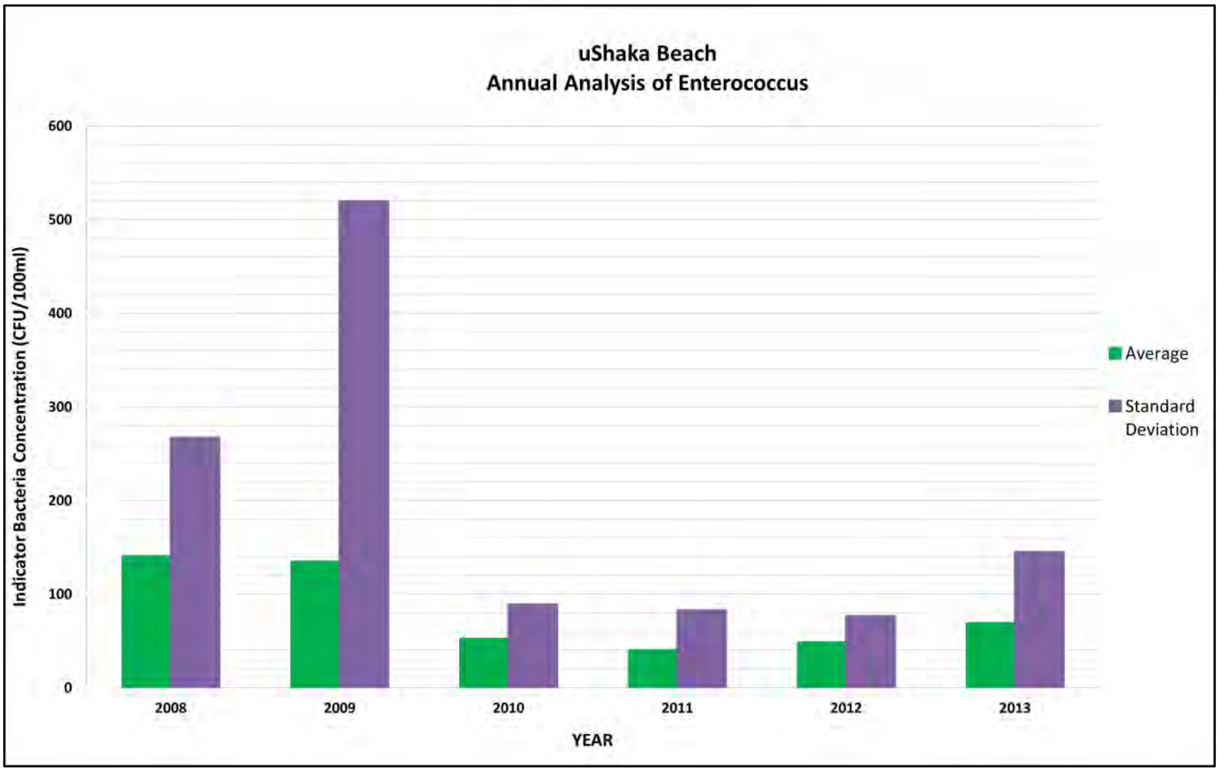


Figure A-74: Annual Analysis of Enterococcus at uShaka Beach

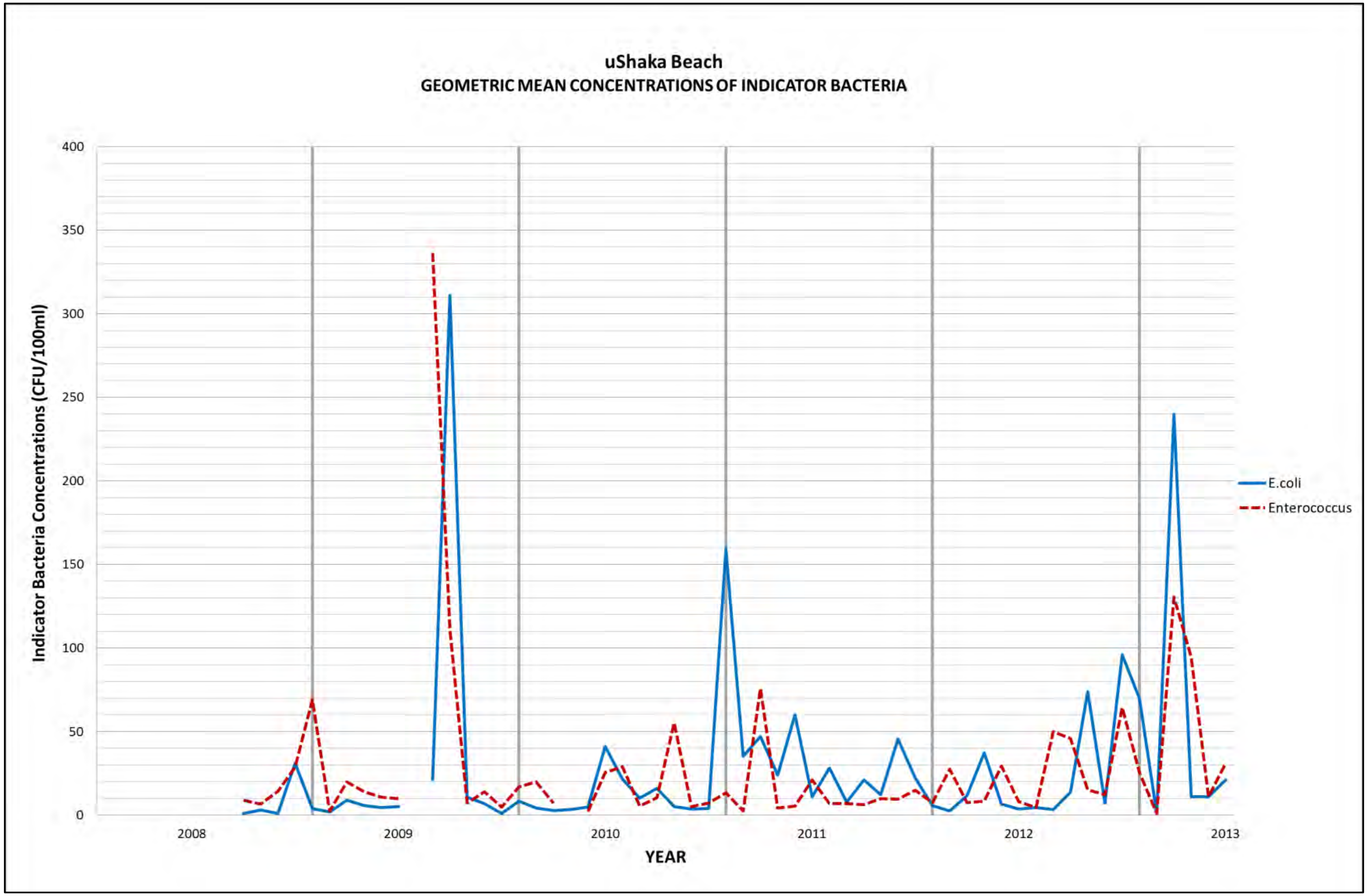


Figure A-75: uShaka – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-75 illustrates the geometric mean concentrations of the two indicator bacteria. Concentrations of E.coli exceeded Enterococcus during most of the study period. Both indicator bacteria have remained variable however, they share the same pattern of variability.

- **SAWQ Guidelines**

Tables A-99and A-100 show the microbiological water quality ratings based on E.coli and Enterococcus respectively.

The waters at uShaka beach have been rated as excellent annually for the last four years of the study. Only one incidence of poor water quality is shown throughout the entire duration of the study period.

Table A-99: uShaka – E.coli Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	E	E	P	E	E
FEB	-	E	E	E	E	E
MAR	-	E	E	E	E	G
APR	-	E	E	E	E	E
MAY	-	E	E	E	G	E
JUN	-	G	G	G	E	E
JUL	-	-	G	E	E	E
AUG	-	E	E	E	-	E
SEP	E	G	E	E	-	E
OCT	E	E	E	E	-	G
NOV	E	G	E	E	-	E
DEC	G	E	E	G	-	E
Annual	G	G	E	E	E	E

Based on Enterococcus there are more frequent occurrences of poor water quality however, they occur randomly. Annually the last four years of the study have shown a good water quality rating based on the guidelines. Overall water quality has been good based on both indicators.

Table A-100: uShaka – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	P	G	E	G	E
FEB	-	G	G	E	G	E
MAR	-	E	E	P	E	P
APR	-	G	-	P	E	P
MAY	-	E	E	E	G	E
JUN	-	P	P	P	E	E
JUL	-	-	G	E	E	-
AUG	-	P	G	G	-	-
SEP	E	E	E	E	-	-
OCT	P	E	G	E	-	-
NOV	P	G	E	E	-	-
DEC	P	G	E	G	-	-
Annual	P	P	G	G	G	G

A.2.13. Vetch’s

- **Seasonal Trends**

Seasonal averages of E.coli at Vetch‟s beach are ranked in Table A-101. Summer is shown to produce the highest average most often but not consistently. There are no clear seasonal trends based on this bacterium at Vetch‟s beach.

Table A-101: Vetch’s – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	**20.0 (1)**	8.90 (2)	12.2 (2)	0.00 (4)	0.00 (4)	54.4 (2)	5.30 (4)	69.5 (2)	58.7 (2)	148 (2)
Winter	5.60 (2)	13.3 (2)	**16.7 (1)**	6.70 (3)	26.7 (3)	55.4 (2)	**70.0 (1)**	**49.4 (1)**	45.1 (4)	8.30 (4)	32.2 (4)
Spring	**73.3 (1)**	3.30 (4)	4.40 (3)	3.30 (4)	56.7 (2)	6.00 (3)	25.8 (4)	20.6 (3)	66.5 (3)	**145 (1)**	65.0 (3)
Summer	0.00 (3)	6.70 (3)	3.30 (4)	**60.0 (1)**	**128 (1)**	**171 (1)**	46.7 (3)	36.7 (2)	**117 (1)**	48.6 (3)	**217 (1)**

Table A-102 shows the seasonal averages for Enterococcus. Autumn produced the highest average most frequently. From 2009 to 2012 summer yielded the second highest average consistently. There are no clear patterns based on Enterococcus. Furthermore there is no correlation between the two indicators.

Table A-102: Vetch’s – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	3.30 (4)	26.7 (3)	**103 (1)**	**41.1 (1)**	137 (2)	40.0 (4)	**57.8 (1)**	21.7 (3)	**55.0 (1)**	41.7 (3)	**242 (1)**
Winter	56.7 (2)	32.2 (2)	10.0 (2)	32.2 (3)	**163 (1)**	141 (2)	52.5 (3)	**131 (1)**	25.3 (3)	13.3 (4)	10.0 (2)
Spring	**303 (1)**	10.0 (4)	5.60 (3)	13.3 (4)	93.3 (4)	134 (3)	42.1 (4)	15.1 (4)	14.0 (4)	**58.3 (1)**	-
Summer	20.0 (3)	**120 (1)**	3.30 (4)	40.0 (2)	109 (3)	**305 (1)**	56.7 (2)	121 (2)	36.4 (2)	48.6 (2)	-

- **Annual Trends**

Figures A-76 and A-77 portray the annual averages and standard deviations for E.coli and Enterococcus respectively. Generally the average concentration of E.coli has increased since 2003. The largest average is noted in 2013 and is six times greater than the average at the start of the study. The deviations were found to be significant in many cases, more so during the latter half of the study period. As E.coli increased it also became more variable throughout the year.

The average levels of Enterococcus fluctuated throughout the study. Initially, from 2003 to 2006 the average concentration appeared to decrease. In 2007 and 2008, however, the average increased to approximately five times the lowest. After the peak the average decreased again and increased drastically in 2013 thereafter, where the highest average is observed. The standard deviations have remained significant throughout most of the study. The large deviations support the variable nature of Enterococcus at Vetch‟s beach.

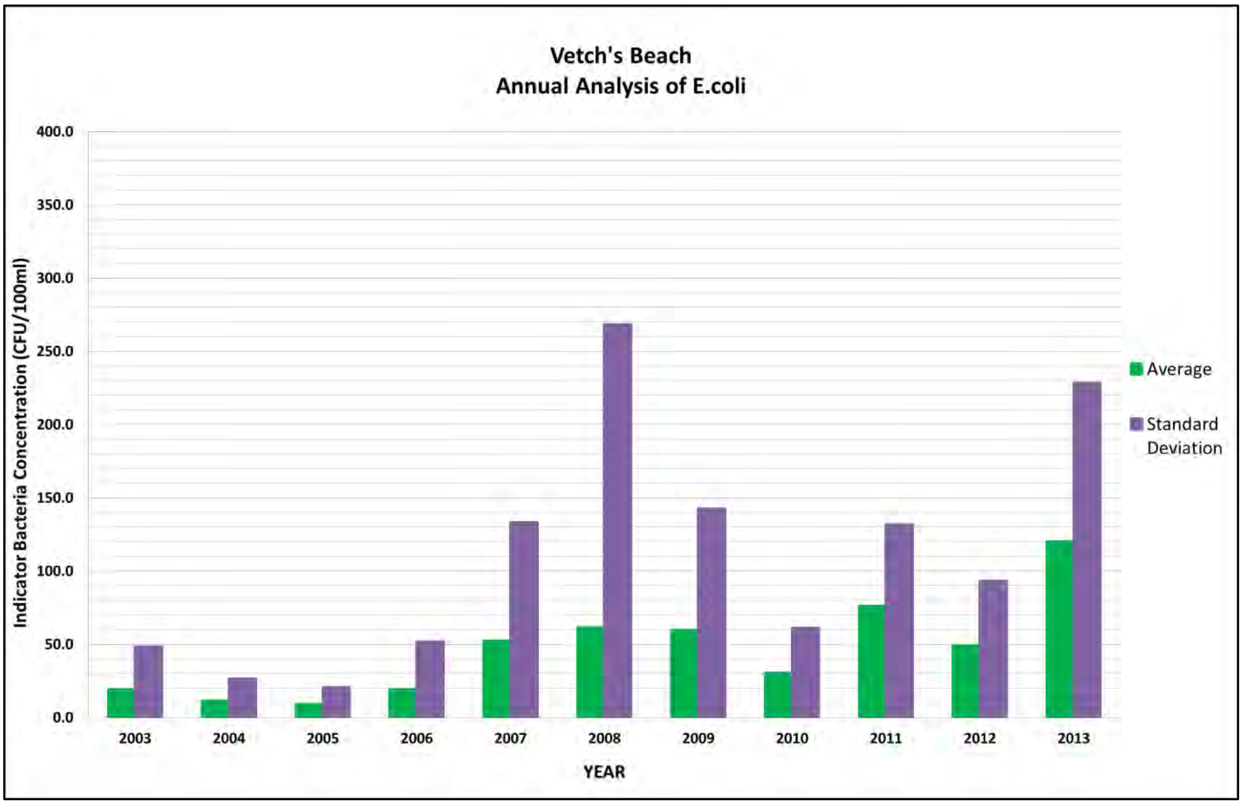


Figure A-76: Annual Analysis of E.coli at Vetch's Beach

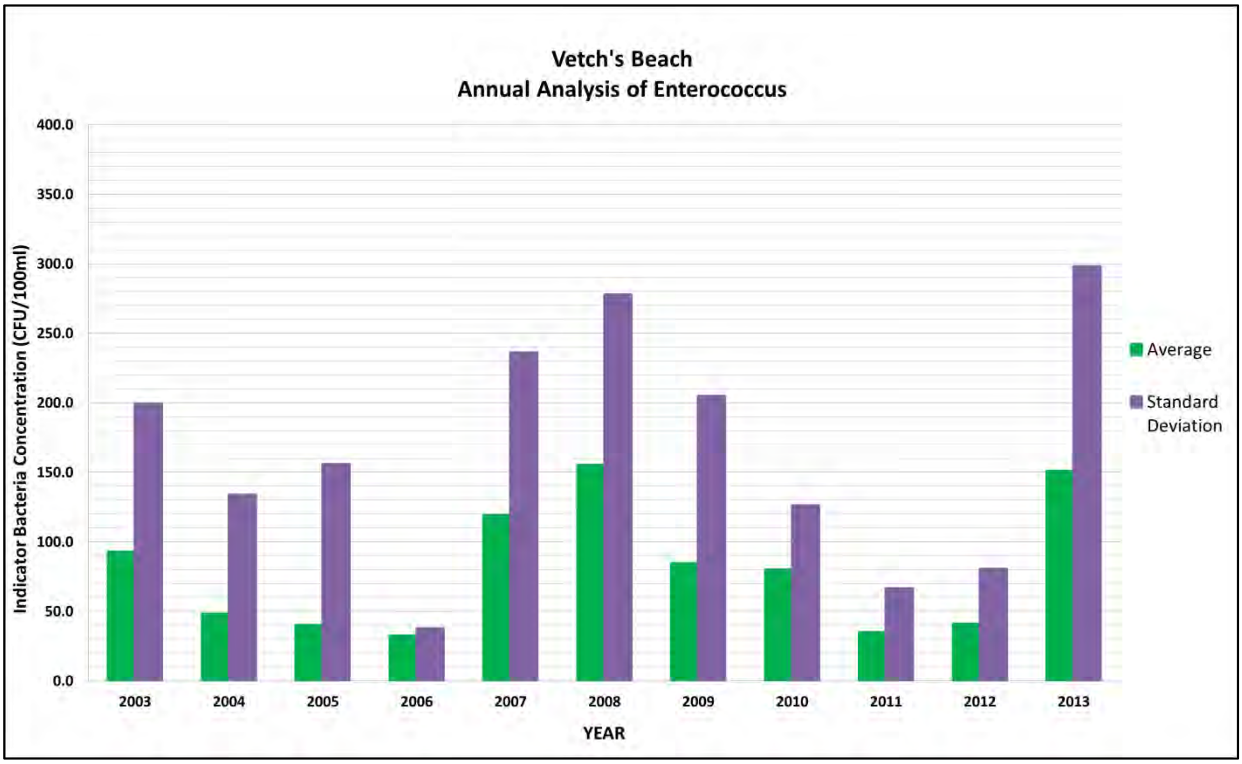


Figure A-77: Annual Analysis of Enterococcus at Vetch's Beach

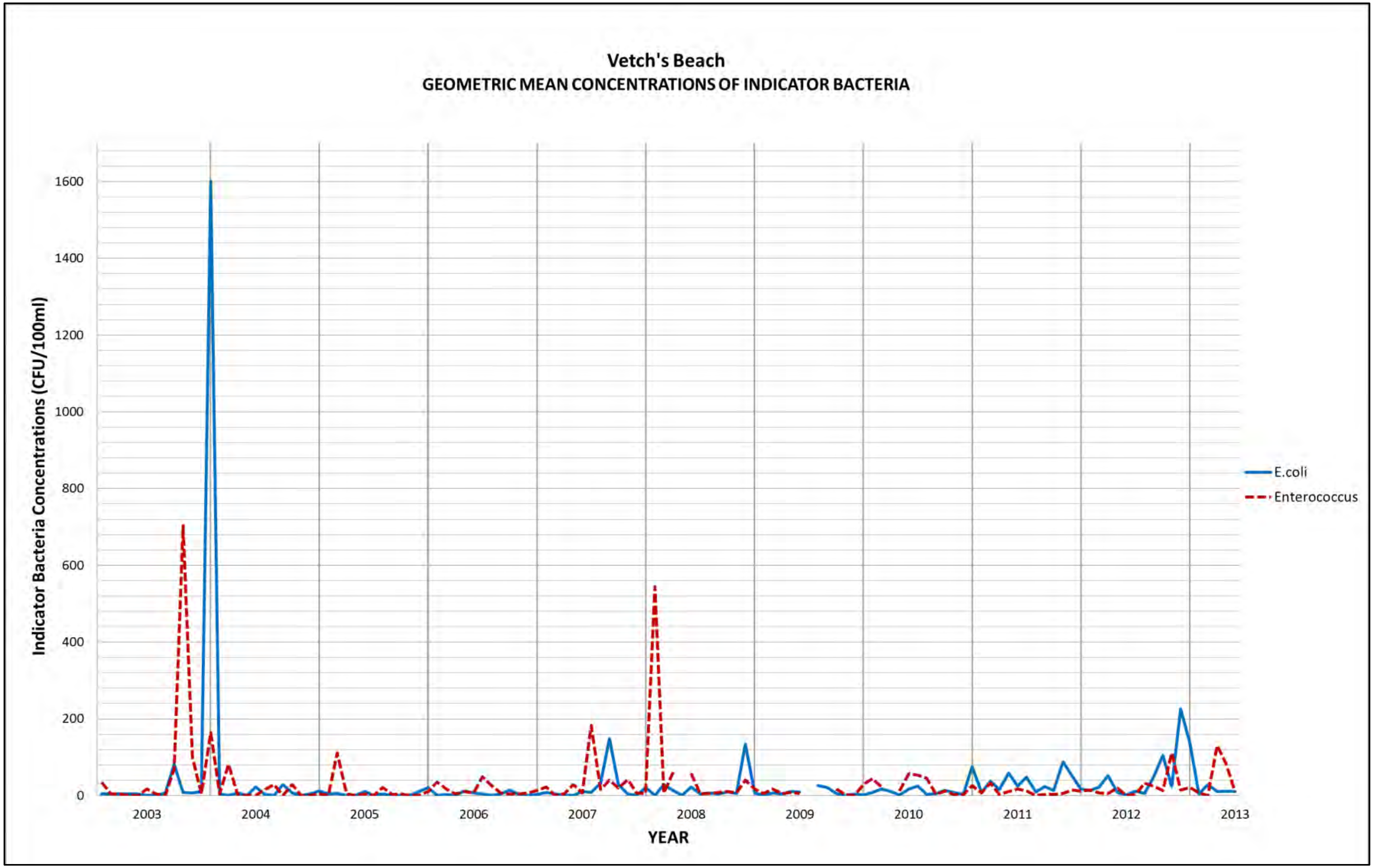


Figure A-78: Vetch's – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-78 shows the geometric means of the indicator organisms at Vetch‟s beach. Initially both indicators showed variability but became more consistent over time. E.coli exceeded Enterococcus on most occasions in the last three year. The geometric means for both bacteria remained below 200CFU/100ml throughout most of the study period.

- **SAWQ Guidelines**

Table A-103 shows the microbiological water quality rating based on the presence of E.coli. The waters at Vetch‟s beach have maintained an excellent rating up to 2010. Thereafter the overall rating was consistently good for last three year of the study. No incidences of poor water quality are noted.

Table A-103: Vetch's – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	G	E	G	E	E
FEB	E	E	E	E	E	E	E	E	E	E	G
MAR	E	E	E	E	E	E	E	E	G	E	E
APR	E	E	E	E	E	E	E	E	E	E	G
MAY	E	E	E	E	E	-	E	E	E	G	E
JUN	E	E	E	E	E	G	G	E	E	E	E
JUL	E	E	E	E	E	E	-	E	F	E	E
AUG	E	E	E	E	E	E	E	E	E	E	E
SEP	E	E	E	E	E	E	-	E	G	E	E
OCT	E	E	E	E	E	E	E	E	E	E	G
NOV	E	E	E	E	E	E	E	E	E	G	E
DEC	E	E	E	E	G	G	E	E	G	E	G
Annual	E	E	E	E	E	E	E	E	G	G	G

Table A-104 depicts the water quality rating based on Enterococcus counts. The annual rating fluctuated between good and poor. The frequency of poor water quality increased from 2008 to 2010, resulting annual ratings dropping from good to poor. As with E.coli, the overall rating has been consistently good for the last three years of the study.

Table A-104: Vetch's – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	P	E	G	G	P	P	P	E	G	E
FEB	E	E	E	E	G	P	E	G	E	G	E
MAR	E	E	G	G	E	E	E	E	P	E	E
APR	E	E	E	E	E	E	E	-	E	E	P
MAY	E	E	E	G	G	-	P	E	G	G	G
JUN	P	E	E	E	E	P	P	P	G	E	E
JUL	E	E	E	E	G	E	-	P	G	E	-
AUG	E	E	E	E	E	G	E	G	E	E	-
SEP	F	E	E	E	E	G	-	E	E	E	-
OCT	P	E	E	E	G	G	G	E	E	E	-
NOV	G	E	E	E	E	P	E	E	E	G	-
DEC	E	G	E	E	E	P	E	E	G	E	-
Annual	G	G	E	G	G	P	P	P	G	G	G

A.3. Section C – Bluff Beaches

A.3.1. Garvies

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-105. The highest levels of E.coli were found to be in summer most often, however, not consistently. The last two years appear to follow the same pattern of ranking.

Table A-105: Garvies – Ranking of E.coli Seasonal Averages

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Autumn	0.00 (2)	0.00 (3)	26.7 (2)	27.8 (2)	16.7 (3)	**1055 (1)**	17.8 (4)	37.0 (2)	142 (4)	**476 (1)**	**230 (1)**
Winter	0.00 (2)	3.30 (2)	**32.2 (1)**	6.70 (3)	5.60 (4)	140 (2)	**114 (1)**	37.0 (2)	152 (3)	79.7 (3)	10.0 (3)
Spring	0.00 (2)	**10.0 (1)**	6.70 (3)	6.70 (4)	**190 (1)**	67.2 (3)	56.7 (3)	**75.0 (1)**	360 (2)	153 (2)	160 (2)
Summer	**30.0 (1)**	**10.0 (1)**	0.00 (4)	**73.3 (1)**	56.7 (2)	23.3 (4)	72.2 (2)	**75.0 (1)**	**458 (1)**	33.3 (4)	3.30 (4)

Table A-106 shows the ranking of seasonal averages for Enterococcus. Autumn and summer yielded the highest average concentration of Enterococcus most frequently. No clear trends are evident at Garvies beach based on Enterococcus and there is no clear link between E.coli and Enterococcus.

Table A-106: Garvies – Ranking of Enterococcus Seasonal Averages

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Autumn	3.30 (2)	6.70 (3)	**88.9 (1)**	37.8 (2)	**140 (1)**	**205 (1)**	36.7 (3)	56.7 (3)	110 (3)	**140 (1)**	**193 (1)**
Winter	3.30 (2)	13.3 (2)	51.1 (3)	**76.7 (1)**	13.3 (4)	186 (2)	20.0 (4)	65.3 (2)	138 (2)	103 (3)	10.0 (2)
Spring	3.30 (2)	0.00 (4)	73.3 (2)	6.70 (4)	100 (3)	143 (3)	89.4 (2)	**72.8 (1)**	91.3 (4)	**140 (1)**	-
Summer	**13.3 (1)**	**23.3 (1)**	16.7 (4)	23.3 (3)	126 (2)	46.7 (4)	**148 (1)**	46.7 (4)	**421 (1)**	113 (2)	-

- **Annual Trends**

The annual analysis for E.coli is summarised in Figure A-79. A gradual increase is clear during the first six years of the study. Thereafter the average concentration varies randomly. Average counts remain below 100/100ml for most of the study. Ultimately the average concentration of E.coli at the end of the study is more than twelve times that at the beginning. Larger deviations are associated with larger averages. Significantly large deviations are noted in 2008, 2011 and 2012, indicating high variability in E.coli concentrations throughout those years.

Figure A-80 depicts the annual averages and standard deviations for Enterococcus. The average concentration of this bacterium fluctuated slightly throughout the study. Ultimately the average Enterococcus levels at the end of the study increased almost twenty times when compared to the levels in 2003

The standard deviations follow the same patterns of fluctuation as the averages. Extremely high standard deviation is evident in 2011, the same year shown to have the highest average. E.coli and Enterococcus share the same patterns.

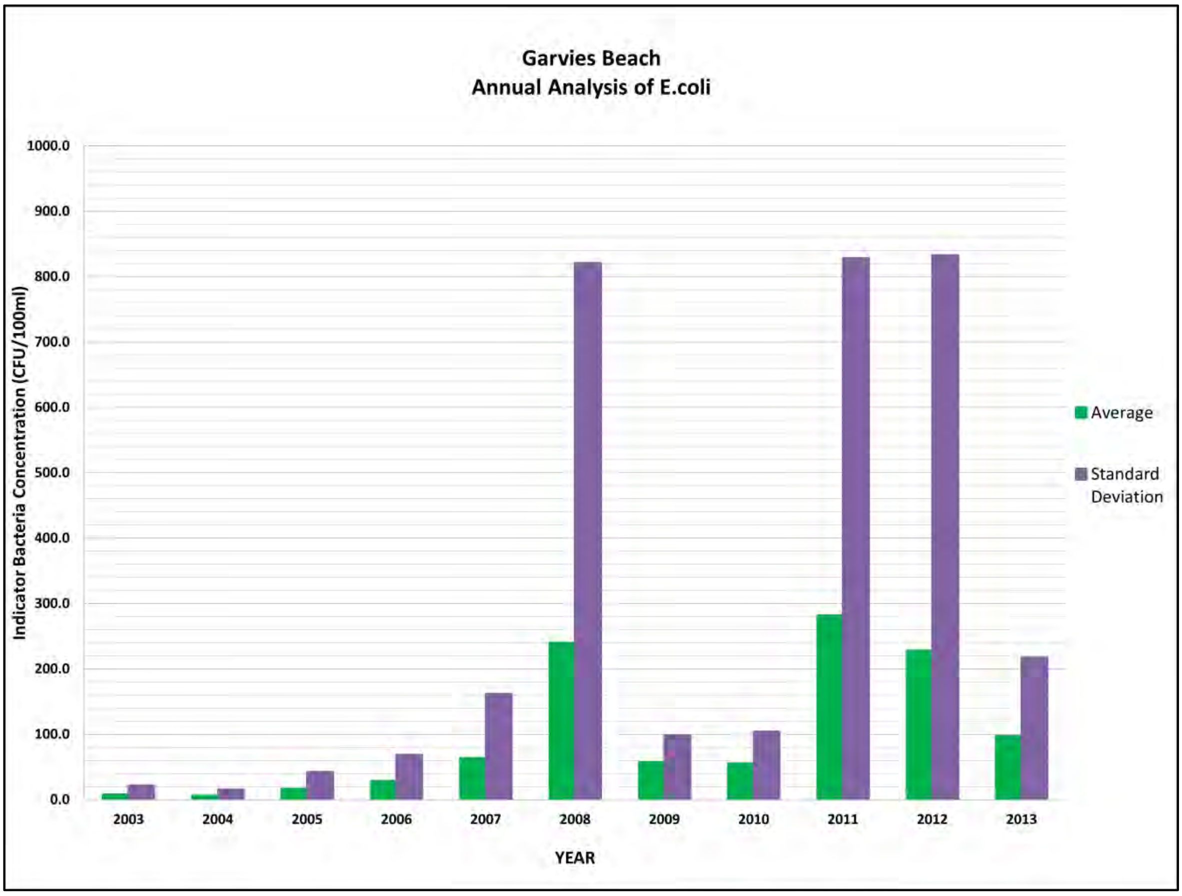


Figure A-79: Annual Analysis of E.coli at Garvies Beach

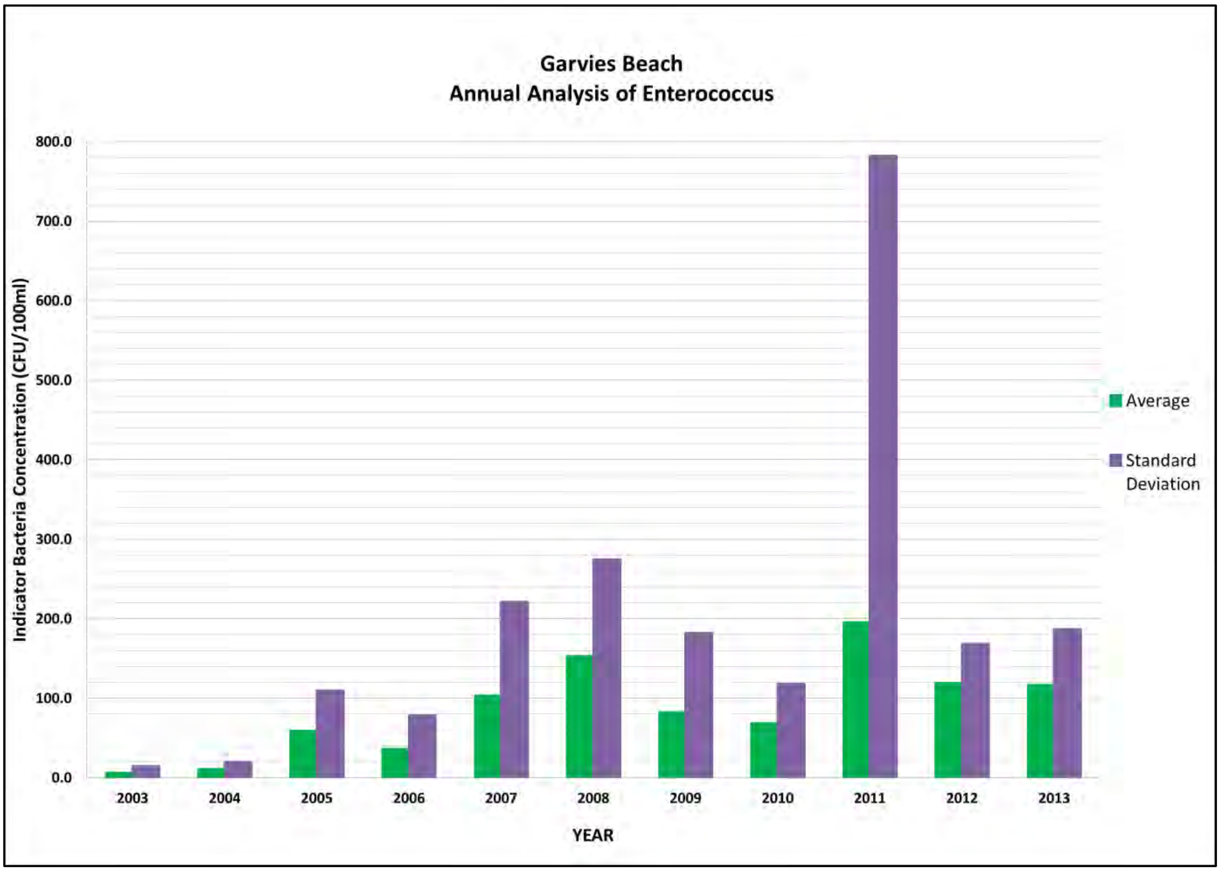


Figure A-80: Annual Analysis of Enterococcus at Garvies Beach

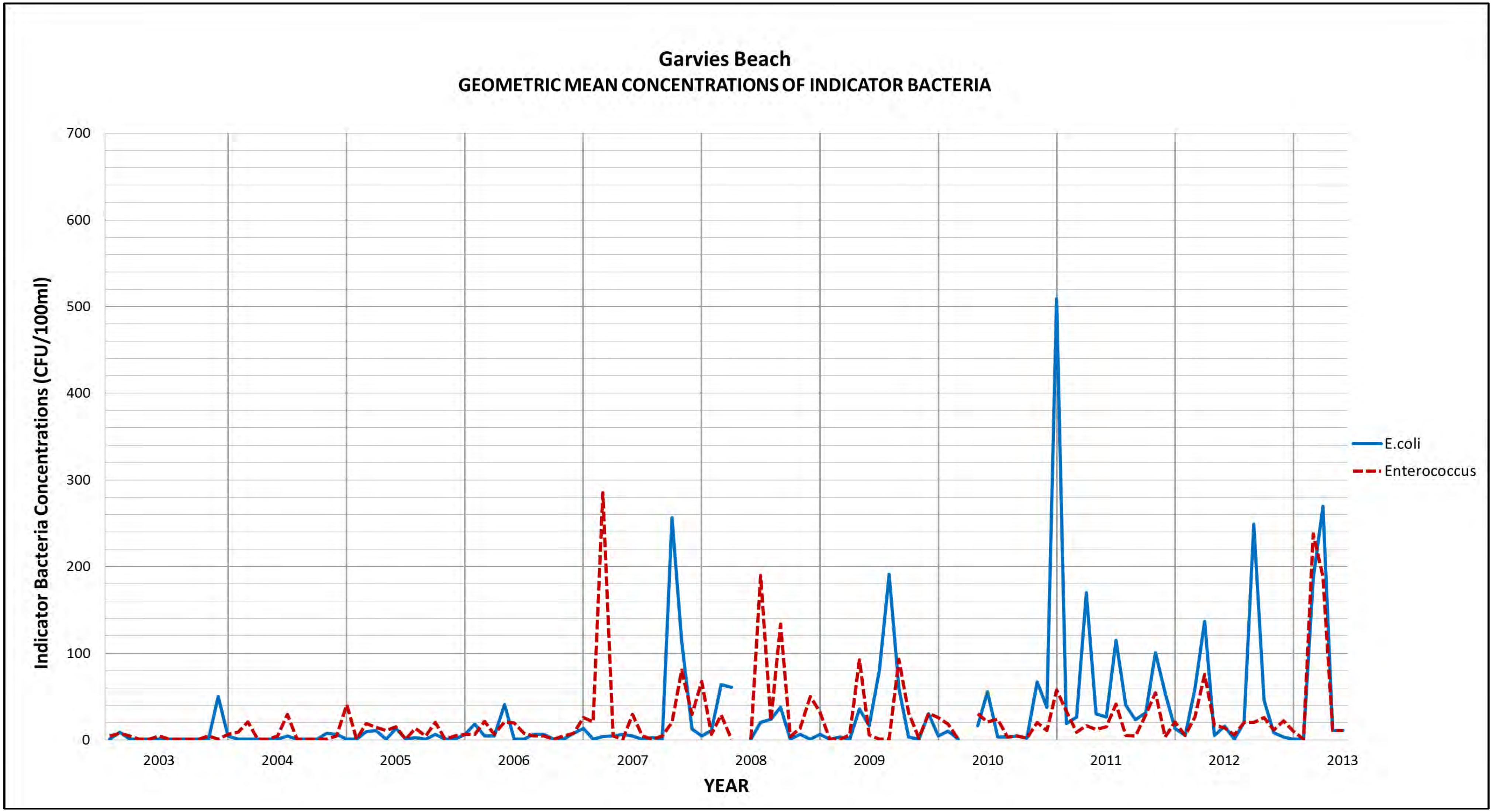


Figure A-81: Garvies – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of the two indicator bacteria are illustrated in Figure A-81. Both bacteria were consistently low for the first four years of the study. Thereafter variability of both increased. E.coli exceeded Enterococcus during the latter years. Although both indicators fluctuated, they followed the same pattern of change.

- **SAWQ Guidelines**

Tables A-107 and A-108 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. The annual water quality based on the presence of E.coli has been consistently excellent from 2003 to 2007. Thereafter the annual ratings drop to good due to increase in the occurrence of good and poor water quality.

Table A-107: Garvies – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	G	E	P	G	E
FEB	E	E	E	G	E	E	E	E	E	E	G
MAR	E	E	E	E	E	G	E	E	E	P	P
APR	E	E	E	E	E	E	E	-	P	G	E
MAY	E	E	E	E	E	-	E	E	G	E	E
JUN	E	E	E	E	E	E	E	G	G	E	G
JUL	E	E	E	E	E	G	E	E	P	E	G
AUG	E	E	E	E	E	G	E	E	E	G	E
SEP	E	E	E	E	E	G	G	E	E	G	E
OCT	E	E	E	E	G	E	E	E	G	G	P
NOV	E	E	E	E	E	E	E	G	G	E	E
DEC	E	E	E	E	E	E	E	G	G	E	G
Annual	E	E	E	E	E	G	G	G	G	G	G

Table A-108: Garvies – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	P	E	P	P	P	P	G
FEB	E	E	E	E	E	E	E	E	P	E	E
MAR	E	E	P	G	P	P	E	E	P	P	P
APR	E	E	G	E	E	E	E	-	P	P	P
MAY	E	E	G	E	E	-	G	P	P	P	E
JUN	E	E	P	P	E	E	G	G	P	P	E
JUL	E	E	E	E	E	P	E	P	P	E	-
AUG	E	E	E	E	E	P	E	E	E	P	-
SEP	E	E	E	E	E	P	P	E	E	P	-
OCT	E	E	P	E	P	E	E	E	P	P	-
NOV	E	E	E	E	E	P	E	P	P	G	-
DEC	E	E	E	E	E	E	P	E	E	P	-
Annual	E	E	P	G	P	P	P	P	P	P	P

Based on Enterococcus however, only the first two years have an overall excellent rating. Frequent incidences of poor water quality are evident, especially during the second half of the study. The overall annual rating has been consistently poor from 2007 onward, where at least a quarter of each year experiencing poor water quality conditions.

A.3.2. Anstey’s

- **Seasonal Trends**

The ranking of seasonal averages for E.coli and Enterococcus are shown in Tables A-109 and A-110 respectively. Summer yielded the highest average of E.coli most often, especially during the beginning of the study. The last two years appear to follow the same pattern of ranking, with autumn yielding the highest average. No trends are evident based on Enterococcus and there is no correlation with E.coli.

Table A-109: Anstey’s – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	6.70 (2)	5.60 (2)	34.4 (3)	11.1 (4)	**640 (1)**	31.7 (2)	0.00 (3)	83.9 (4)	**126 (1)**	**233 (1)**
Winter	0.00 (3)	6.70 (2)	**40.0 (1)**	8.90 (4)	15.6 (3)	0.00 (3)	15.0 (3)	57.2 (2)	**120 (1)**	109 (3)	25.0 (3)
Spring	3.30 (2)	4.40 (3)	0.00 (3)	43.3 (2)	**280 (1)**	0.00 (3)	**73.3 (1)**	0.00 (3)	98.2 (2)	118 (2)	33.3 (2)
Summer	**53.3 (1)**	**10.0 (1)**	5.60 (2)	**60.0 (1)**	40.0 (2)	15.6 (2)	15.0 (3)	**63.3 (1)**	91.3 (3)	24.9 (4)	5.00 (4)

Table A-110: Anstey’s – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	16.7 (3)	6.70 (3)	33.3 (3)	20.0 (3)	111 (3)	153 (2)	**56.7 (1)**	5.00 (4)	46.7 (4)	70.8 (3)	**75.0 (1)**
Winter	6.70 (4)	6.70 (3)	45.0 (2)	23.3 (2)	45.6 (4)	**280 (1)**	13.3 (3)	77.8 (2)	**202 (1)**	**112 (1)**	10.0 (2)
Spring	63.3 (2)	**46.7 (1)**	**50.0 (1)**	0.00 (4)	**300 (1)**	0.00 (4)	40.0 (2)	71.7 (3)	95.1 (2)	84.4 (2)	-
Summer	**136 (1)**	16.7 (2)	45.0 (2)	**26.7 (1)**	143 (2)	8.90 (3)	5.00 (4)	**126 (1)**	62.9 (3)	68.5 (4)	-

- **Annual Trends**

The annual averages and standards deviations for E.coli and Enterococcus are depicted in Figures A-82 and A-83 respectively. Apart from the significant increase in 2008 Enterococcus averages have remained consistently below 100CFU/100ml. Despite this the average at the end of the study is approximately five times greater than at the beginning. Extremely large deviations are evident in 2007 and 2008. The deviations became consistent in the last three years of the study. Although the average has increased, E.coli has become less variable.

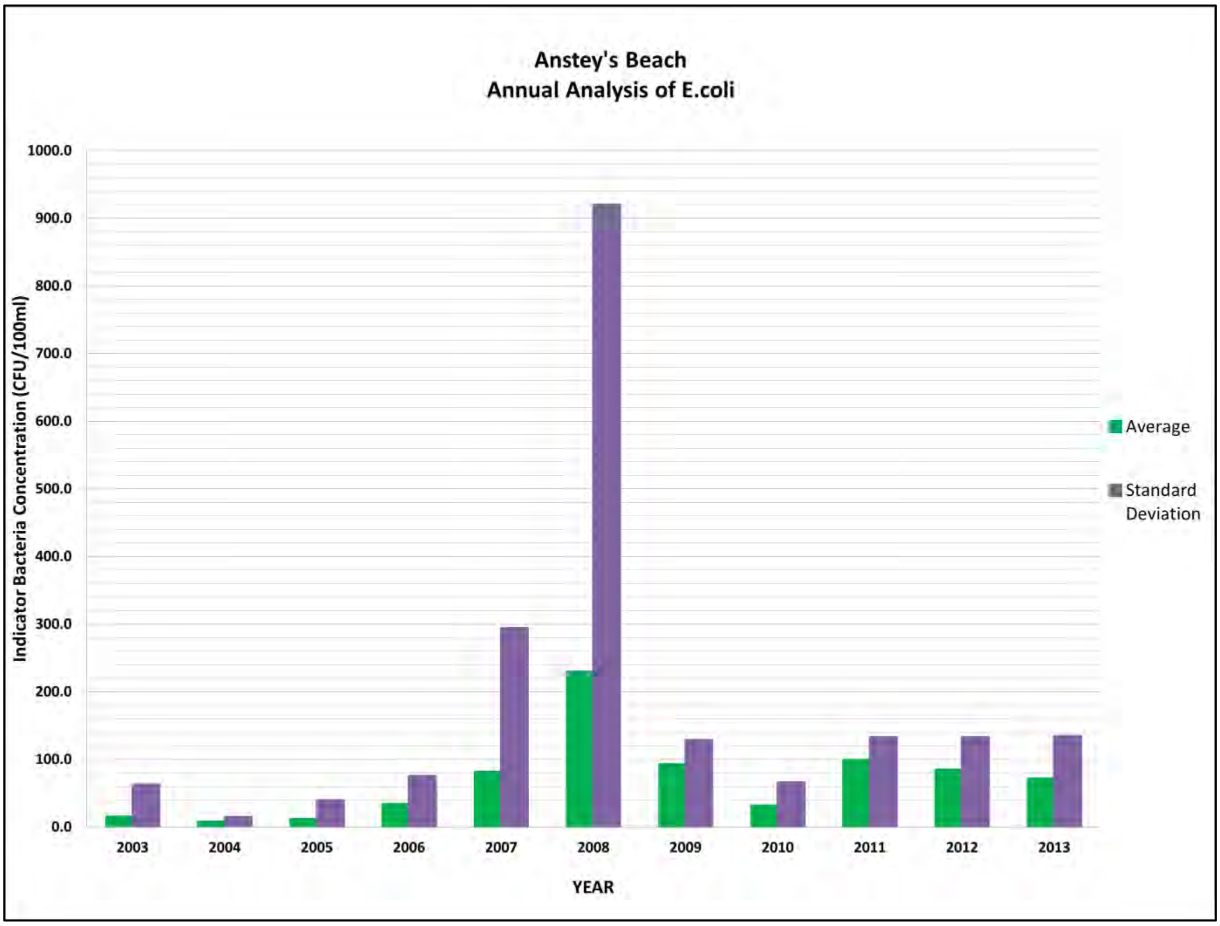


Figure A-82: Annual Analysis of E.coli at Anstey's Beach

There has been slight variation in Enterococcus levels the average concentrations have remained below 150CFU/100ml for the duration of the study. The variations in the average concentrations have been random and there is no pattern in the variation. The standard deviations were found to be large in most cases. Although the average varied only slightly over the years, large deviations indicate that Enterococcus has maintained a variable nature. E.coli and Enterococcus do not share any patterns.

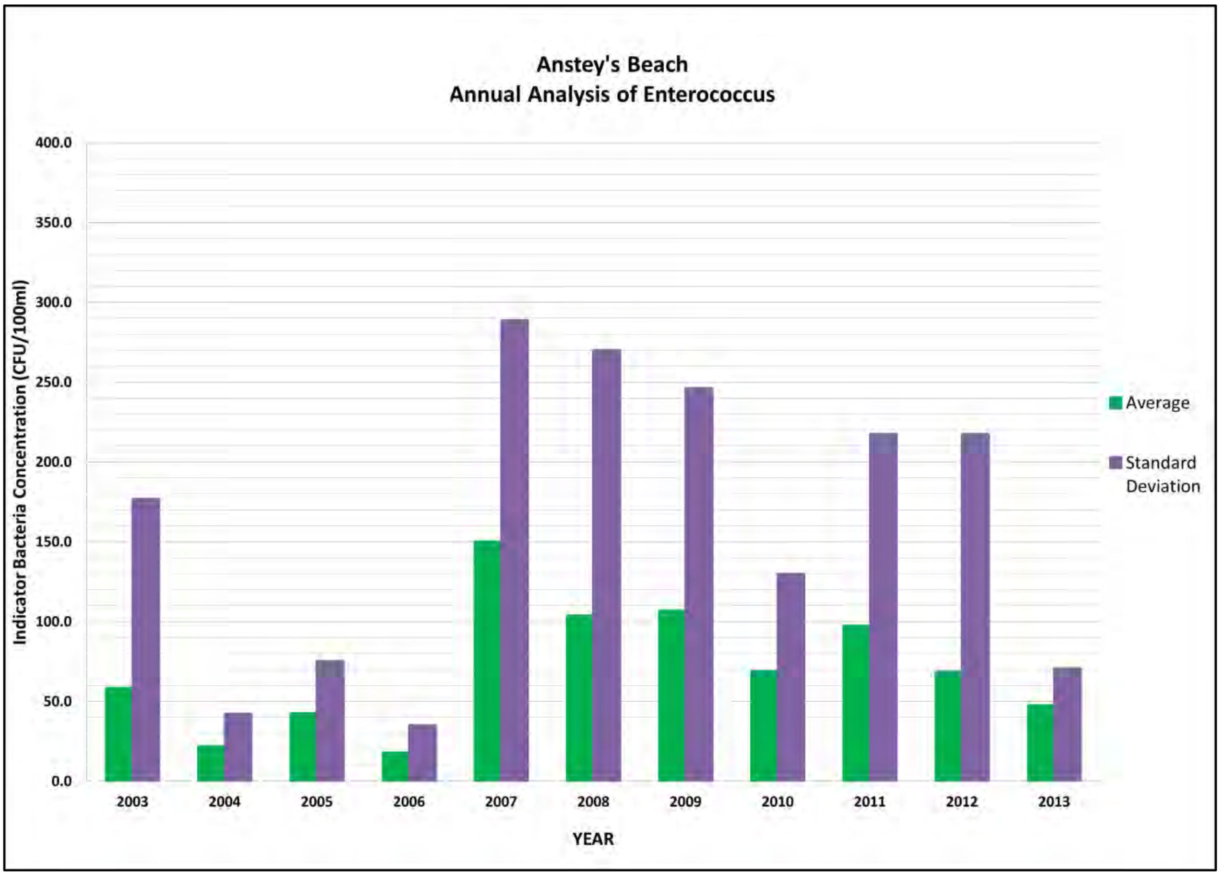


Figure A-83: Annual Analysis of Enterococcus at Anstey's Beach

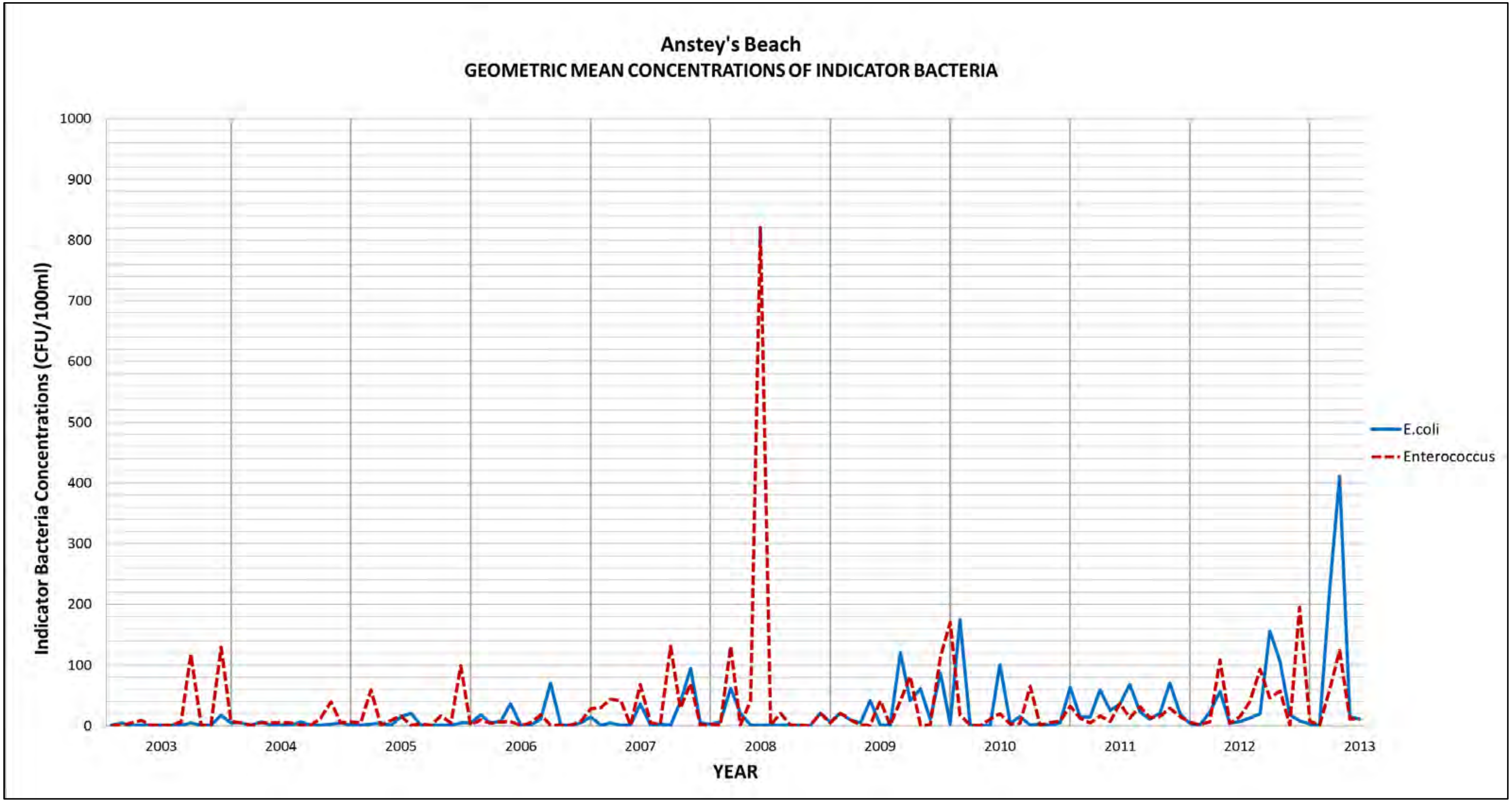


Figure A-84: Anstey's – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-84 illustrates the geometric means of the indicator bacteria at Anstey‟s beach. Both indicators have been consistent throughout most of the study, with exception to the large peaks of Enterococcus in 2008 and E.coli in 2013. The same patterns of fluctuation are observed for both E.coli and Enterococcus.

- **SAWQ Guidelines**

Table A-111 shows the rating of the E.coli levels at Anstey‟s beach for each month over the study period. The water quality during the first five years of the study was consistently excellent. The only incidence of poor water quality occurred in 2008, resulting in a drop in the overall water quality rating for that year. During the second half of the study the annual water quality rating fluctuated between excellent and good.

Table A-111: Anstey's – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	E	E	G	E	E
FEB	E	E	E	G	E	E	E	E	G	E	E
MAR	E	E	E	E	E	P	E	E	E	G	G
APR	E	E	E	E	E	E	E	-	G	G	G
MAY	E	E	E	E	E	E	E	E	G	E	E
JUN	E	E	E	E	E	E	E	E	G	E	E
JUL	E	E	E	E	E	E	-	E	G	E	E
AUG	E	E	E	E	E	E	E	E	G	G	E
SEP	E	E	E	E	E	E	E	E	E	E	E
OCT	E	E	E	E	G	E	E	E	E	G	E
NOV	E	E	E	E	E	-	E	E	G	E	E
DEC	G	E	E	E	E	E	E	E	E	E	E
Annual	E	E	E	E	E	G	E	E	G	G	E

Table A-112: Anstey's – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	P	E	E	P	P	E	E
FEB	E	E	E	E	E	E	E	P	G	E	E
MAR	E	E	E	E	P	P	E	E	E	P	E
APR	E	E	E	E	E	E	P	-	P	G	P
MAY	E	E	E	E	E	E	E	E	G	E	E
JUN	E	E	G	E	P	P	E	P	P	P	E
JUL	E	E	E	E	E	E	-	E	P	E	-
AUG	E	E	E	G	E	E	E	E	P	P	-
SEP	P	E	E	E	P	E	E	G	P	G	-
OCT	E	G	G	E	P	E	E	E	E	P	-
NOV	E	E	E	E	E	-	E	E	P	E	-
DEC	G	G	G	E	E	E	E	E	E	P	-
Annual	G	G	G	E	P	P	P	P	P	P	P

Generally the annual water quality for the first three years was good. From 2007 the frequency of poor water quality increased, resulting in every year since then having an overall poor water quality rating. The water quality at Anstey‟s beach has been classified as poor more frequently based on Enterococcus levels than E.coli.

A.3.3. Brighton

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-113. Autumn is shown to yield the highest average counts of E.coli most frequently, however, not consistently. Spring has never produced the highest average of this bacterium.

Table A-113: Brighton – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**6.70 (1)**	0.00 (3)	2.20 (2)	14.4 (2)	**100 (1)**	**85.0 (1)**	24.0 (3)	**50.0 (1)**	85.0 (3)	**104 (1)**	**190 (1)**
Winter	3.30 (2)	3.30 (2)	**8.90 (1)**	6.70 (3)	0.00 (3)	3.30 (2)	24.0 (3)	17.2 (3)	85.0 (3)	89.0 (2)	27.2 (2)
Spring	0.00 (3)	3.30 (2)	0.00 (3)	6.70 (3)	0.00 (3)	0.00 (3)	46.7 (2)	10.0 (4)	218 (2)	85.8 (3)	23.3 (3)
Summer	3.30 (2)	**20.0 (1)**	0.00 (3)	**80.0 (1)**	15.0 (2)	0.00 (3)	**113 (1)**	36.1 (2)	**265 (1)**	18.3 (4)	11.7 (4)

Table A-114 shows the ranking of seasonal averages for Enterococcus at Brighton beach. The highest levels of Enterococcus were found to be in autumn and summer most often. Based on available data, Enterococcus follows the same patterns of ranking as E.coli from 2008 onward.

Table A-114: Brighton – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	6.70 (2)	0.00 (4)	**46.7 (1)**	24.4 (2)	210 (2)	**205 (1)**	32.2 (3)	**170 (1)**	91.1 (3)	**105 (1)**	**146 (1)**
Winter	0.00 (4)	**43.3 (1)**	15.6 (3)	6.70 (3)	0.00 (4)	140 (2)	60.0 (2)	28.9 (3)	38.3 (4)	90.0 (2)	10.0 (2)
Spring	3.30 (3)	3.30 (3)	6.70 (4)	0.00 (4)	**740 (1)**	15.0 (3)	26.7 (4)	26.7 (4)	101 (2)	74.2 (3)	-
Summer	**20.0 (1)**	13.3 (2)	20.0 (2)	**86.7 (1)**	155 (3)	15.0 (3)	**120 (1)**	128 (2)	**1023 (1)**	55.7 (4)	-

- **Annual Trends**

Figures A-85 and A-86 represent the annual averages and standard deviation for E.coli and Enterococcus respectively. There has been a clear increase in the average concentration of E.coli at Brighton beach. Despite this, the average still remained below 100CFU/100ml every year except in 2011. The average in 2013 is more than 17 times that in 2003. The lowest average occurred in 2005 and the highest occurred in 2011. The highest average is approximately 54 times greater than the lowest. Large deviations are noted and the data set for E.coli is spread over a large range throughout most of the study.

Enterococcus levels increased steadily though slightly from 2003 to 2007. Thereafter the average fluctuated until the end of the study. Nevertheless, the average concentration of this bacterium increased approximately 25 times when compared to the lowest average at the beginning of the study period.

Extremely large standard deviations are noted in 2008, 2010 and 2011, indicating great variability in Enterococcus levels throughout those years. The two indicators do not have a direct link in their changes over the study period.

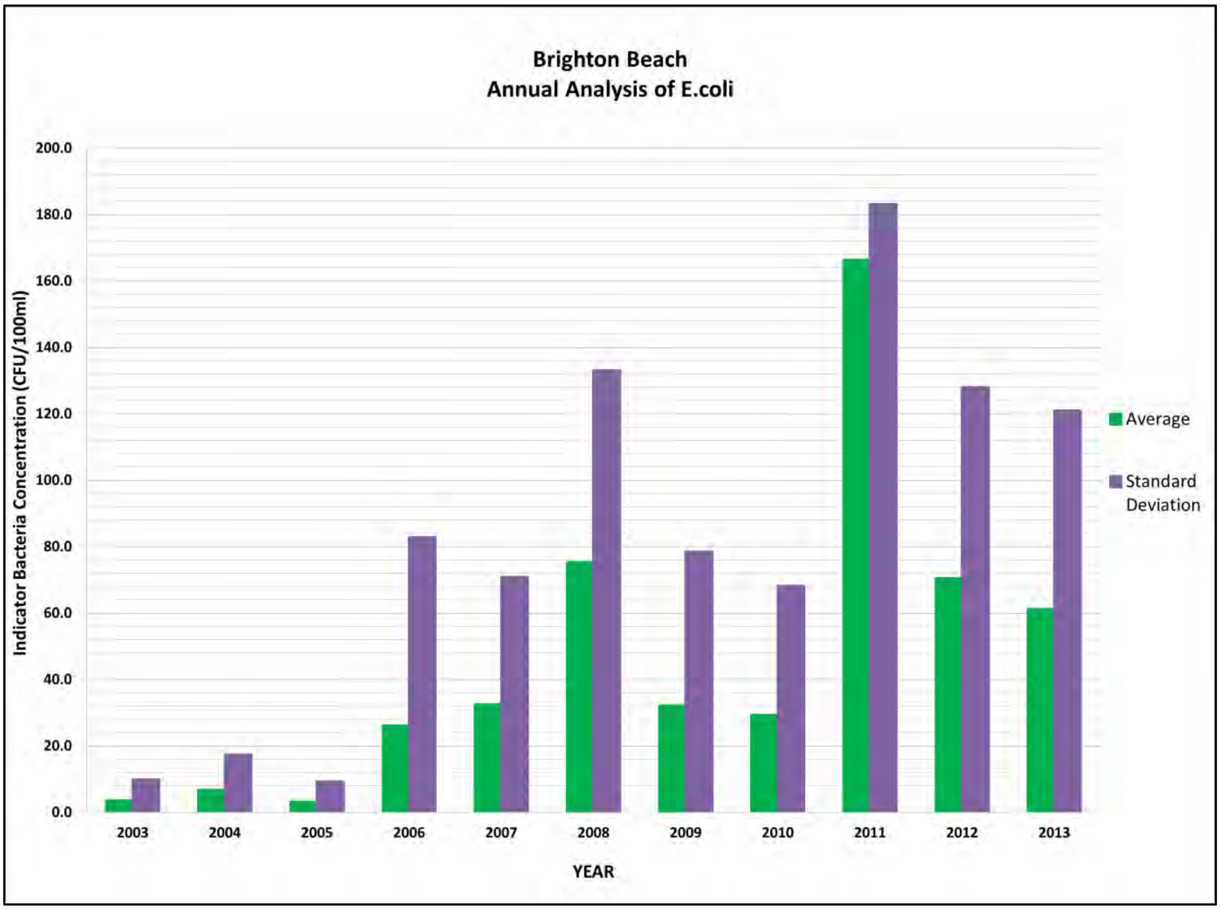


Figure A-85: Annual Analysis of E.coli at Brighton Beach

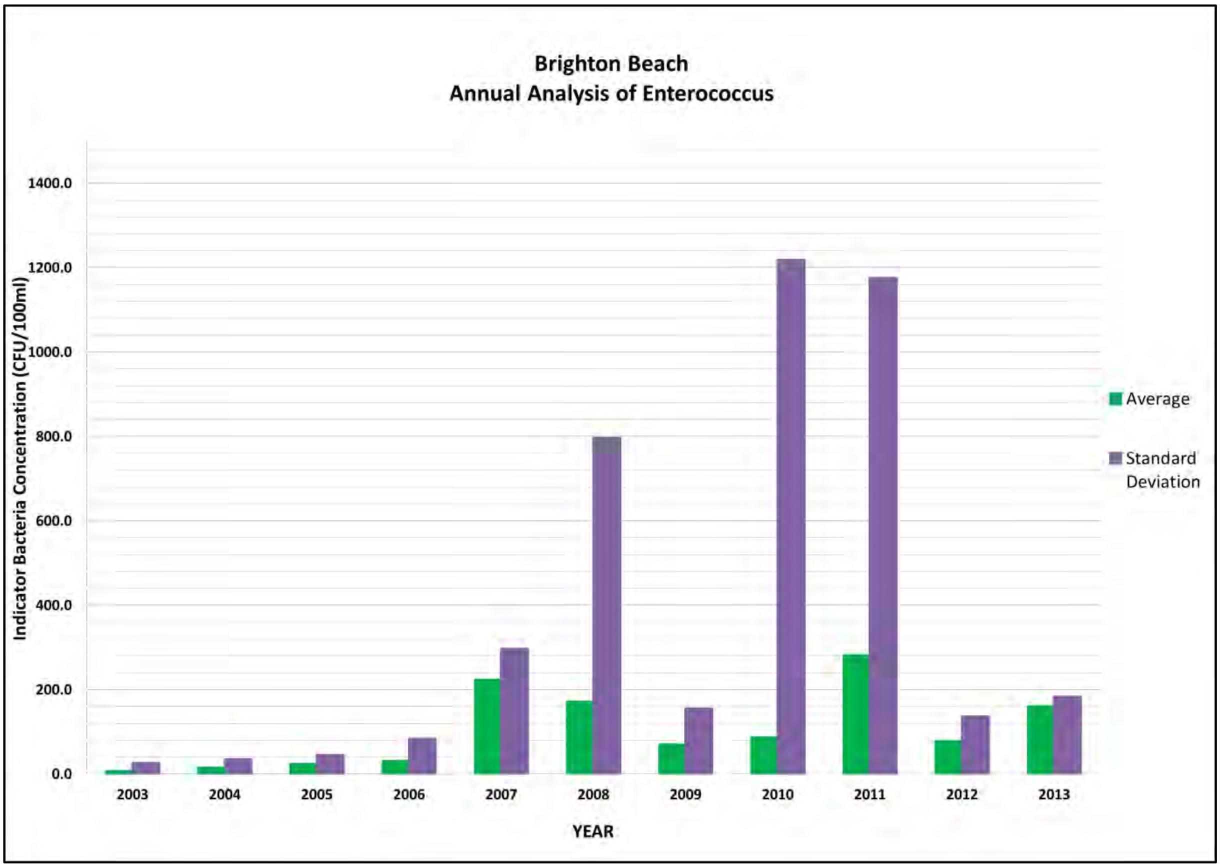


Figure A-86: Annual Analysis of Enterococcus at Brighton Beach

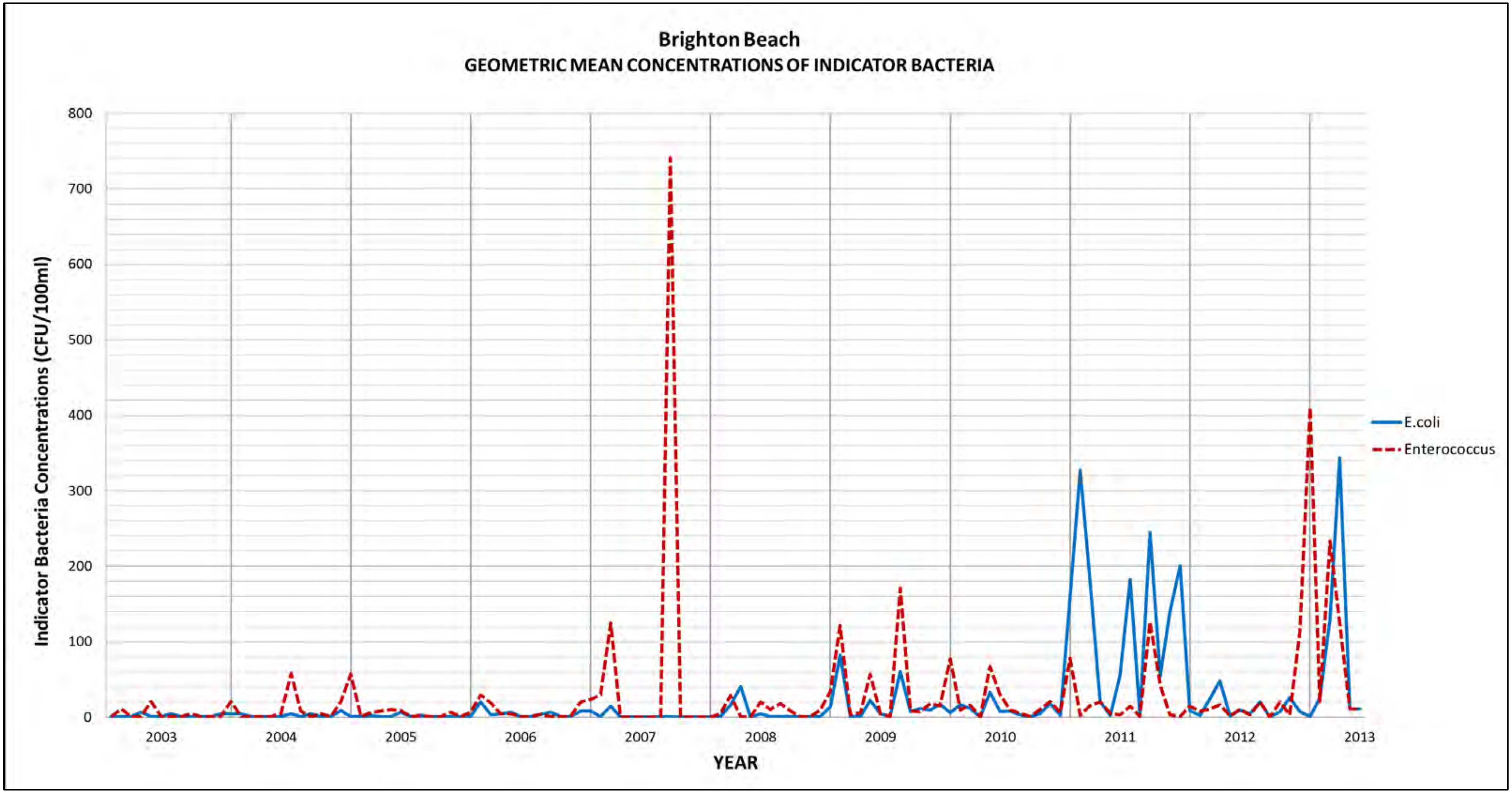


Figure A-87: Brighton – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-87 illustrates the geometric means of E.coli and Enterococcus. Both indicators are shown to be consistent during the first four years of the study. Enterococcus exceeded E.coli during this time. From 2007 both indicator bacteria became more erratic and the geometric means increased significantly.

- **SAWQ Guidelines**

The microbiological water quality rating for E.coli is shown in Table A-115. The water quality was consistently excellent up to 2010. One incidence of poor water quality during the entire study period in 2011 resulted in the annual rating dropping to good. Brighton beach has maintained an overall good rating from 2011 onward.

Table A-115: Brighton – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	-	G	E	G	E	E
FEB	E	E	E	G	E	E	G	G	G	E	E
MAR	E	E	E	E	E	E	E	E	G	G	G
APR	E	E	E	E	-	E	E	-	E	G	G
MAY	E	E	E	E	-	-	E	E	E	E	E
JUN	E	E	E	E	-	E	E	E	E	E	E
JUL	E	E	E	E	-	E	F	E	E	E	E
AUG	E	E	E	E	E	E	E	E	E	G	E
SEP	E	E	E	E	E	E	E	E	P	-	E
OCT	E	E	E	E	-	E	E	E	E	G	E
NOV	E	E	E	E	-	E	E	E	G	E	E
DEC	E	E	E	E	-	E	E	E	G	E	E
Annual	E	E	E	E	E	E	E	E	G	G	G

Table A-116: Brighton – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	P	-	P	P	P	E	P
FEB	G	E	E	E	E	E	P	P	E	E	E
MAR	E	E	G	E	P	P	E	P	E	P	P
APR	E	E	E	E	-	E	E	-	P	P	G
MAY	E	E	E	E	-	-	E	G	G	E	E
JUN	E	E	E	E	-	P	E	E	E	G	E
JUL	E	G	E	E	-	E	E	E	P	E	-
AUG	E	E	E	E	E	G	G	E	E	P	-
SEP	E	E	E	E	G	E	E	E	P	-	-
OCT	E	E	E	E	-	E	E	G	G	P	-
NOV	E	E	E	E	-	E	E	E	E	E	-
DEC	E	E	E	G	-	E	P	G	E	G	-
Annual	E	E	E	E	P	P	P	P	P	P	P

Table A-116 depicts the microbiological water quality rating for Enterococcus. The annual water quality rating was consistently excellent for the first four years of the study. Thereafter incidences of poor water increased, resulting in every year from 2007 to 2013 having an overall rating of poor.

A.3.4. Treasure

- **Seasonal Trends**

The seasonal averages for E.coli and Enterococcus at Treasure beach are ranked in Tables A-117 and A-118 respectively. Autumn and summer produced the highest average most often; however, no clear trends are evident based on this bacterium. Autumn produced the highest average of Enterococcus most frequently. Based on available data, Enterococcus follows the same pattern of ranking as E.coli from 2011 onward.

Table A-117: Treasure – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	66.7 (3)	366 (2)	113 (4)	**1114 (1)**	670 (4)	**2650 (1)**	76.7 (2)	77.5 (2)	146 (4)	**344 (1)**	**568 (1)**
Winter	86.7 (2)	60.0 (4)	126 (3)	84.4 (3)	1060 (2)	197 (3)	**486 (1)**	62.1 (3)	**752 (1)**	120 (3)	146 (2)
Spring	10.0 (4)	123 (3)	153 (2)	1020 (2)	**1936 (1)**	299 (2)	0.00 (3)	49.9 (4)	185 (3)	252 (2)	76.7 (4)
Summer	**1833 (1)**	**776 (1)**	**723 (1)**	33.3 (4)	703 (3)	75.3 (4)	0.00 (3)	**151 (1)**	441 (2)	102 (4)	80.0 (3)

Table A-118: Treasure – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	200 (2)	33.3 (4)	106 (3)	**375 (1)**	370 (2)	**560 (1)**	81.1 (2)	**210 (1)**	111 (4)	**186 (1)**	**368 (1)**
Winter	80.0 (3)	53.3 (3)	46.7 (4)	32.2 (3)	370 (2)	235 (2)	**310 (1)**	76.2 (4)	**699 (1)**	119 (3)	50.0 (2)
Spring	10.0 (4)	143 (2)	**153 (1)**	156 (2)	**623 (1)**	156 (4)	0.00 (3)	93.2 (3)	433 (3)	180 (2)	-
Summer	**296 (1)**	**536 (1)**	143 (2)	20.0 (4)	183 (3)	190 (3)	0.00 (3)	169 (2)	540 (2)	101 (4)	-

- **Annual Trends**

Figure A-88 shows the annual averages and standard deviations for E.coli. The levels of E.coli varied greatly at Treasure beach. Averages fluctuated randomly and there is no clear pattern. The highest average occurred in 2007 and the lowest occurred in 2010. The highest average is more than 14 times the lowest. Ultimately the average at the end of the study is almost half of that at the start. The standard deviations are notably large in most cases. Together with the random changes in the average, this confirms the variable nature of E.coli at Treasure beach.

Figure A-89 shows the annual averages and standard deviations for Enterococcus. The average levels varied slightly throughout the study period, increasing and decreasing randomly. The highest average is noted in 2011. Ultimately the average concentration of Enterococcus in 2013 is almost double that in 2003.

The year with the highest average also produced the highest standard deviation. Generally the deviations were found to be significant. This compliments the random changes in the averages and shows that Enterococcus has been erratic. Although both indicator bacteria concentrations fluctuated, there was no direct relationship between their variations over the years.

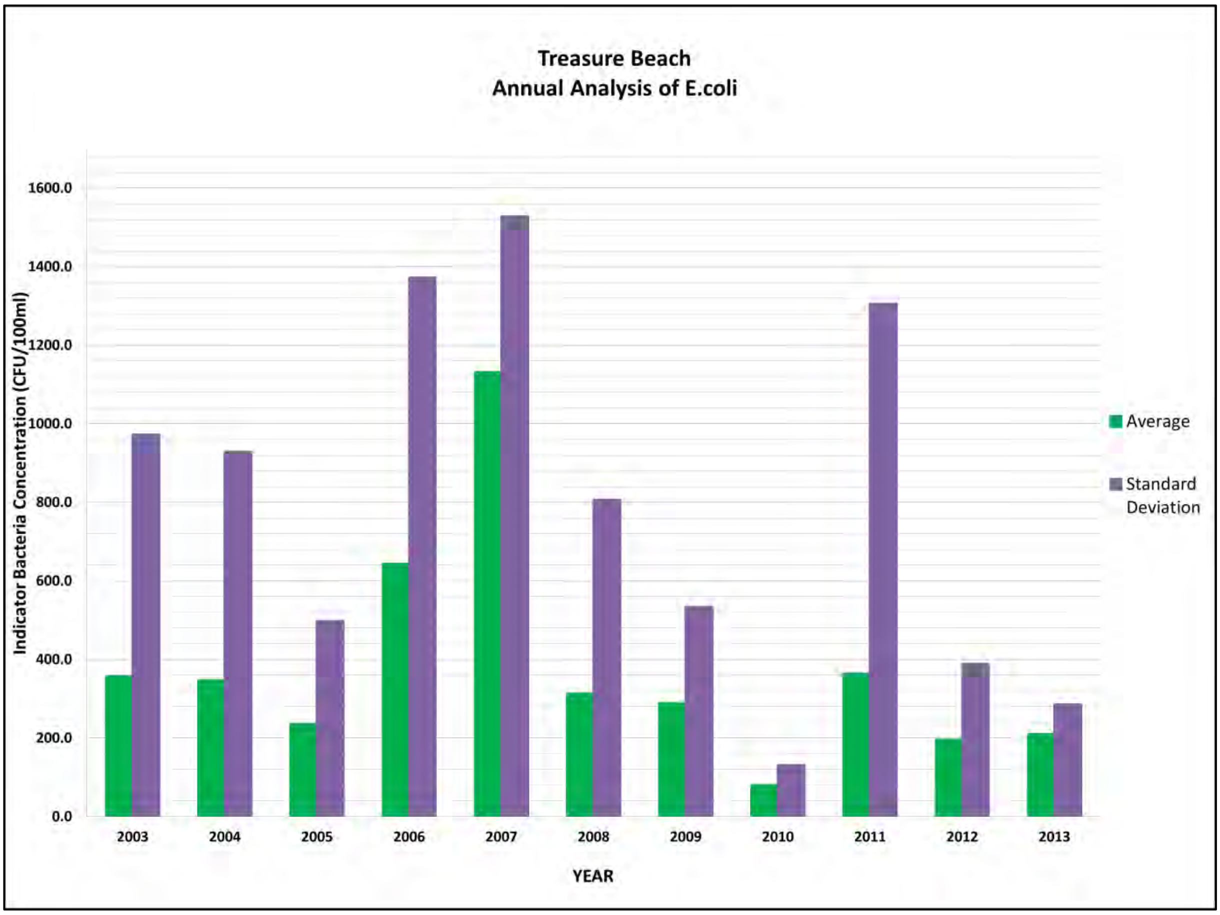


Figure A-88: Annual Analysis of E.coli at Treasure Beach

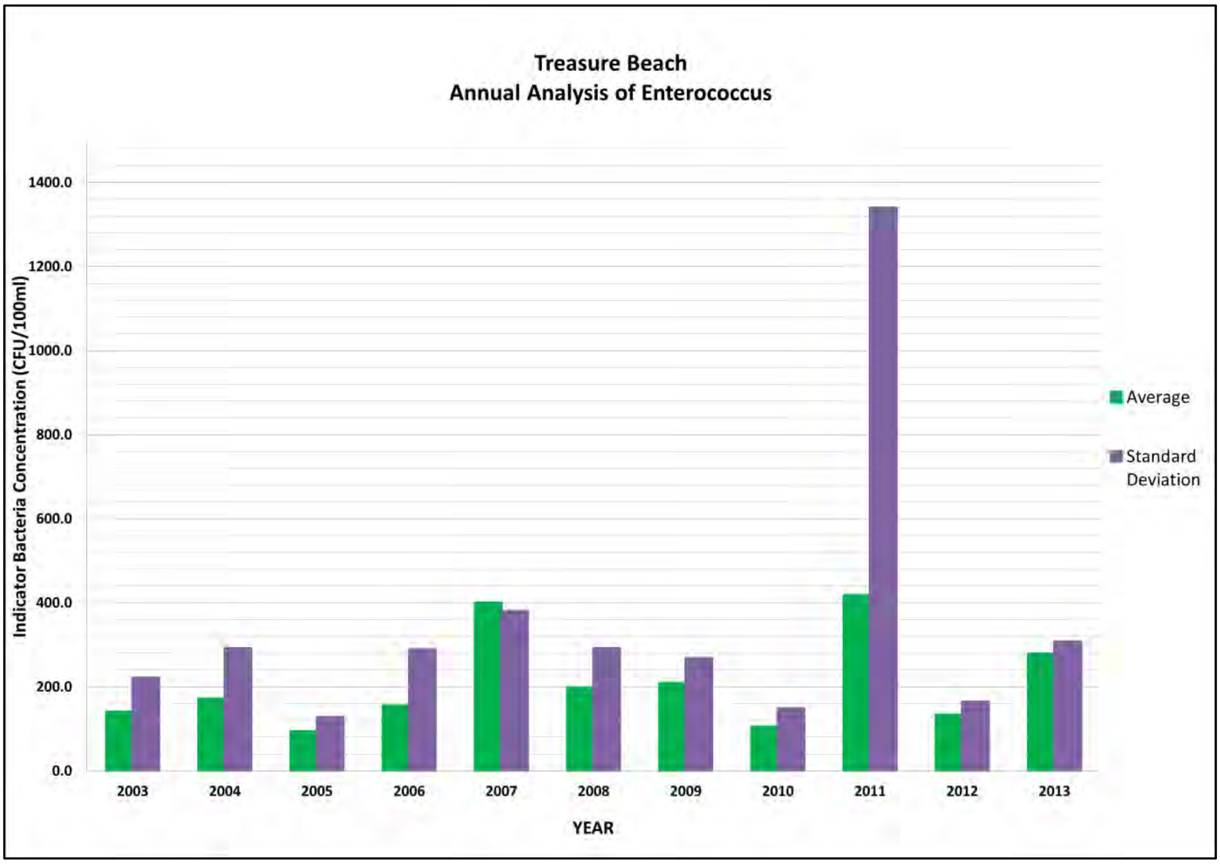


Figure A-89: Annual Analysis of Enterococcus at Treasure Beach

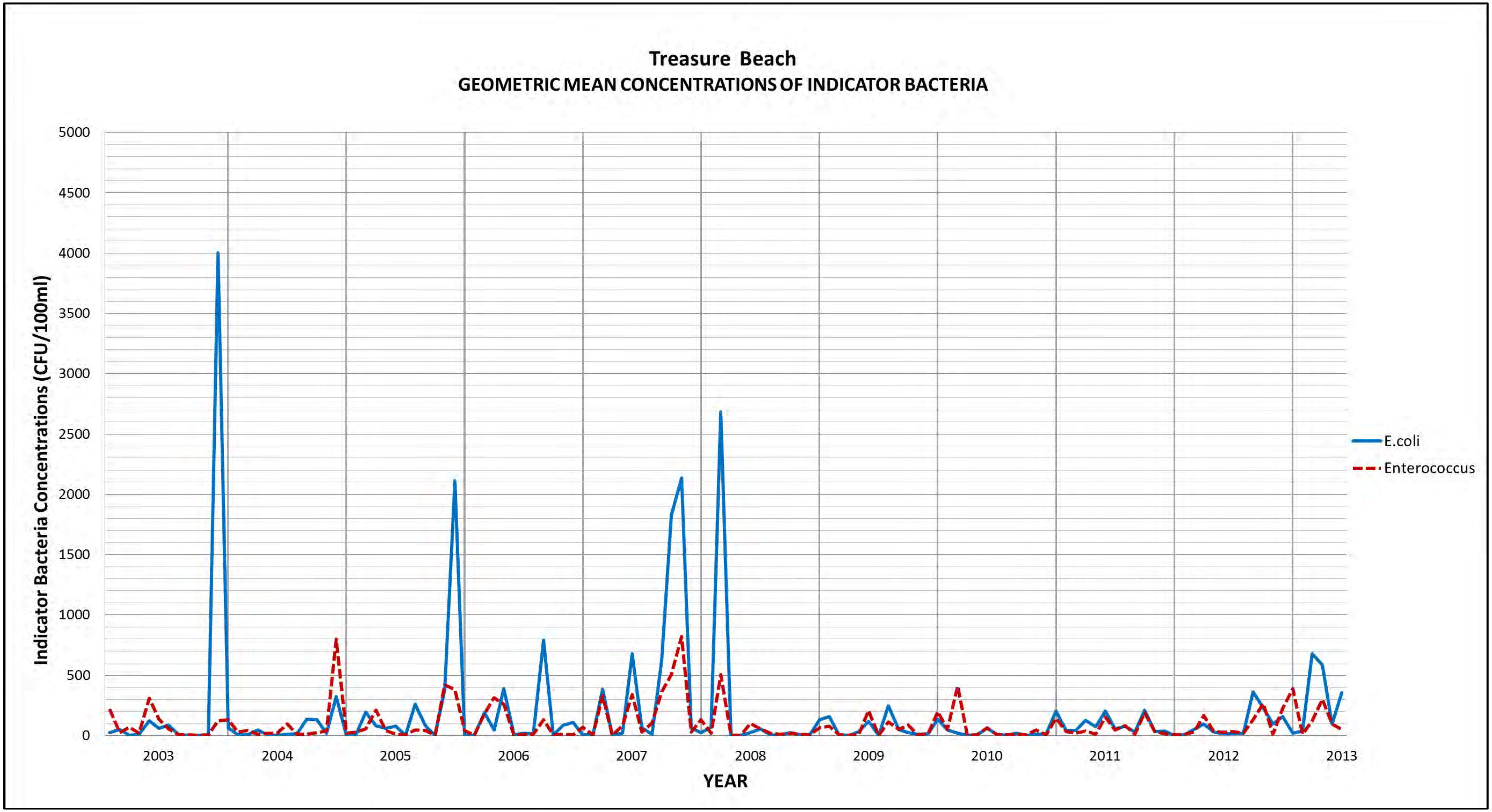


Figure A-90: Treasure – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are illustrated in Figure A-90. E.coli is shown to be extremely variable during first half of the study. Enterococcus also appears to be variable, though to a lesser degree than its counterpart. Both bacteria became more consistent from 2008 and follow the same pattern.

- **SAWQ Guidelines**

Table A-119 shows the microbiological water quality rating for E.coli. The overall annual rating is split between good and poor. The most frequent occurrences of poor water quality are shown to be from 2006 to 2009 with at least a third of each year experiencing poor water quality conditions. The most frequent occurrence of poor water quality is 2007. This corresponds to the high average noted in Figure A-93.

Table A-119: Treasure – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	P	E	E	E	E	P	G	P	E	G
FEB	P	E	E	E	E	E	P	G	G	E	G
MAR	E	E	G	P	P	P	G	G	E	P	P
APR	E	P	E	P	-	-	E	E	G	G	P
MAY	E	E	E	P	G	-	G	E	G	G	E
JUN	E	E	E	E	P	G	P	G	G	E	P
JUL	G	E	E	G	P	P	-	E	G	E	G
AUG	E	E	G	E	E	E	P	E	P	G	E
SEP	E	E	E	P	P	E	E	E	E	G	G
OCT	E	G	E	E	P	P	E	E	G	G	E
NOV	E	E	G	G	P	P	E	G	G	E	E
DEC	P	G	G	E	P	E	E	E	E	G	E
Annual	G	G	G	P	P	P	P	G	G	G	P

Table A-120: Treasure – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	P	E	E	P	P	P	P	P	E	P
FEB	P	P	E	E	E	P	P	P	P	E	E
MAR	G	E	G	P	P	P	P	P	G	P	P
APR	P	E	P	P	-	-	E	-	P	P	P
MAY	P	E	E	P	G	-	P	E	P	P	P
JUN	P	E	G	E	P	P	P	P	P	P	E
JUL	G	E	E	G	P	P	-	E	P	E	-
AUG	E	E	E	E	P	P	P	G	P	P	-
SEP	E	E	E	P	P	P	E	P	E	P	-
OCT	E	P	E	E	P	P	P	G	P	P	-
NOV	E	E	P	E	P	P	E	P	P	E	-
DEC	G	P	P	E	P	P	E	E	E	P	-
Annual	P	P	P	P	P	P	P	P	P	P	P

The microbiological water quality rating for Enterococcus is shown in Table A-120. Annually the water quality has been poor for the entire study period. Poor water quality conditions dominate each year, with most years experiencing poor water quality for more than half the year.

A.3.5. Umlaas

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-121. Autumn yielded the highest average counts of E.coli most frequently. Winter never produced the highest. The actual value of the highest average is shown to be extremely high, especially during the first seven years of the study.

Table A-121: Umlaas – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	416 (3)	**1446 (1)**	530 (3)	**1883 (1)**	1302 (4)	**2700 (1)**	**1207 (1)**	191 (3)	224 (4)	**449 (1)**	**706 (1)**
Winter	430 (2)	253 (4)	733 (2)	712.2 (4)	1596 (2)	784 (2)	1000 (2)	262 (2)	593 (3)	257 (3)	572 (2)
Spring	153 (4)	750 (2)	226 (4)	1040 (3)	**2500 (1)**	506 (3)	0.00 (3)	139 (4)	670 (2)	410 (2)	305 (3)
Summer	**1446 (1)**	720 (3)	**1416 (1)**	1376 (2)	1463 (3)	506 (3)	0.00 (3)	**293 (1)**	**842 (1)**	105 (4)	241 (4)

Table A-122 shows the ranking of the Enterococcus seasonal averages. Autumn produced the highest average most often; however, no trends are evident based on this bacterium and there is no correlation with E.coli.

Table A-122: Umlaas – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	309 (3)	166 (4)	**526 (1)**	**516 (1)**	544 (2)	720 (2)	378 (2)	**311 (1)**	128 (4)	**803 (1)**	613 (2)
Winter	389 (2)	286 (3)	66.7 (4)	122 (4)	513 (3)	448 (3)	**473 (1)**	212 (3)	556 (3)	162 (4)	**800 (1)**
Spring	66.7 (4)	**554 (1)**	153 (3)	236 (3)	**646 (1)**	264 (4)	0.00 (3)	136 (4)	760 (2)	341 (2)	-
Summer	**516 (1)**	329 (2)	296 (2)	356 (2)	373 (4)	**1169 (1)**	0.00 (3)	260 (2)	**837 (1)**	139 (3)	-

- **Annual Trends**

Figures A-91 and A-92 portray the annual averages and standard deviations for E.coli and Enterococcus respectively.

The average levels of E.coli varied throughout the study period. During the first half average fluctuated but showed a general increase. Averages are extremely high, with the highest in 2007 reaching more than 1500CFU/100ml. During the second half of the study the average remains variable but shows a general decrease. The average at the end of the study is nearly equal to that at the beginning. The standard deviations were found to be tremendously large for the duration of the study, highlighting extreme variation in E.coli concentrations.

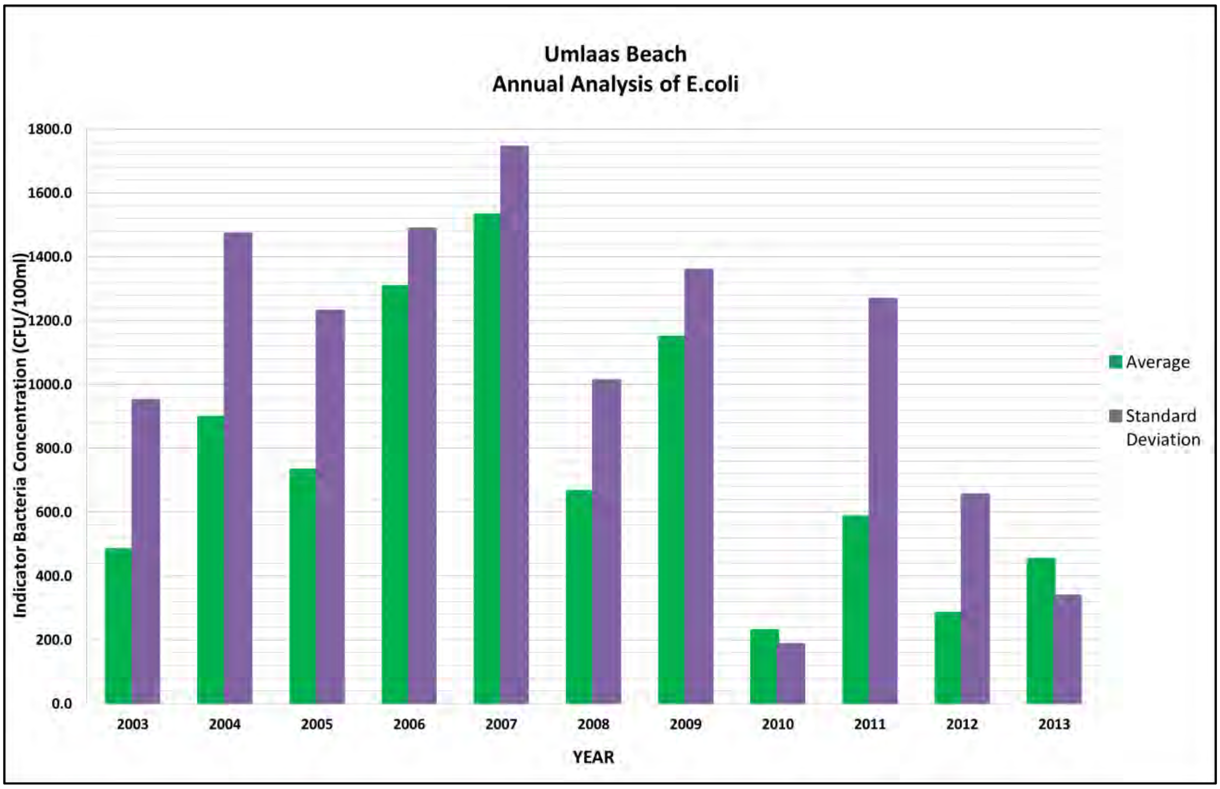


Figure A-91: Annual Analysis of E.coli at Umlaas Beach

Enterococcus varied slightly over the duration of the study; however, the average remained above 200CFU/100ml. The last three years of the study show average concentrations greater than 400CFU/100ml. The standard deviations were found to be notably large in 2008, 2011 and 2012. Enterococcus concentrations varied significantly from the average during these years.

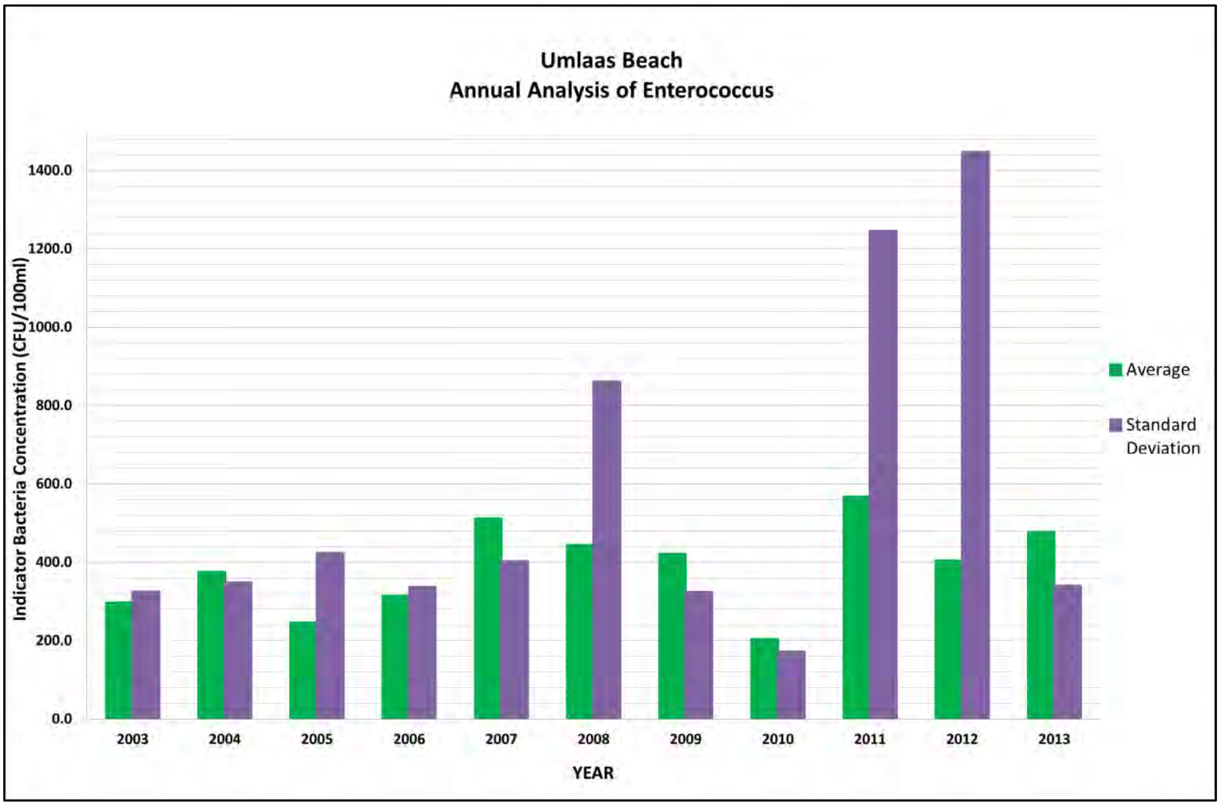


Figure A-92: Annual Analysis of Enterococcus at Umlaas Beach

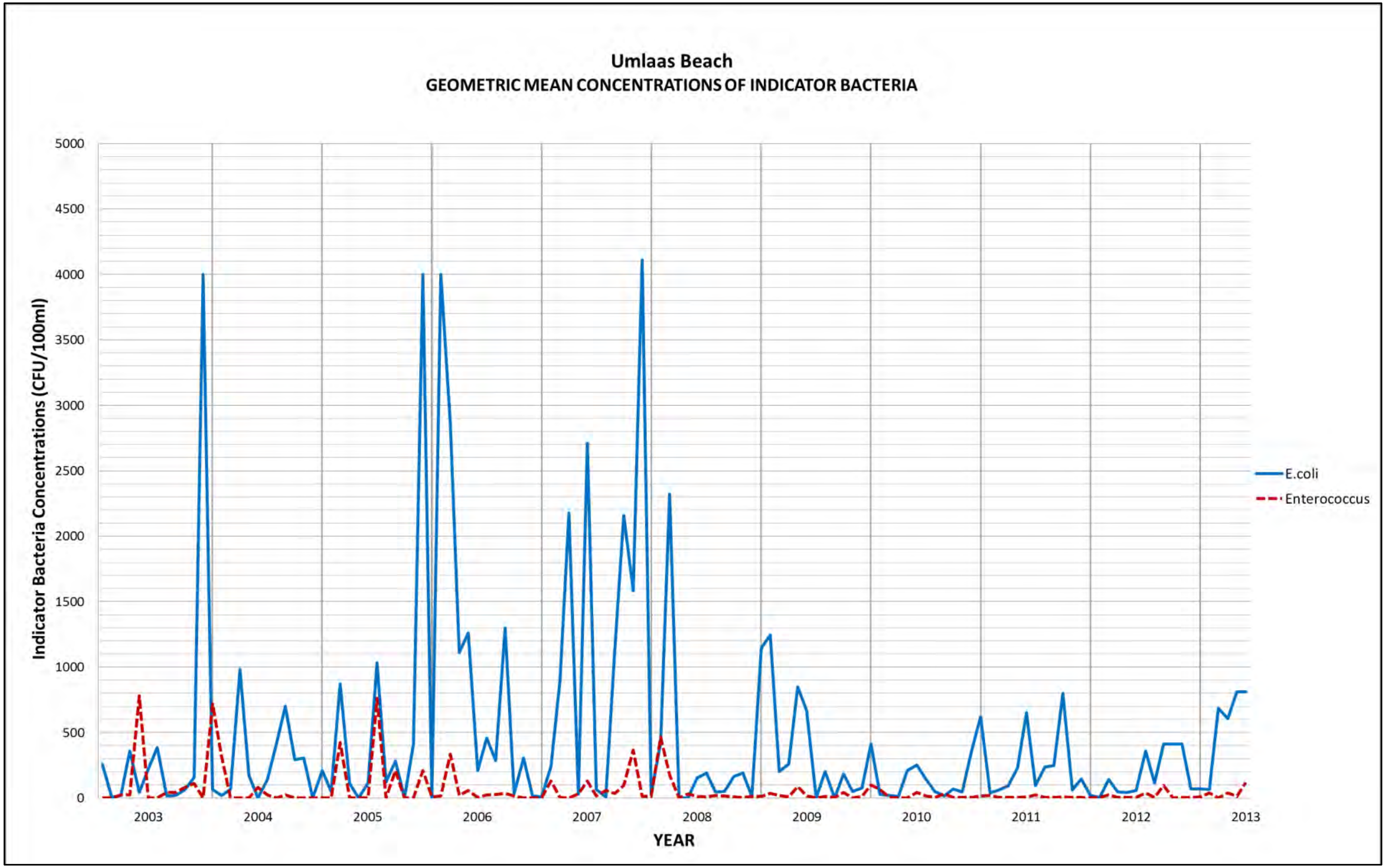


Figure A-93: Umlaas – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are compared in Figure A-93. E.coli exceeded Enterococcus greatly throughout the entire study. E.coli has been capricious with the geometric means varying from extremely high to extremely low from month to month. Enterococcus was erratic during the first half of the study but it stabilized from 2008 onward.

- **SAWQ Guidelines**

Table A-123 depicts the microbiological water quality rating based on E.coli. The annual water quality rating varies from good to poor. The most frequent incidences of poor water quality are shown to be during the middle years of the study, where poor water quality conditions occurred at least a third each year from 2006 to 2009. Table A-124 summarises the microbiological water quality rating based on Enterococcus. The water quality at Umlaas beach has been predominantly poor for the entire study period. Infrequent incidences of excellent water quality occurred during the first four years of the study, but were absent for the remainder.

Table A-123: Umlaas – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	P	E	E	E	E	P	G	P	G	G
FEB	E	G	E	G	G	G	P	G	G	E	G
MAR	G	G	G	P	P	P	G	G	G	P	P
APR	G	P	E	P	G	-	G	E	G	G	P
MAY	E	G	E	P	G	-	G	G	G	G	E
JUN	G	E	G	G	P	G	P	G	G	G	P
JUL	G	G	G	G	P	P	-	G	G	G	G
AUG	E	G	G	G	E	G	P	G	P	G	G
SEP	G	G	G	P	P	G	E	E	G	G	G
OCT	E	G	E	G	P	P	G	G	G	G	G
NOV	E	G	G	G	P	P	E	G	G	G	G
DEC	P	E	G	E	P	G	E	G	G	G	E
Annual	G	G	G	P	P	P	P	G	P	G	P

Table A-124: Umlaas – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	P	P	E	E	P	G	P	P	P	G	P
FEB	G	P	E	G	G	P	P	P	P	G	G
MAR	G	G	G	P	P	P	P	P	G	P	P
APR	P	G	P	P	P	-	G	-	P	G	P
MAY	P	E	E	P	G	-	P	G	P	P	P
JUN	P	E	G	E	P	P	P	P	P	P	G
JUL	G	G	E	G	P	P	-	G	P	G	-
AUG	G	G	G	G	P	P	P	G	P	P	-
SEP	E	G	G	P	P	P	G	P	G	P	-
OCT	G	P	E	G	P	P	P	G	P	P	-
NOV	E	G	P	G	P	P	G	P	P	G	-
DEC	G	G	P	E	P	P	G	G	G	P	-
Annual	P	P	P	P	P	P	P	P	P	P	P

3.5.1. Section D – Southern Beaches

A.4.1. Reunion

- **Seasonal Trends**

The ranking of seasonal averages for E.coli and Enterococcus are shown in Tables A-125 and A-126 respectively.

Autumn is shown to produce the highest average of E.coli most frequently, though not consistently. Spring yielded the second highest every year from 2010 to 2013. There are no definitive patterns based on E.coli.

Table A-125: Reunion – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**967 (1)**	553 (2)	**2050 (1)**	46.7 (4)	**133.3 (1)**	**1000 (1)**	33.3 (4)	50.3 (3)	101 (3)	**466 (1)**	**270 (1)**
Winter	0.00 (4)	**2187 (1)**	73.3 (3)	113 (3)	20.0 (4)	112 (4)	63.3 (2)	48.6 (4)	157 (2)	108 (3)	41.1 (3)
Spring	227 (2)	180 (3)	160 (2)	**1027 (1)**	73.3 (2)	200 (2)	55.3 (3)	54.7 (2)	157 (2)	292 (2)	95.0 (2)
Summer	147 (3)	70.0 (4)	10.0 (4)	160 (2)	60.0 (3)	190 (3)	**136 (1)**	**158 (1)**	**810 (1)**	55.0 (4)	8.30 (4)

As with E.coli, autumn yielded the highest average concentrations of Enterococcus most often. The season which yielded the highest average each year corresponded to that of E.coli consistently from 2003 to 2008.

Table A-126: Reunion – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**366 (1)**	280 (2)	**409 (1)**	60.0 (3)	**553 (1)**	**420 (1)**	50.0 (4)	**171 (1)**	76.1 (4)	157 (2)	**201 (1)**
Winter	13.3 (3)	**626 (1)**	160 (2)	33.3 (4)	40.0 (3)	186 (2)	**1668 (1)**	46.6 (4)	751 (2)	95.0 (3)	70.0 (2)
Spring	46.7 (2)	273 (3)	50.0 (3)	**313 (1)**	73.3 (2)	138 (4)	122 (3)	51.2 (3)	90.9 (3)	**324 (1)**	-
Summer	46.7 (2)	30.0 (4)	0.00 (4)	140 (2)	33.3 (4)	149 (3)	210 (2)	125 (2)	**961 (1)**	35.4 (4)	-

- **Annual Trends**

The annual averages and standards deviations for E.coli and Enterococcus are depicted in Figures A-94 and A-95 respectively. The average counts of E.coli vary somewhat with random increases and decreases evident throughout the study. At the end of the study the average is less than half if that at the start. Significantly large standard deviations are associated with the larger averages. This highlights the variable nature of E.coli at Reunion beach.

Generally the average concentration of Enterococcus has remained consistent. Levels remained below 200CFU/100ml except in 2009 and 2011. A peak in Enterococcus levels is evident in 2011. The average in 2011 is nearly seven times greater than the lowest average in the previous year. The standard deviations were not found to be extremely large with exception to 2009 and 2009. Significantly large standard deviations show that the data set for Enterococcus during those years was spread over a large range.

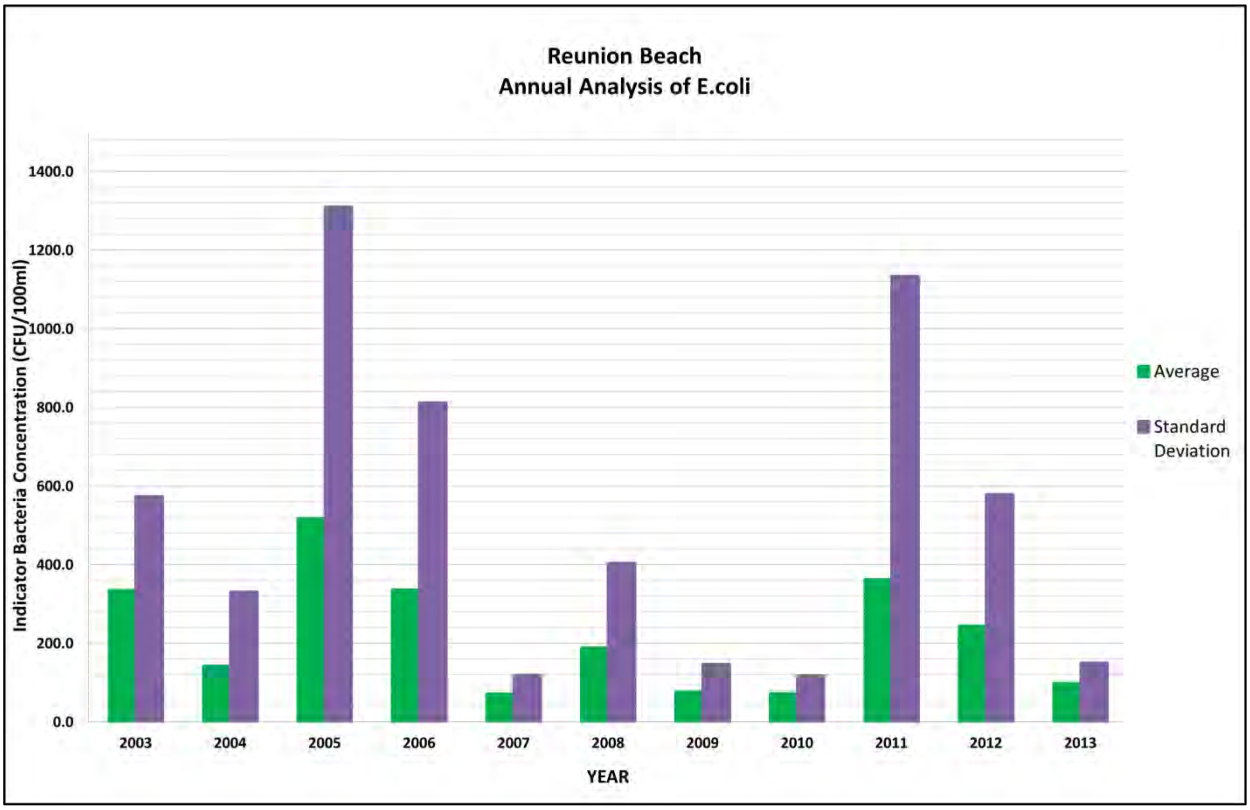


Figure A-94: Annual Analysis of E.coli at Reunion Beach

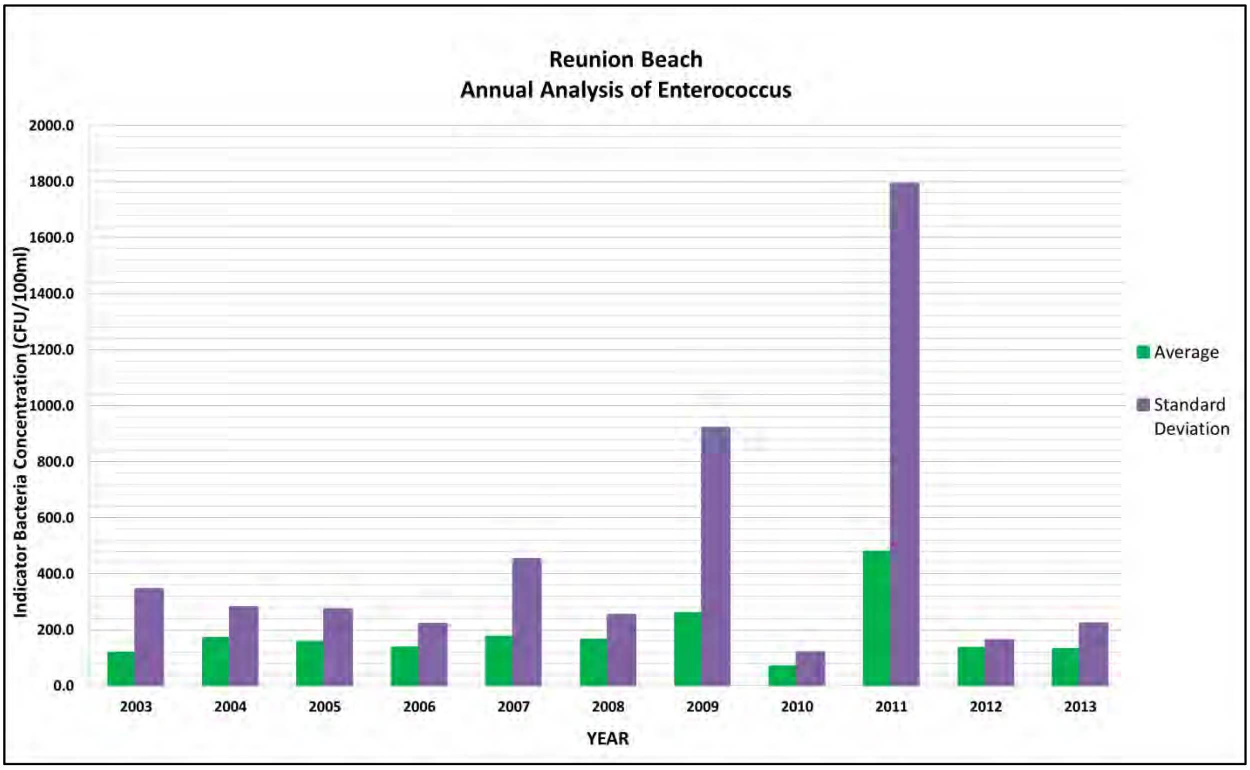


Figure A-95: Annual Analysis of Enterococcus at Reunion Beach

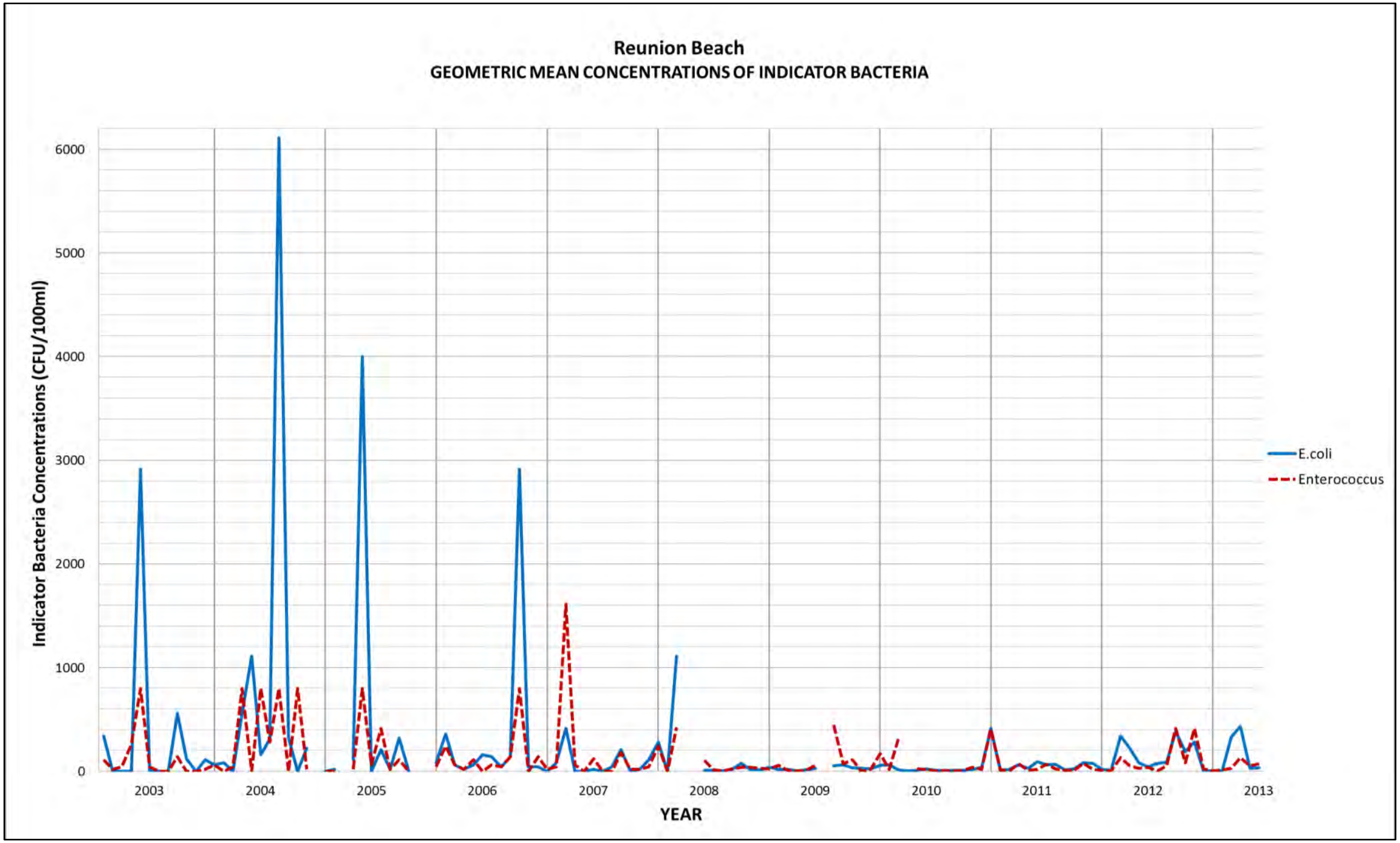


Figure A-96: Reunion – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric mean concentrations of the two indicator bacteria at Reunion are compared in Figure A-96. E.coli levels vary from extremely high to extremely low each month throughout the first half of the study period, becoming more consistent in the second half. The geometric mean concentration of E.coli often exceeded 1000CFU/100ml during the first half of the study period. Enterococcus also varies in the first half of the study period, though not as greatly as E.coli. Towards the end of the study both bacteria rarely exceed 200CFU/100ml and mirror each other.

- **SAWQ Guidelines**

Table A-127 shows the rating of the E.coli levels at Reunion beach for each month over the study period. Poor water quality conditions have been experienced on several occasions, resulting in poor annual ratings for approximately half of the study period. The last two year of the study have received a good overall rating.

Table A-127: Reunion – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	E	E	E	E	G	G	G	P	G	E
FEB	E	E	E	G	E	E	G	G	E	G	E
MAR	E	E	-	E	G	P	E	E	E	P	G
APR	E	P	E	E	E	-	E	E	G	G	G
MAY	P	P	P	E	E	-	E	E	G	G	E
JUN	E	E	E	E	E	P	E	G	G	G	E
JUL	E	G	E	E	E	G	-	E	P	E	E
AUG	E	P	E	E	E	E	E	E	G	E	E
SEP	P	G	G	E	E	E	E	E	E	G	E
OCT	E	E	E	P	E	P	E	E	G	E	G
NOV	-	E	-	E	E	G	E	E	P	G	E
DEC	-	-	-	E	E	P	G	G	P	E	E
Annual	P	P	P	P	G	P	E	G	P	G	G

The microbiological water quality rating for Enterococcus is shown in Table A-128. Reunion beach‟s waters have experienced poor microbiological quality for the duration of the study. Annually the rating has been poor every year except for 2013. Lack of data for the second of half of 2013 influences this outcome; however, it may be possible that the overall annual rating for this year follows the same trend as the previous years. A clear deterioration in microbiological water quality each month is evident from 2008, with the frequency of poor water quality conditions is shown to be extremely high during the second half of the study.

Table A-128: Reunion – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	P	P	P	P	P	E
FEB	E	E	E	P	E	E	P	P	G	E	G
MAR	E	E	-	E	P	P	E	P	E	P	P
APR	P	P	E	E	E	-	E	-	P	P	G
MAY	P	E	P	E	E	-	P	G	P	P	G
JUN	E	P	E	E	G	P	G	P	P	P	E
JUL	E	P	P	E	E	P	-	E	P	E	-
AUG	E	P	E	E	E	E	P	E	P	P	-
SEP	G	E	E	G	G	P	E	E	E	P	-
OCT	E	P	E	G	E	P	P	G	E	P	-
NOV	E	E	-	E	E	P	E	G	P	P	-
DEC	E	-	-	G	E	P	G	G	E	E	-
Annual	P	P	P	P	P	P	P	P	P	P	G

A.4.2. Isipingo

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-129. The highest average levels of E.coli were found to occur in summer and autumn most often, however, not consistently. No clear seasonal trends are observed at Isipingo beach based on E.coli concentrations.

Table A-129: Isipingo – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**247 (1)**	53.3 (3)	**350 (1)**	53.3 (2)	20.0 (2)	**360 (1)**	42.2 (4)	28.3 (4)	243 (4)	231 (3)	**211 (1)**
Winter	0.00 (4)	**1133 (1)**	6.70 (4)	33.3 (3)	20.0 (2)	75.3 (4)	76.7 (2)	50.3 (3)	150 (3)	140 (4)	16.7 (4)
Spring	6.70 (3)	167 (2)	160 (2)	**446 (1)**	0.00 (3)	81.1 (3)	**86.7 (1)**	65.6 (2)	463 (2)	286 (2)	126 (2)
Summer	13.3 (2)	0.00 (4)	60.0 (3)	20.0 (4)	**93.3 (1)**	136 (2)	72.1 (3)	**113 (1)**	**796 (1)**	**354 (1)**	101 (3)

Table A-130 shows the ranking of seasonal averages for Enterococcus. Summer yielded the highest average most frequently. There are no notable seasonal trends based on the presence of Enterococcus and there is no correlation with E.coli.

Table A-130: Isipingo – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**273 (1)**	26.7 (4)	10.0 (2)	113 (2)	80.0 (2)	**300 (1)**	104 (2)	138 (2)	100 (3)	150 (3)	**85.0 (1)**
Winter	0.00 (3)	**266 (1)**	6.70 (3)	26.7 (4)	20.0 (4)	210 (2)	68.3 (3)	50.0 (4)	356 (2)	166 (2)	-
Spring	187 (2)	146 (2)	10.0 (2)	**306 (1)**	**147 (1)**	95.4 (3)	63.0 (4)	60.0 (3)	66.4 (4)	**193 (1)**	-
Summer	0.00 (3)	60.0 (3)	**170 (1)**	33.3 (3)	40.0 (3)	78.7 (4)	**122 (1)**	**156 (1)**	**1118 (1)**	44.8 (4)	-

- **Annual Trends**

The annual averages and standard deviations of E.coli for Isipingo beach are depicted in Figure A-97. Average concentrations have varied slightly over the course of the study period. A significant dip in E.coli is evident from 2007 to 2010. Thereafter the averages peaked up again. Large standard deviations are clear in many cases and also linked with greater averages, emphasizing the variable behaviour of this bacterium. The largest average noted in 2011 is partnered with the most pronounced deviation.

Figure A-98 shows the annual averages and standard deviations of Enterococcus. On average Enterococcus has remained consistently below 200 counts/100ml with exception to 2011. In 2011 the average is more than five times that of the lowest. The deviations have also been consistent with he averages, however, deviations in 2011 oppose this trend. As with E.coli, the largest average as well as deviation occurred in 2011.

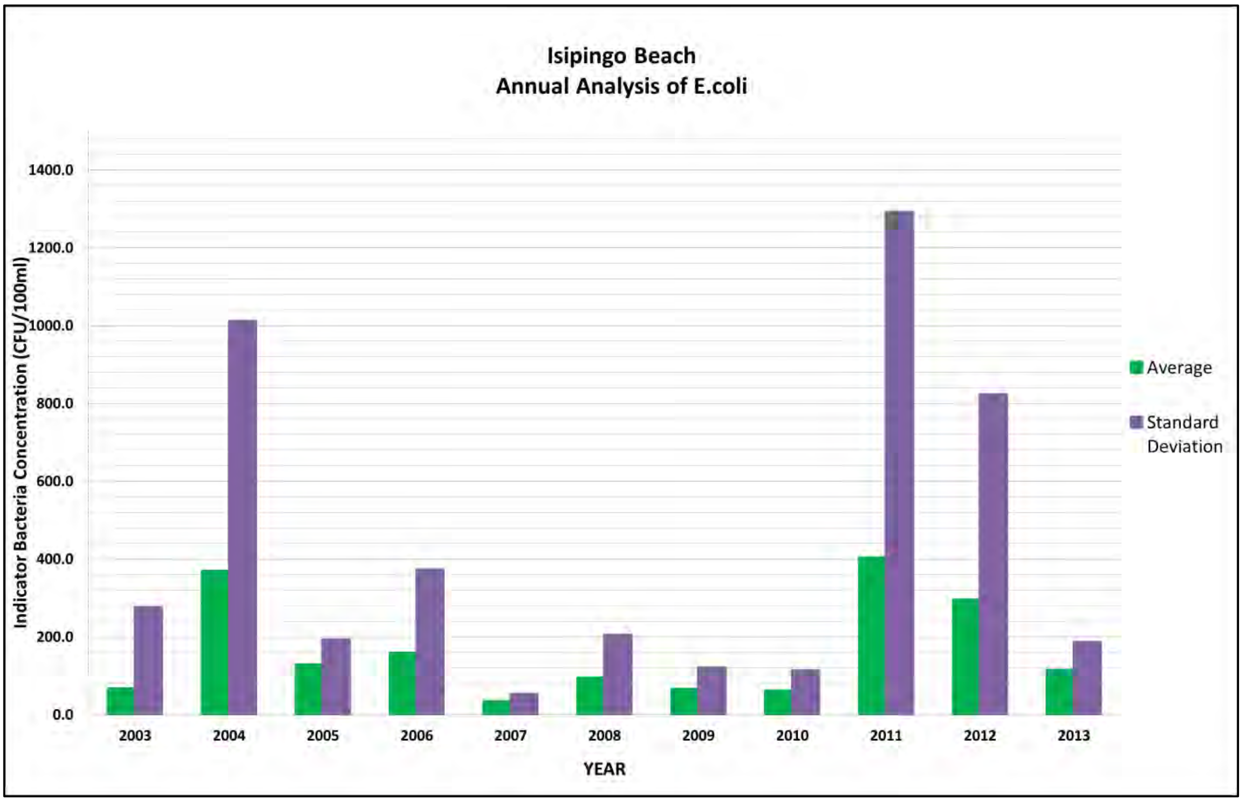


Figure A-97: Annual Analysis of E.coli at Isipingo Beach

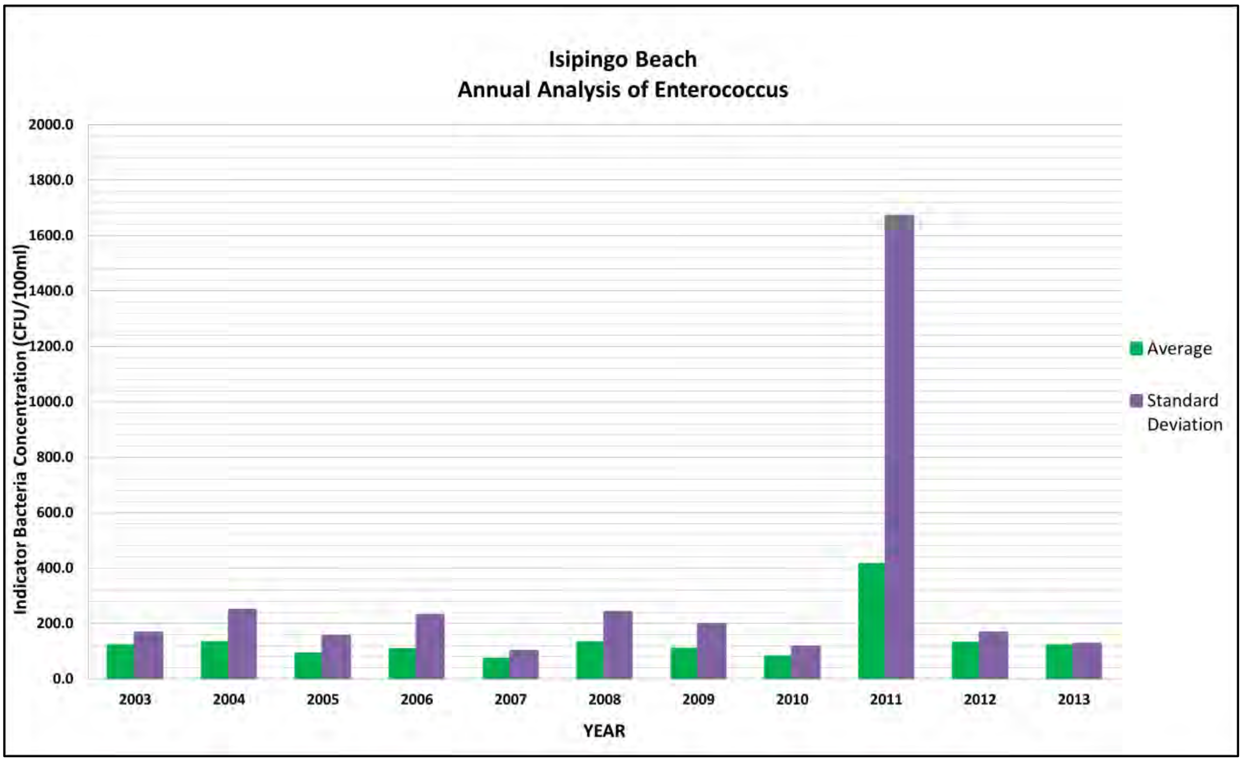


Figure A-98: Annual Analysis of Enterococcus at Isipingo Beach

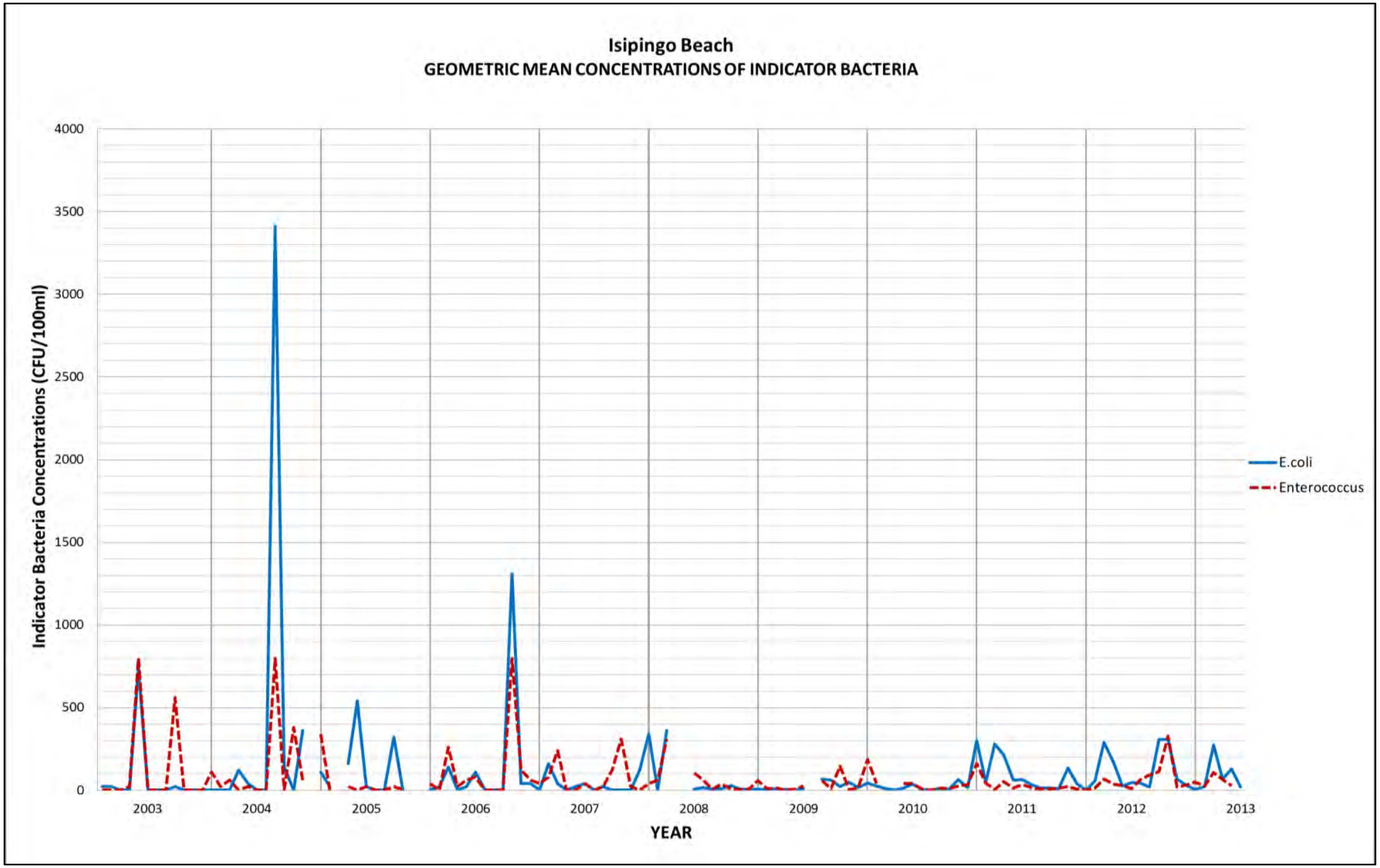


Figure A-99: Isipingo – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-99 illustrates the geometric mean concentrations of E.coli and Enterococcus at Isipingo beach. During the first half of the study E.coli is shown to vary from high to low each month. Enterococcus also varied in the first half of the study period, though not as greatly as E.coli. Towards the end of the study both bacteria appear more stable and rarely exceed 300CFU/100ml. Although the geometric mean concentrations differ for both indicators, they are shown to fluctuate in unison.

- **SAWQ Guidelines**

Tables A-131 and A-132 show the microbiological water quality ratings based on E.coli and Enterococcus respectively.

Table A-131: Isipingo – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	G	G	G	P	E	E
FEB	E	E	E	E	E	E	G	E	G	G	P
MAR	E	E	-	E	E	G	E	E	G	G	G
APR	E	E	E	E	E	-	E	E	G	G	G
MAY	P	E	P	E	E	-	E	E	P	G	E
JUN	E	E	E	E	E	E	E	G	P	G	E
JUL	E	E	E	E	E	G	-	E	P	E	E
AUG	E	P	E	E	E	E	E	E	P	G	E
SEP	E	E	G	E	E	E	E	E	E	G	E
OCT	E	E	E	P	E	G	G	E	E	G	P
NOV	E	G	-	E	E	E	E	G	P	G	E
DEC	E	-	-	E	E	G	E	G	E	E	E
Annual	G	G	G	G	E	G	G	G	P	G	G

Isipingo beach has an annual rating good throughout most of the study. Incidences of poor water quality are shown to be infrequent during the early years of the study. In 2011, however, a significant occurrence of poor water quality is evident with more than half of the year receiving a poor rating.

Based on Enterococcus concentrations the water quality at Isipingo beach has deteriorated from an annual rating of good to poor. During the first half of the study poor water quality conditions occurred randomly and infrequently. From 2008 the frequency of poor water quality increased drastically. Water quality was classified as poor for at least half of each year from 2008 onward, resulting in the annual water quality rating being consistently poor for consecutive six years.

Table A-132: Isipingo – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	P	E	E	E	P	P	P	E	E
FEB	E	E	E	E	E	E	P	P	P	P	P
MAR	E	E	-	P	P	P	P	P	G	P	P
APR	E	E	E	E	E	-	P	-	P	P	G
MAY	P	E	E	E	E	-	P	P	P	P	E
JUN	E	E	E	E	E	P	P	P	P	P	P
JUL	E	E	E	E	E	P	-	E	P	P	-
AUG	E	P	E	E	E	E	E	E	P	P	-
SEP	P	E	E	E	G	P	E	E	E	P	-
OCT	E	P	E	P	P	G	P	G	G	P	-
NOV	E	E	-	G	E	P	E	P	P	E	-
DEC	E	-	-	E	E	P	G	P	E	E	-
Annual	G	G	G	G	G	P	P	P	P	P	P

A.4.3. Dakota (Umbogintwini)

Sample data for both indicator bacteria at Dakota Beach was only provided for 2003 up to 2007.

- **Seasonal Trends**

Seasonal averages of E.coli at Dakota beach are ranked in Table A-133. It is clear that spring never yielded the highest average concentration of E.coli but is most often the second highest ranked. No clear seasonal trends are evident.

Table A-133: Dakota (Umbogintwini) – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007
Autumn	0.00 (2)	40.0 (3)	**433 (1)**	**220 (1)**	0.00 (4)
Winter	0.00 (2)	**166 (1)**	0.00 (4)	6.70 (4)	33.3 (2)
Spring	0.00 (2)	93.3 (2)	370 (2)	33.3 (2)	20.0 (3)
Summer	**26.7 (1)**	20.0 (4)	220 (3)	30.0 (3)	**233 (1)**

Table A-134 shows the ranking of seasonal averages for Enterococcus. Summer yielded the highest most frequently but not consistently. Winter is shown to be ranked consistently on the lower end. There is no correlation between E.coli and Enterococcus seasonal averages.

Table A-134: Dakota (Umbogintwini) – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007
Autumn	0.00 (4)	**33.3 (1)**	147 (2)	93.3 (2)	110 (2)
Winter	13.3 (3)	0.00 (3)	0.00 (4)	33.3 (3)	46.7 (4)
Spring	60.0 (2)	20.0 (2)	50.0 (3)	6.70 (4)	**300 (1)**
Summer	**93.3 (1)**	0.00 (3)	**230 (1)**	**100 (1)**	60.0 (3)

- **Annual Trends**

The annual analysis for E.coli is summarised in Figure A-100. A clear increase in the average concentration of E.coli is noticeable at Dakota beach. The largest average in 2005 is more than 40 times that of the lowest at the start of the study in 2003. The standard deviations are also significantly large in many cases.

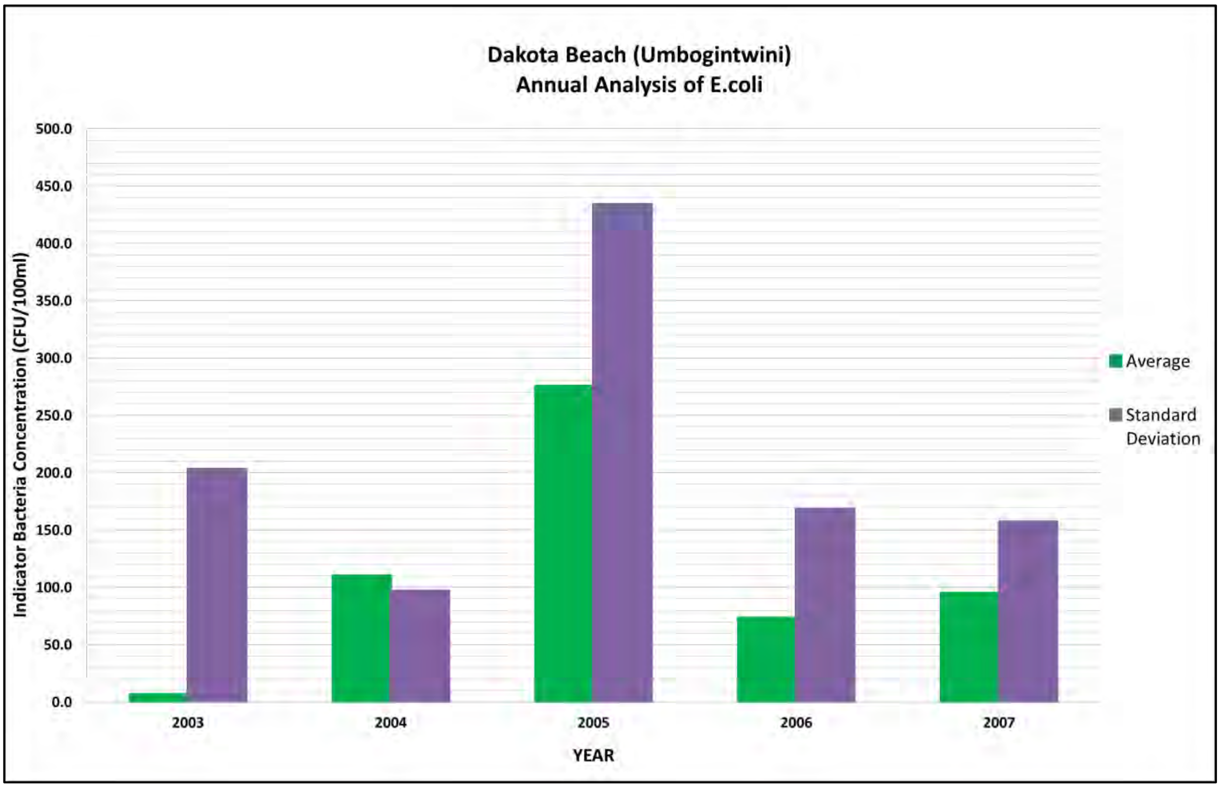


Figure A-100: Annual Analysis of E.coli at Dakota (Umbogintwini) Beach

Figure A-101 depicts the annual averages and standard deviations for Enterococcus. Concentrations have varied slightly with levels of Enterococcus in 2007 being approximately than 3 times higher than in 2003. Deviations were not large with exception to 2003. This shows less variability in Enterococcus concentrations.

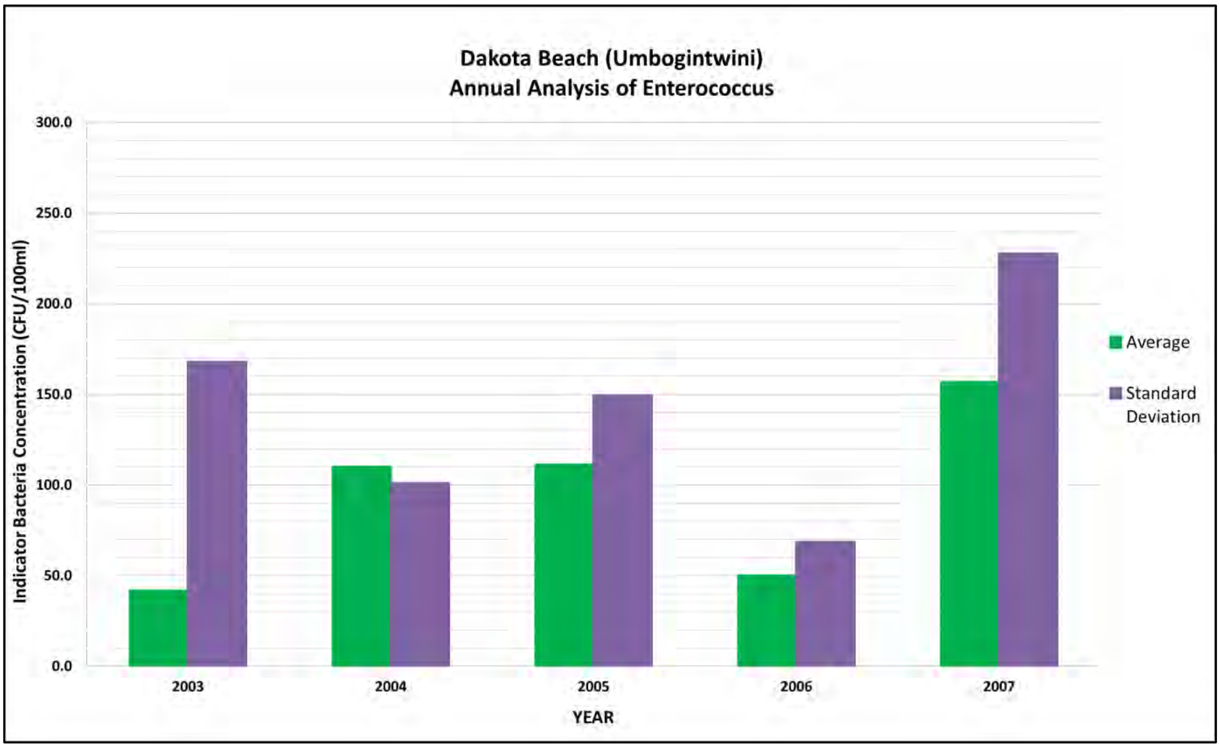


Figure A-101: Annual Analysis of Enterococcus at Dakota (Umbogintwini) Beach

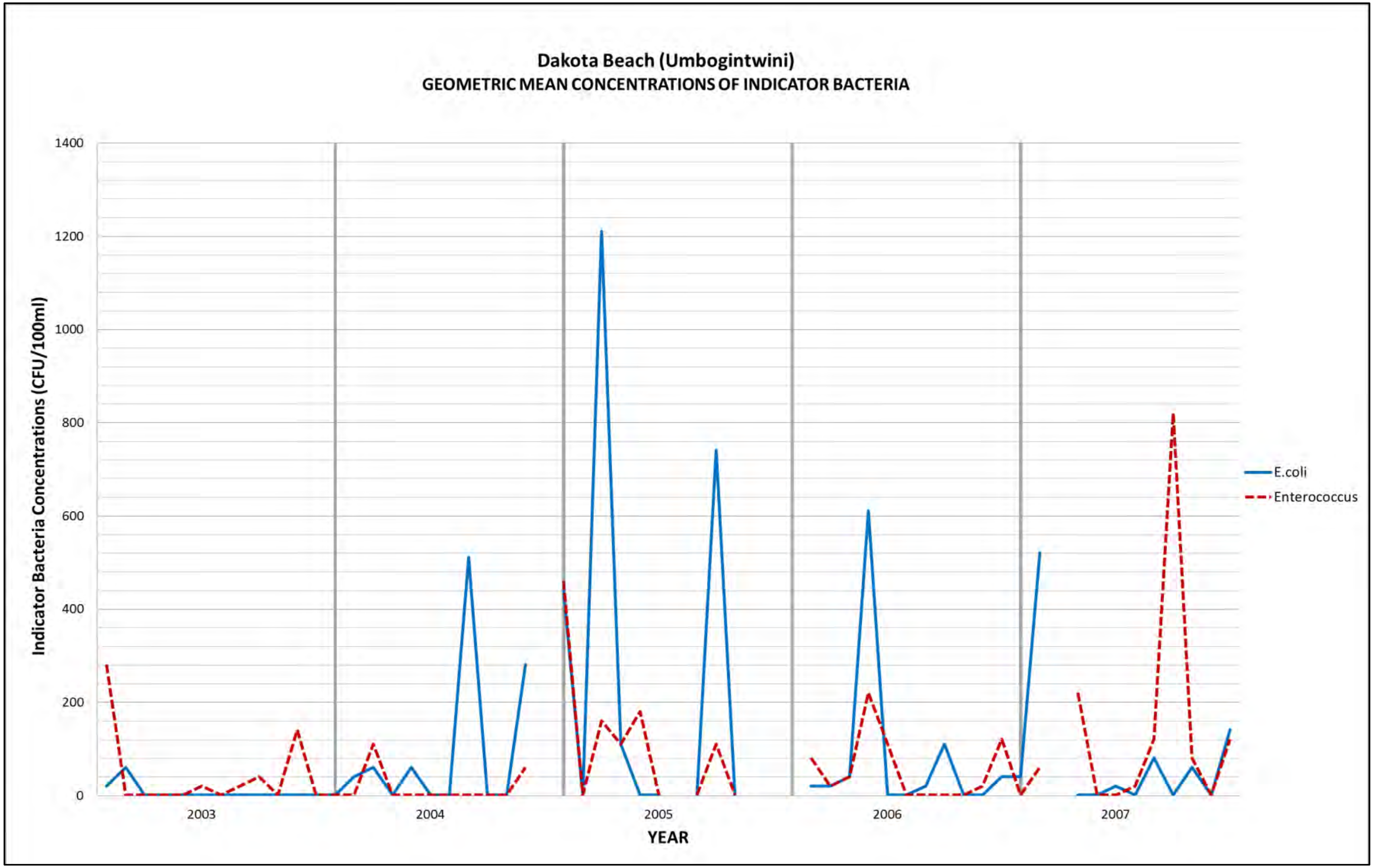


Figure A-102: Dakota (Umbogintwini) – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of the two indicator bacteria are illustrated in Figure A-102. Although both bacteria are variable, E.coli is shown to be more variable than Enterococcus.

- **SAWQ Guidelines**

Table A-135 shows that the quality of Dakota‟s waters has been mostly good based on E.coli concentrations. Generally an overall good rating has been maintained at Dakota beach based on the presence of E.coli. Incidences of poor water quality have been infrequent up to 2007.

Table A-135: Dakota (Umbogintwini) – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007
JAN	E	E	G	P	E
FEB	E	E	E	E	P
MAR	E	E	G	E	P
APR	E	E	E	E	E
MAY	E	E	E	P	E
JUN	E	E	E	E	E
JUL	E	E	G	E	E
AUG	E	G	E	E	E
SEP	E	E	P	E	E
OCT	E	E	E	E	E
NOV	E	G	-	E	E
DEC	E	-	-	E	E
Annual	E	G	G	G	G

Table A-136 summarises the microbiological rating of the waters at Dakota based on Enterococcus concentrations. Annually the water quality has been rated as poor every alternate year. Incidences of poor water quality have been random from 2003 to 2007.

Table A-136: Dakota (Umbogintwini) – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007
JAN	P	E	P	P	E
FEB	E	E	E	E	E
MAR	E	E	-	E	P
APR	E	E	E	E	P
MAY	E	E	G	P	E
JUN	E	E	E	E	E
JUL	E	E	P	E	E
AUG	E	E	E	E	G
SEP	E	E	E	E	P
OCT	E	E	E	E	E
NOV	G	E	-	E	E
DEC	E	-	-	G	G
Annual	P	E	P	G	P

A.4.4. Amanzimtoti Pipeline

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-137. The highest average counts of this bacterium were experienced in autumn most often. From 2007 this occurred every alternate year.

Table A-137: Amanzimtoti Pipeline – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (2)	**1380 (1)**	73.3 (2)	0.00 (3)	**230 (1)**	160 (2)	**48.9 (1)**	21.0 (3)	**393 (1)**	90.7 (2)	**231 (1)**
Winter	0.00 (2)	0.00 (3)	**90.0 (1)**	0.00 (3)	6.70 (3)	**249 (1)**	8.00 (3)	15.6 (4)	100 (3)	86.3 (3)	181 (2)
Spring	**20.0 (1)**	0.00 (3)	0.00 (3)	**40.0 (1)**	6.70 (3)	94.0 (3)	8.00 (3)	41.3 (2)	28.4 (4)	**210 (1)**	76.7 (3)
Summer	0.00 (2)	10.0 (2)	0.00 (3)	13.3 (2)	40.0 (2)	6.70 (4)	25.4 (3)	**86.4 (1)**	120 (2)	70.6 (4)	66.7 (4)

The seasonal averages for Enterococcus are ranked in Table A-138. It is shown that autumn and winter yielded the highest average counts of Enterococcus most often, however there is no consistency. There is no direct relationship between the two indicators.

Table A-138: Amanzimtoti Pipeline – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	13.3 (2)	86.7 (2)	**280 (1)**	**146 (1)**	**300 (1)**	180 (2)	31.1 (2)	10.0 (4)	108 (2)	53.8 (3)	**101 (1)**
Winter	**60.0 (1)**	**233 (1)**	20.0 (3)	86.7 (2)	226 (2)	**185 (1)**	6.70 (4)	40.2 (3)	**409 (1)**	31.3 (4)	-
Spring	13.3 (2)	20.0 (4)	173 (2)	**146 (1)**	33.3 (4)	74.4 (3)	19.3 (3)	**134 (1)**	27.7 (4)	**132 (1)**	-
Summer	13.3 (2)	40.0 (3)	0.00 (4)	46.7 (3)	66.7 (3)	2.70 (4)	**64.0 (1)**	90.8 (2)	47.2 (3)	88.2 (2)	-

- **Annual Trends**

Figures A-103 and A-104 depict the annual analysis for E.coli and Enterococcus respectively. Average concentrations have varied slightly but remained below 200 counts/100ml except in 2004. The largest average is clear in 2004 with the average count increasing more than 75 times that of the previous year. Generally the last 3 years of the study show that the average count is approximately 30 times that of 2003. The standard deviations were found to be significant on many occasions, indicating that concentrations of E.coli varied from the average throughout the years. Larger averages are linked to larger deviations, thus confirming the unpredictable nature of E.coli.

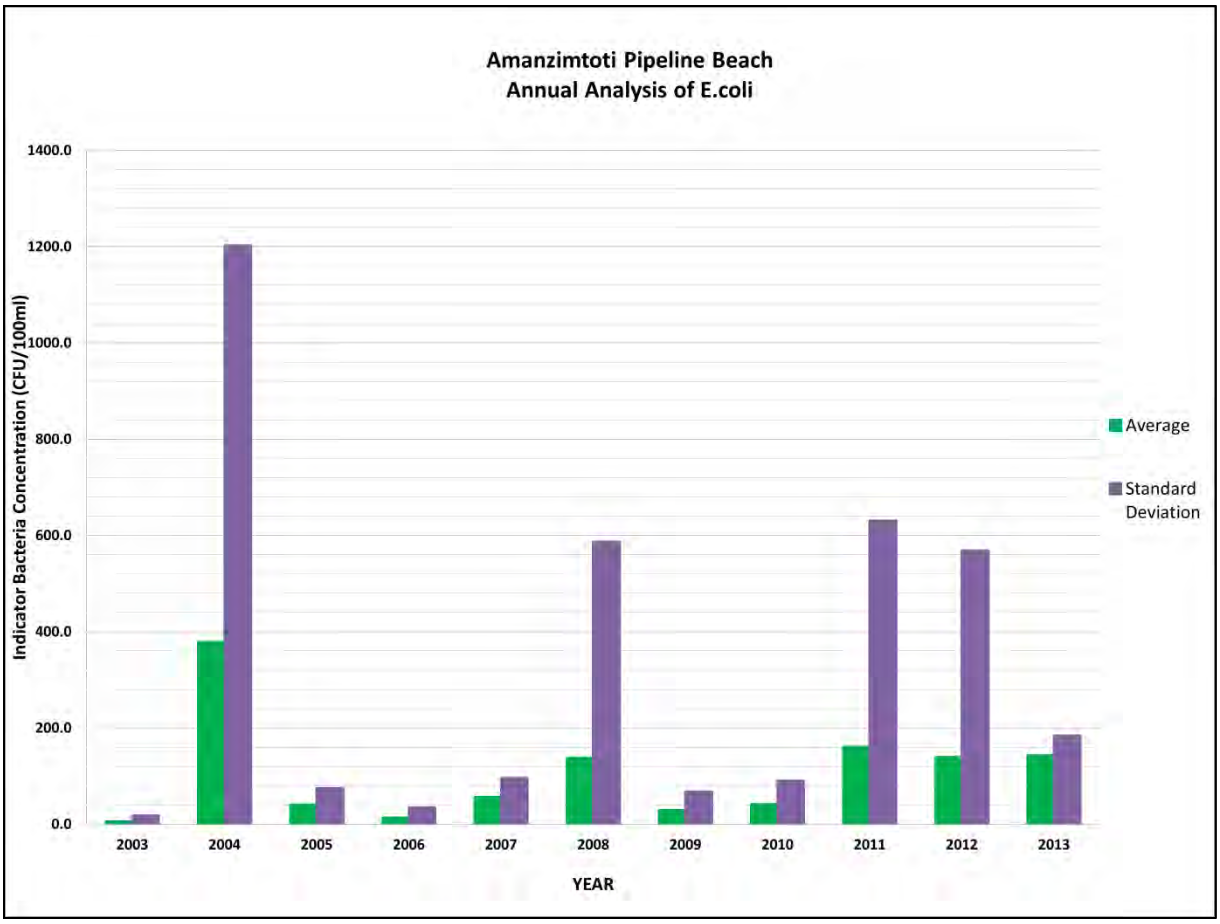


Figure A-103: Annual Analysis of E.coli at Amanzimtoti Pipeline Beach

Average concentrations of have increased since the initial year of the study and have remained consistently between 100 and 150CFU/100ml throughout most of the study. Ultimately the average concentration at the end of the study is more than 20 times that at the beginning.

Large deviations were experienced throughout most of the study but exceptionally large deviations are noted in 2011 and 2012. The data set for Enterococcus is spread over a significantly large range for most of the study.

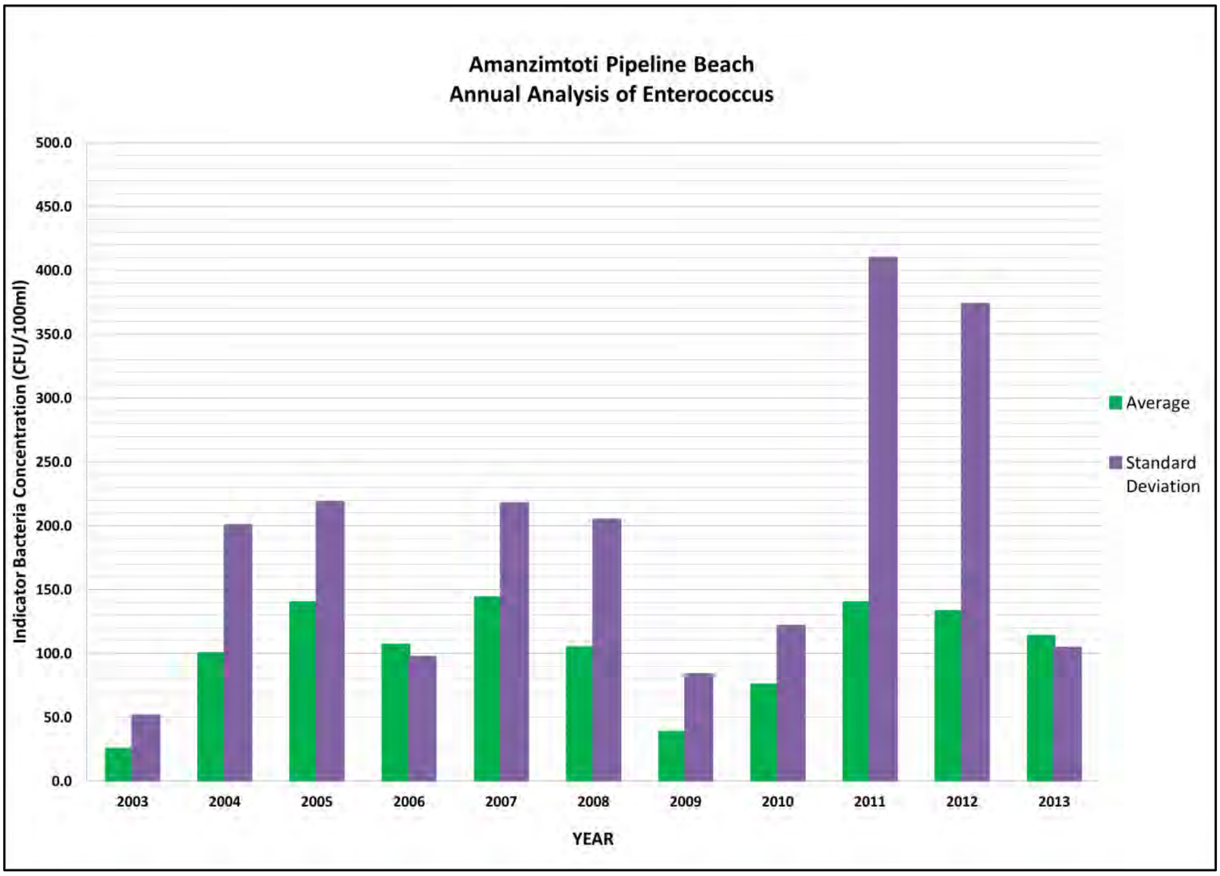


Figure A-104: Annual Analysis of Enterococcus at Amanzimtoti Pipeline Beach

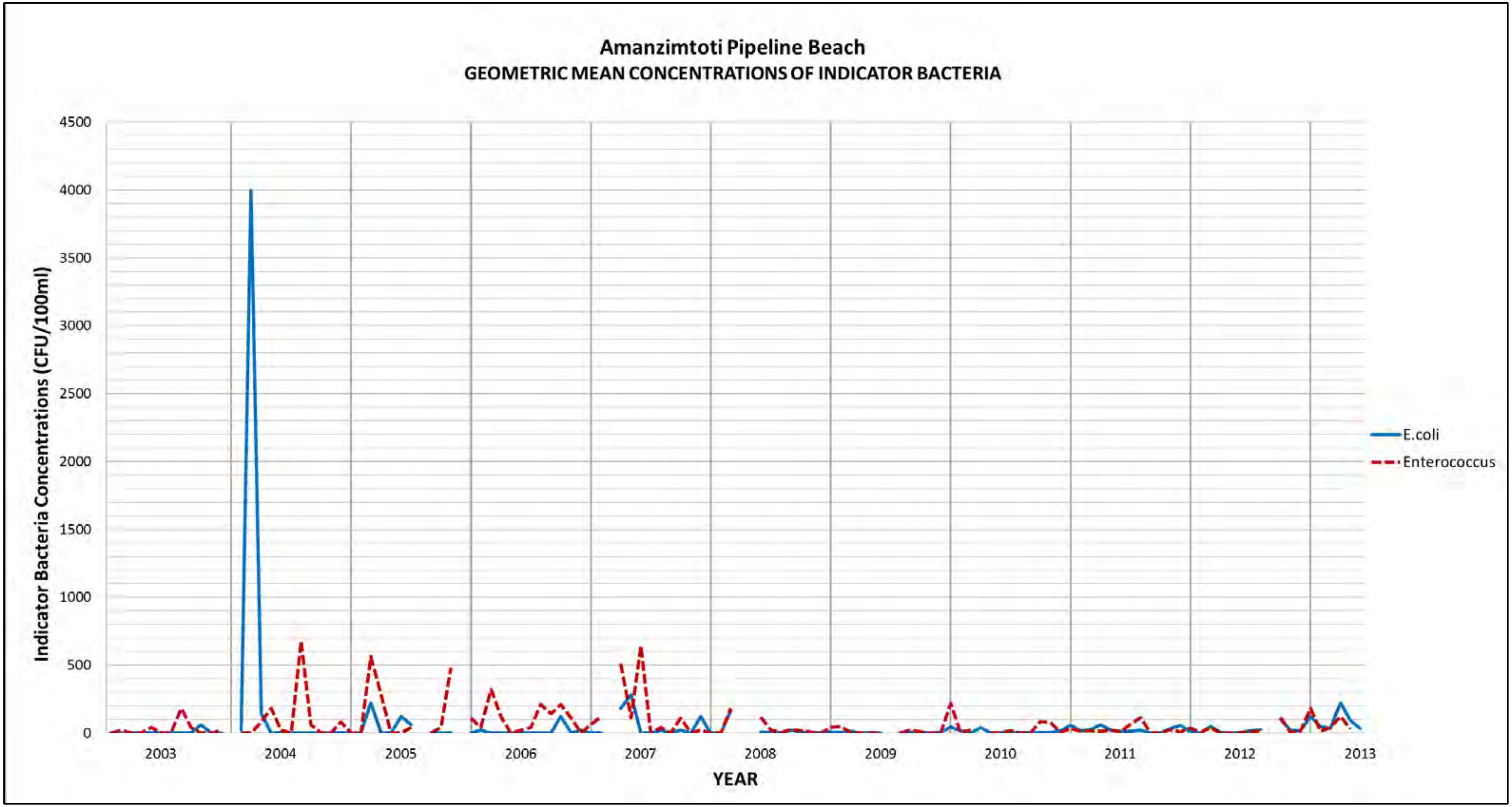


Figure A-105: Amanzimtoti Pipeline – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-105 illustrates the geometric mean concentrations of the indicator bacteria at Amanzimtoti Pipeline. During the first half of the study Enterococcus exceeded E.coli. The geometric means of both bacteria remained below 200CFU/100ml in most cases, especially during the latter half of the study period. E.coli peaked significant in 2004 with counts reaching 4000/100ml. This correlates to the high average noted in Figure A-108. During the second half both indicators follow the same pattern closely.

- **SAWQ Guidelines**

The microbiological water quality rating for E.coli is shown in Table A-139. Overall annual rating of the beach waters at Amanzimtoti Pipeline have been split between good and excellent. A few random occurrences of poor water quality are evident in the latter years.

Table A-139: Amanzimtoti Pipeline – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	-	E	E	E	E	E	G	G	E	E
FEB	E	E	E	E	E	E	E	E	G	E	E
MAR	E	P	E	E	-	E	E	E	E	P	E
APR	E	E	E	E	E	-	E	E	P	E	G
MAY	E	E	E	E	G	-	G	E	P	E	P
JUN	E	E	E	E	E	P	E	E	E	G	E
JUL	E	E	E	E	E	E	-	E	G	G	G
AUG	E	E	-	E	E	E	E	E	G	E	E
SEP	E	E	E	E	E	G	E	E	E	P	E
OCT	E	E	E	E	E	G	E	G	E	G	E
NOV	E	E	E	E	E	E	E	E	E	G	G
DEC	E	E	-	E	E	E	E	G	G	G	E
Annual	E	G	E	E	E	G	E	E	G	G	G

Table A-140 depicts the microbiological water quality rating for Enterococcus. The overall annual rating has been mostly poor. The last four years of the study have consistently been rated poor annually with at least a quarter of each of those years experiencing poor water quality. From 2005 onward poor water quality conditions have occurred every year. Water quality is rated poor more frequently based on Enterococcus than E.coli.

Table A-140: Amanzimtoti Pipeline – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	-	E	E	E	E	P	P	G	P	P
FEB	E	E	E	E	G	E	G	E	G	G	G
MAR	E	E	P	P	-	G	P	E	P	P	G
APR	E	E	P	G	P	-	E	-	P	E	P
MAY	E	G	E	E	E	-	E	E	P	E	E
JUN	E	E	E	E	P	P	E	E	G	P	P
JUL	E	E	E	E	E	G	-	P	P	E	-
AUG	G	G	-	P	E	G	E	E	P	E	-
SEP	E	E	E	G	E	G	E	E	E	P	-
OCT	E	E	E	P	E	G	G	G	E	P	-
NOV	E	E	P	E	E	P	E	P	G	E	-
DEC	E	E	-	E	E	E	E	E	E	G	-
Annual	G	G	P	P	P	P	G	P	P	P	P

A.4.5. Amanzimtoti Main

- **Seasonal Trends**

The seasonal averages for E.coli and Enterococcus at Amanzimtoti Main beach are ranked in Tables A-141 and A-142 respectively. No clear patterns are evident as the season which produces the highest average concentration of E.coli varies each year.

Table A-141: Amanzimtoti Main – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	**13.3 (1)**	**1186 (1)**	0.00 (3)	22.2 (2)	16.7 (3)	93.3 (2)	**42.2 (1)**	5.00 (4)	108 (2)	124 (2)	**300 (1)**
Winter	6.70 (2)	0.00 (3)	0.00 (3)	11.1 (3)	65.6 (2)	**254 (1)**	3.30 (4)	18.3 (3)	**118 (1)**	97.0 (3)	115 (3)
Spring	**13.3 (1)**	0.00 (3)	2.20 (2)	5.60 (4)	**210 (1)**	66.1 (3)	9.70 (3)	37.4 (2)	19.7 (4)	**178 (1)**	161 (2)
Summer	0.00 (3)	10.0 (2)	**6.70 (1)**	**26.7 (1)**	16.7 (3)	39.1 (4)	28.2 (2)	**52.5 (1)**	53.6 (3)	22.2 (4)	105 (4)

As with E.coli, there are no clear trends evident based on Enterococcus at Amanzimtoti Main beach. There is also no correlation between the two bacteria.

Table A-142: Amanzimtoti Main – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	6.70 (2)	**150 (1)**	13.3 (2)	107 (2)	64.4 (3)	**413 (1)**	16.1 (4)	10.0 (4)	125 (2)	**490 (1)**	**70.0 (1)**
Winter	6.70 (2)	20.0 (3)	0.00 (4)	18.9 (4)	16.7 (4)	185 (3)	**358 (1)**	21.0 (3)	**280 (1)**	235 (2)	-
Spring	**147 (1)**	66.7 (2)	**30 (1)**	54.4 (3)	**350 (1)**	66.6 (4)	39.7 (2)	86.2 (2)	45.0 (3)	110 (3)	-
Summer	0.00 (3)	**150 (1)**	6.70 (3)	**122 (1)**	160 (2)	160 (2)	24.4 (3)	**154 (1)**	45.0 (3)	60.0 (4)	-

- **Annual Trends**

Figure A-106 shows the annual averages and standard deviations for E.coli. The average concentrations of E.coli have varied slightly. Averages increased and decreased variably during the first half of the study. From 2009 a constant but slight increase is clear. The average concentration of E.coli in 2013 increased more than 20 fold from 2003. The largest standard deviations are evident in 2004 and 2008, concentrations of E.coli varied significantly from the average during these years.

Enterococcus averages have remained consistent, fluctuating marginally throughout the study. The standard deviations were not prominent in most cases. However, larger deviations are noted in 2011 and 2012.

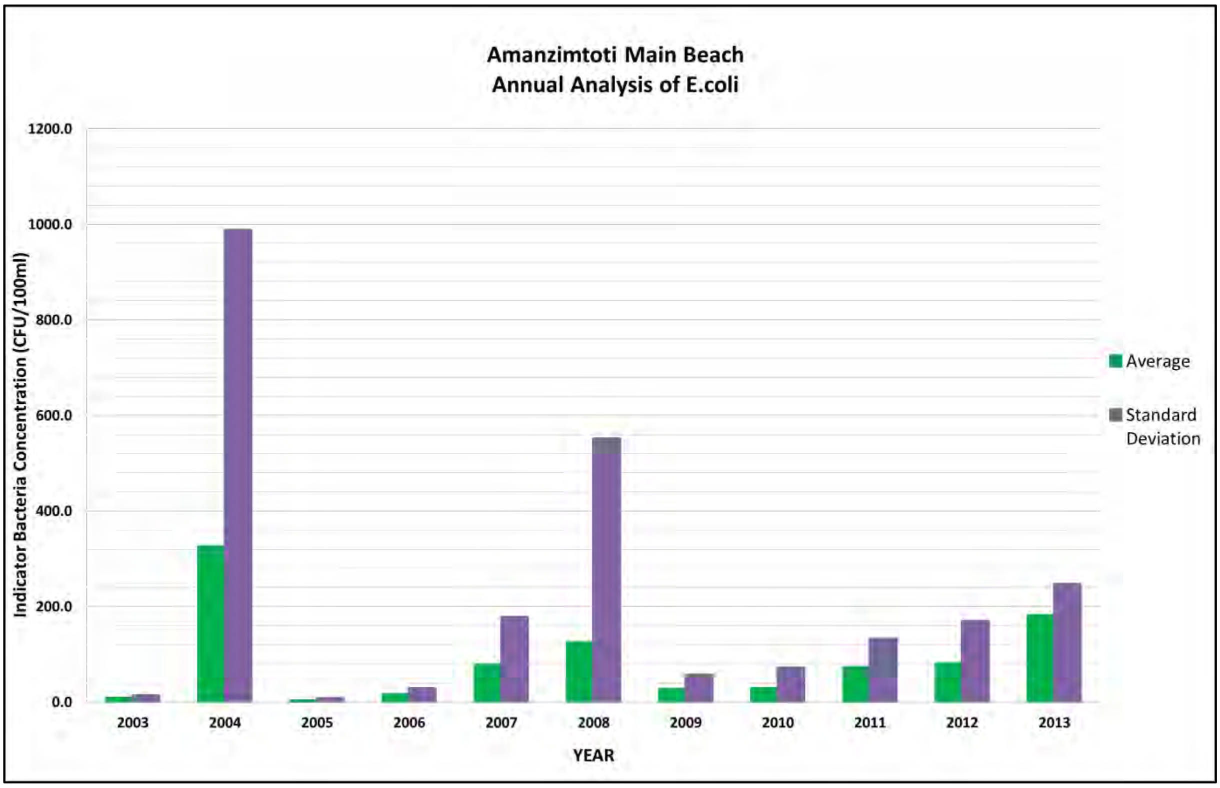


Figure A-106: Annual Analysis of E.coli at Amanzimtoti Main Beach

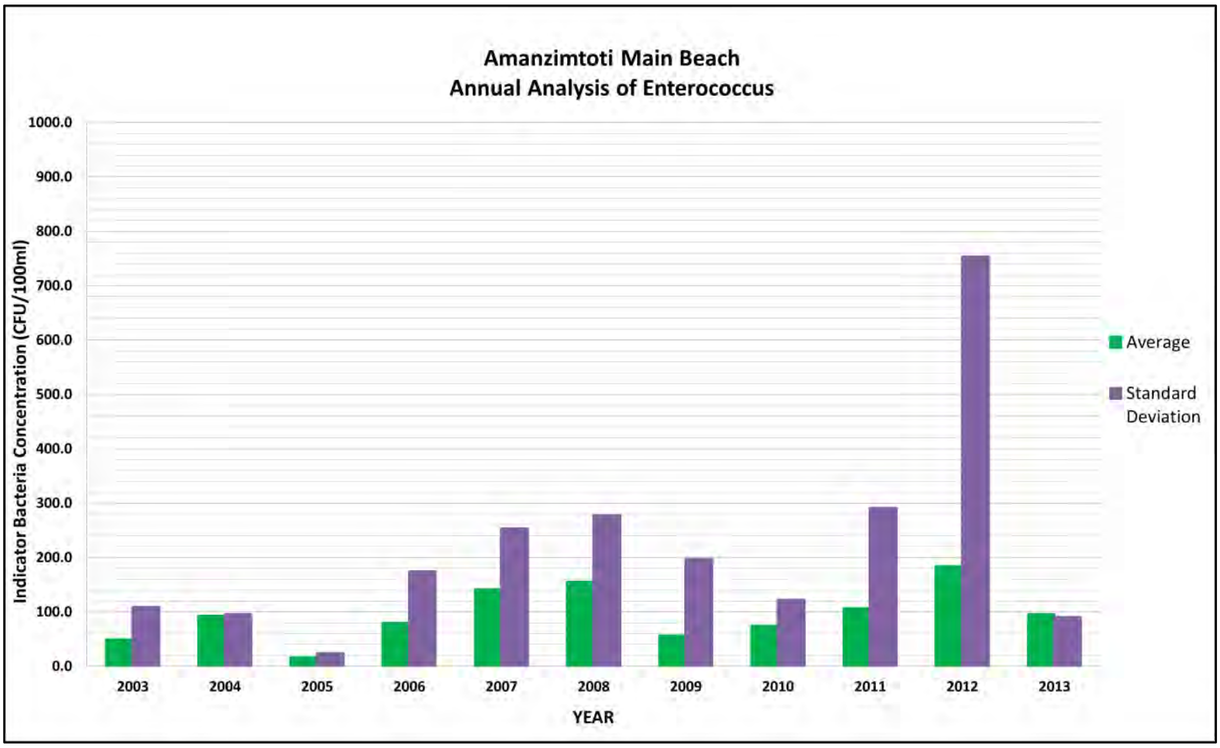


Figure A-107: Annual Analysis of Enterococcus at Amanzimtoti Main Beach

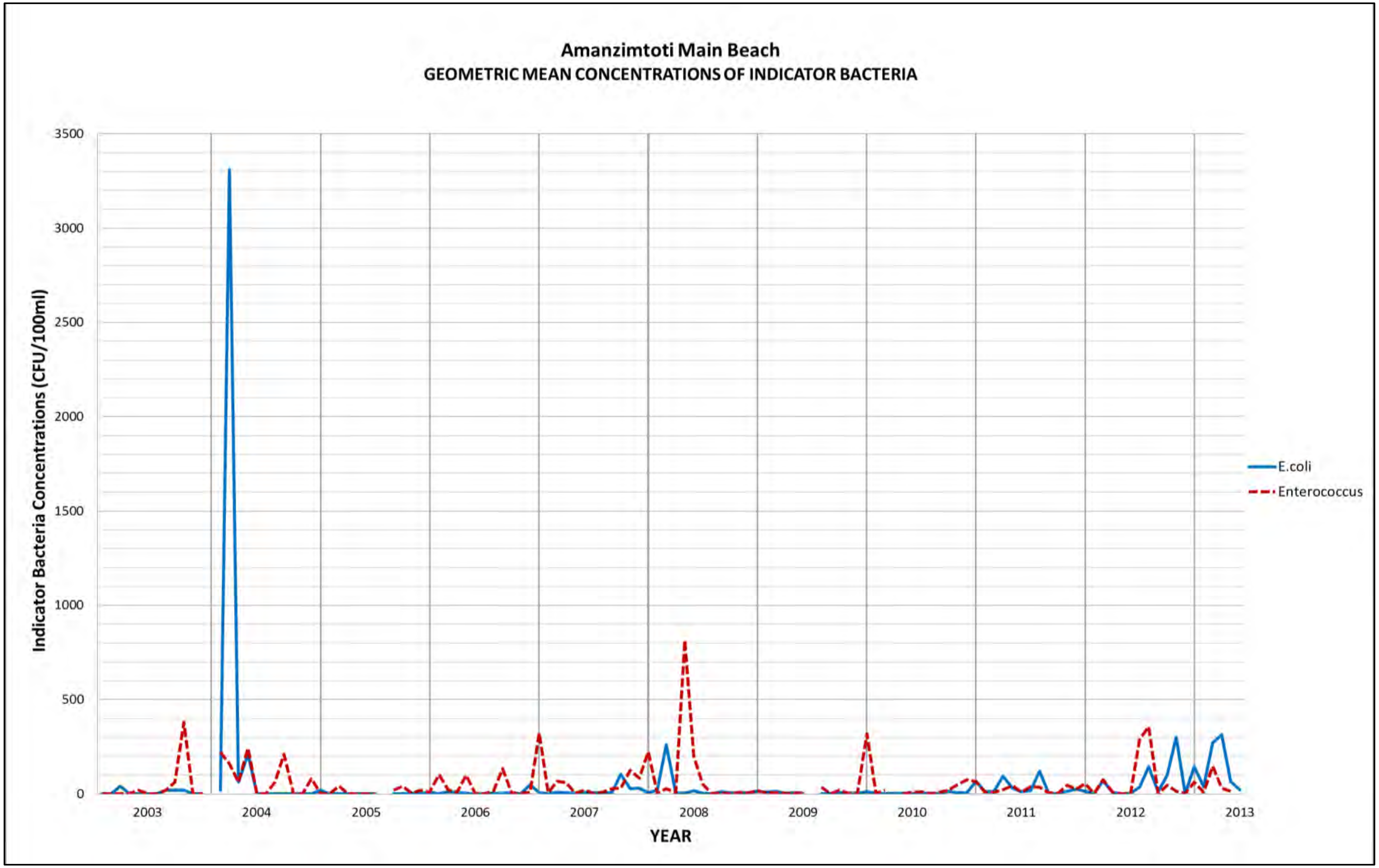


Figure A-108: Amanzimtoti Main – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

The geometric means of E.coli and Enterococcus are illustrated in Figure A-108. Enterococcus counts are shown to be greater than E.coli. E.coli peaked significant in 2004 with counts exceeding 3000/100ml. This correlates to the high average noted in Figure A-119. During the second half both indicators follow the same pattern closely.

- **SAWQ Guidelines**

Table A-143 shows the microbiological water quality rating for E.coli at Amanzimtoti Main beach. The annual ratings have been mostly good to excellent, with exception to the last year of the study. Occurrences of poor water quality become more frequent in the last two years of the study.

Table A-143: Amanzimtoti Main – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	-	E	E	E	E	E	G	E	E	G
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	G	E	E	E	G	E	E	E	P	P
APR	E	E	E	E	E	E	E	E	G	E	P
MAY	E	E	E	E	E	-	E	E	G	E	E
JUN	E	E	E	E	E	P	E	E	E	E	E
JUL	E	E	E	E	E	E	-	E	G	E	G
AUG	E	E	-	E	G	E	E	E	G	G	E
SEP	E	E	E	E	E	E	E	E	E	G	E
OCT	E	E	E	E	G	G	E	E	E	G	E
NOV	E	E	E	E	G	E	E	E	E	G	P
DEC	E	E	E	E	E	G	E	E	E	E	E
Annual	E	G	E	E	G	G	E	E	G	G	P

The microbiological water quality rating for Enterococcus is shown in Table A-144. Annually water quality has been classified as excellent only once. Generally the annual rating is shown to be split between good and poor. Incidences of poor ratings are evident throughout the entire study period. Many years experienced poor quality at least 4 months of the year. From 2010 to 2012 annual water quality has been consistently poor. In 2013, however, the rating is good. Lack of data for the second of half of 2013 influences this outcome. It is possible that the trend of poor water quality continued.

Table A-144: Amanzimtoti Main – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	-	E	E	P	P	E	P	G	G	E
FEB	E	P	E	P	E	E	G	E	E	G	E
MAR	E	G	E	P	G	P	E	E	G	P	G
APR	E	E	E	E	G	E	E	-	P	G	E
MAY	E	P	E	G	E	-	E	E	P	E	E
JUN	E	E	E	E	E	P	G	G	E	G	P
JUL	E	E	E	E	E	P	-	E	P	P	-
AUG	E	E	-	E	E	E	P	E	P	P	-
SEP	E	G	E	P	P	G	E	G	E	P	-
OCT	P	E	E	E	P	E	P	G	E	P	-
NOV	E	E	E	E	P	P	E	P	P	P	-
DEC	E	E	E	E	E	P	E	P	E	E	-
Annual	G	P	E	G	P	P	G	P	P	P	G

A.4.6. Warner

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-145. Although autumn and summer are shown to produce the highest average most often, the season which produced the highest average at Warner beach was not consistent over the course of the study. As such, no clear trends are evident.

Table A-145: Warner – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	**80.0 (1)**	6.70 (3)	**33.3 (1)**	**133 (1)**	0.00 (4)	60.0 (2)	26.0 (3)	117 (4)	84.7 (3)	**178 (1)**
Winter	20.0 (2)	13.3 (2)	13.3 (2)	0.00 (4)	53.3 (2)	**82.5 (1)**	54.2 (3)	**42.0 (1)**	167 (3)	**130 (1)**	156 (2)
Spring	0.00 (3)	0.00 (3)	0.00 (4)	26.7 (2)	33.3 (3)	65.2 (2)	40.0 (4)	**42.0 (1)**	362 (2)	102 (2)	145 (3)
Summer	**33.3 (1)**	13.3 (2)	**30.0 (1)**	13.3 (3)	33.3 (3)	8.00 (3)	**273 (1)**	36.9 (2)	**468 (1)**	50.0 (4)	110 (4)

Winter produced the highest average of Enterococcus most often. However, this was not consistent throughout the study period. There is no notable relationship between E.coli and Enterococcus.

Table A-146: Warner – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	60.0 (3)	110 (2)	6.70 (3)	**26.7 (1)**	**240 (1)**	40.0 (4)	36.7 (4)	35.0 (2)	135 (3)	124 (2)	**163 (1)**
Winter	**153 (1)**	**213 (1)**	**33.3 (1)**	6.70 (3)	220 (2)	147 (2)	77.5 (2)	17.7 (3)	**690 (1)**	**227 (1)**	-
Spring	80.0 (2)	0.00 (4)	0.00 (4)	0.00 (4)	6.70 (3)	112 (3)	48.3 (3)	**85.0 (1)**	355 (2)	106 (3)	-
Summer	0.00 (4)	13.3 (3)	20.0 (2)	13.3 (2)	6.70 (3)	**220 (1)**	**144 (1)**	**85.0 (1)**	125 (4)	90.6 (4)	-

- **Annual Trends**

The annual averages and standard deviations for E.coli are summarised in Figure A-109. The average concentration of E.coli at Warner beach has remained consistent for the first four years of the study period. Thereafter a slight increase in evident. The average levels of E.coli at the end of the study period are approximately 10 times greater than in 2003. The standard deviations during the first half of the study were low. During the second half, however, deviations became significantly larger. Larger deviations are associated with larger averages.

Figure A-109 depicts the annual averages and standard deviations for Enterococcus at Warner beach. Average levels of Enterococcus remained below 200CFU/100ml throughout the study except for 2011 and 2012. Extremely low averages are noted in 2005 and 2006. Larger averages in 2011 and 2012 are also linked with larger deviations, thus highlighting the variability of Enterococcus during those years.

There is a shared pattern in average fluctuations in the two indicators from 2010 to 2013. Standard deviations for both E.coli and Enterococcus increased during the latter half of the study.

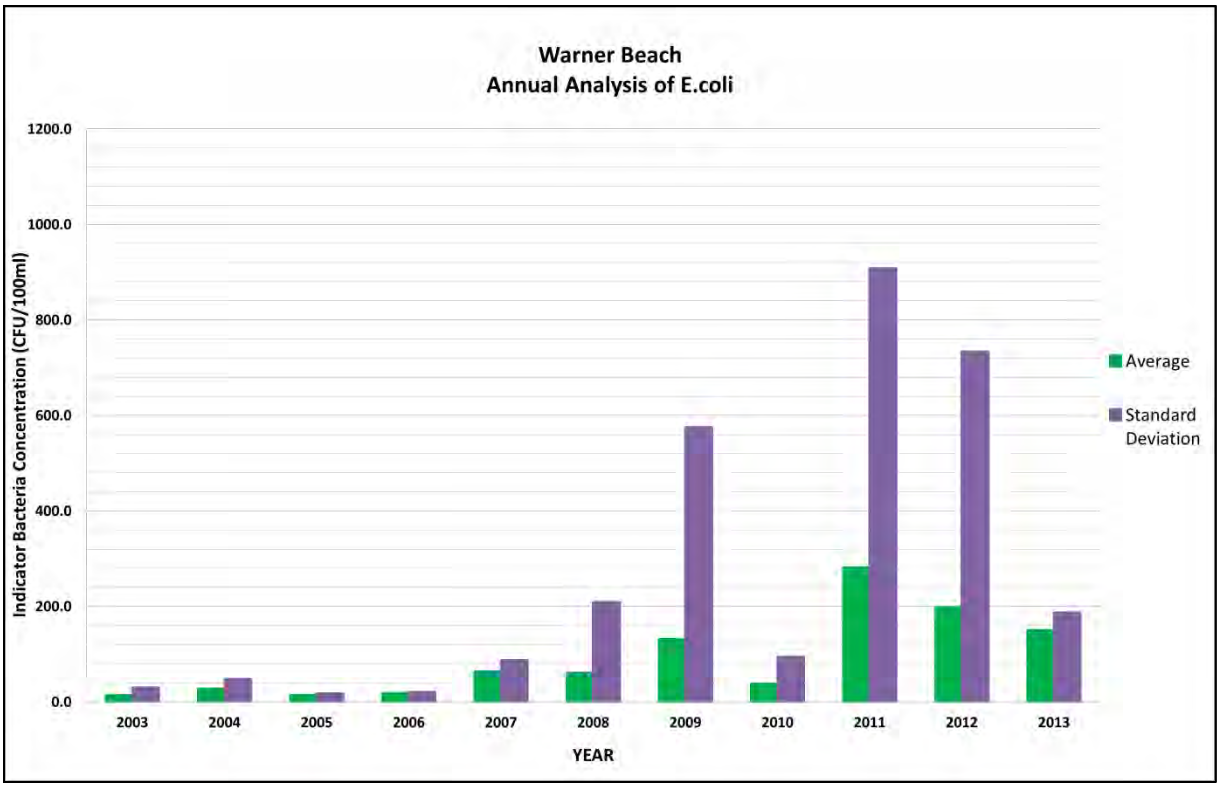


Figure A-109: Annual Analysis of E.coli at Warner Beach

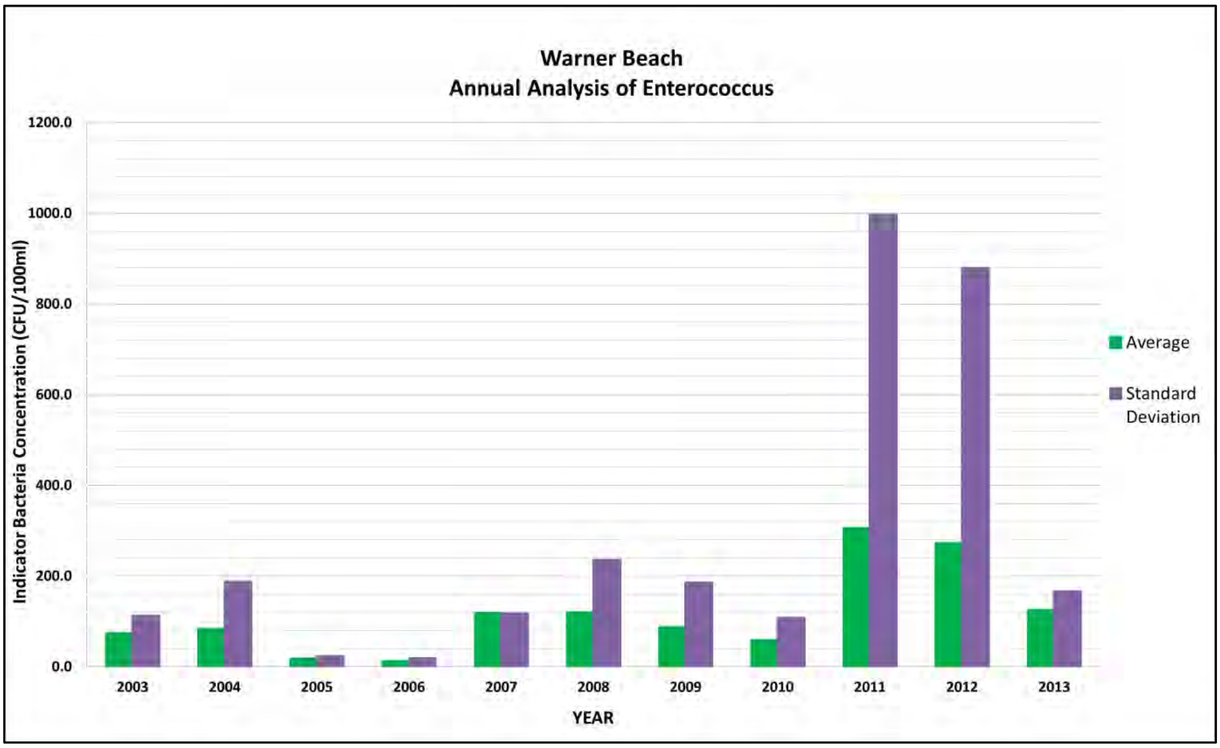


Figure A-110: Annual Analysis of Enterococcus at Warner Beach

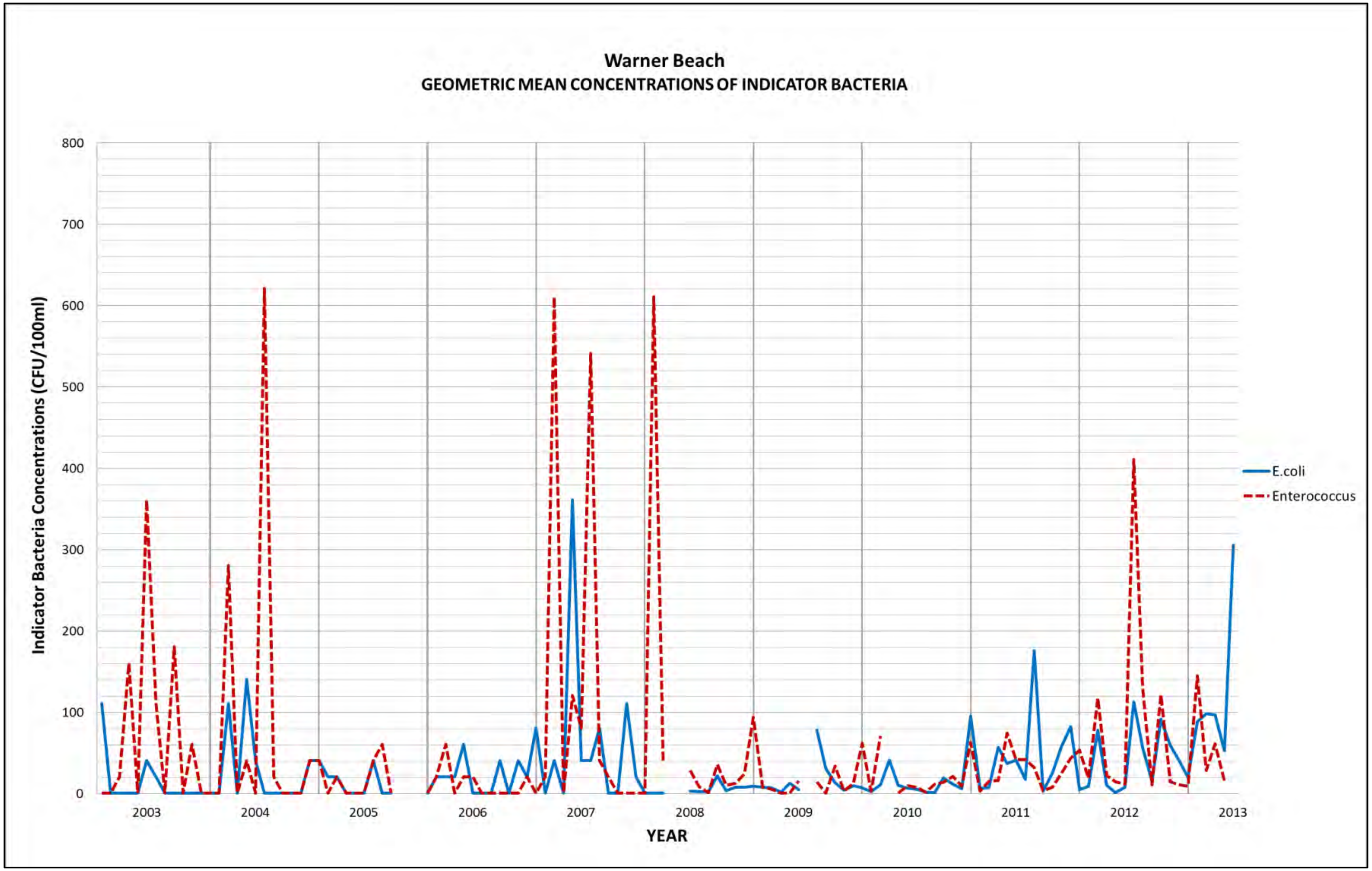


Figure A-111: Warner – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-110 compares the geometric means of E.coli and Enterococcus. Both indicators have remained capricious for the duration of the study. Enterococcus exceeded E.coli on most occasions.

- **SAWQ Guidelines**

Tables A-147 and A-148 show the microbiological water quality ratings based on E.coli and Enterococcus respectively.

Based on E.coli concentrations, the water quality has been classified as predominantly excellent with exception to 2011. In 2011 the frequency of the occurrence of poor water quality increased drastically, with almost half of the year falling within the poor rating. Water quality ratings clearly dropped from consistent excellency to good/poorer ratings.

Table A-147: Warner – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	P	E	P	G	G
FEB	E	E	E	E	E	E	E	E	E	E	E
MAR	E	E	E	E	E	E	G	E	E	G	G
APR	E	E	E	E	E	-	E	E	P	E	G
MAY	E	E	E	E	G	-	E	E	G	E	E
JUN	E	E	E	E	E	P	E	G	E	E	P
JUL	E	E	E	E	E	E	-	E	G	G	E
AUG	E	E	E	E	E	E	E	E	P	G	E
SEP	E	E	E	E	E	G	E	E	E	G	E
OCT	E	E	-	E	E	E	E	E	G	G	G
NOV	E	E	-	E	E	E	E	G	P	-	E
DEC	E	E	-	E	E	E	E	G	P	G	E
Annual	E	E	E	E	E	G	G	E	P	G	G

Annually water quality has been predominantly poor based on counts of Enterococcus, with every year since 2007 through to 2013 being classified as poor. Water quality has only been rated as excellent twice annually. The summer months from 2009 to 2012, show patterns of poor water quality. At least a quarter of each year from 2008 onward has a poor rating due to high concentrations of Enterococcus. Although poor water quality was only experienced two months in 2004 overall rating of poor due to extremely high counts.

Table A-148: Warner – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	E	E	P	P	P	P	E
FEB	E	E	E	E	E	G	P	E	E	G	G
MAR	E	P	E	E	P	E	P	E	P	P	P
APR	G	E	E	E	E	-	E	P	P	P	G
MAY	E	E	E	E	G	-	E	G	P	E	E
JUN	P	E	E	E	E	P	G	E	P	G	P
JUL	E	E	E	E	P	E	-	E	P	P	-
AUG	E	E	E	E	E	E	P	E	P	P	-
SEP	G	E	E	E	E	P	E	P	E	P	-
OCT	E	E	-	E	E	G	P	P	G	P	-
NOV	E	E	-	E	E	P	E	P	P	-	-
DEC	E	P	-	E	E	G	G	G	P	P	-
Annual	G	P	E	E	P	P	P	P	P	P	P

A.4.7. Warner Baggies

Sample data for both indicator bacteria at Warner - Baggies Beach was only provided for 2008 to 2013. Data for E.coli was from September 2008 to December 2013 and data for Enterococcus was from September 2008 to June 2013.

- **Seasonal Trends**

Seasonal averages for E.coli at Warner Baggies beach are ranked in Table A-149. Spring consistently lowest from 2011 to 2013. Autumn yielded the highest most. Summer is shown to produce the second highest most often.

Table A-149: Warner Baggies– Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	**34.4 (1)**	43.3 (2)	83.8 (3)	**140 (1)**	**161 (1)**
Winter	-	0.00 (4)	9.20 (3)	**456 (1)**	78.0 (3)	100 (2)
Spring	**11.5 (1)**	22.5 (3)	43.3 (2)	24.7 (4)	78.0 (3)	91.7 (3)
Summer	4.00 (2)	30.0 (2)	**48.1 (1)**	98.5 (2)	88.3 (2)	100 (2)

Table A-150 shows the ranking of the Enterococcus seasonal averages. As with E.coli, summer yielded the second highest average concentration of Enterococcus most often. The season which produced the highest average of this bacterium differed each year. There is no correlation between the two bacteria regarding the seasonal average.

Table A-150: Warner Baggies – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	38.0 (3)	38.8 (3)	143 (3)	88.8 (4)	**178 (1)**
Winter	-	6.00 (4)	22.2 (4)	**618 (1)**	**157 (1)**	30.0 (2)
Spring	**77.5 (1)**	44.0 (2)	**72.3 (1)**	27.6 (4)	102 (3)	-
Summer	56.0 (2)	**127 (1)**	62.8 (2)	125 (2)	113 (2)	-

- **Annual Trends**

Figures A-112 and A-113 portray the annual averages and standard deviations for E.coli and Enterococcus respectively.

The concentrations for 2008 are low due to only four months data for that year. Since 2009 average concentration of E.coli increased slightly. The average in 2013 is approximately 5 times greater than in 2009. A large deviations standard deviation is observed in 2011, which also has the largest average. E.coli varied concentrations varied more during this time than the rest of the study.

Average levels of Enterococcus varied marginally. The largest average is evident in 2011. As with E.coli, the largest standard deviation is associated with the largest average. Enterococcus levels varied significantly throughout this year.

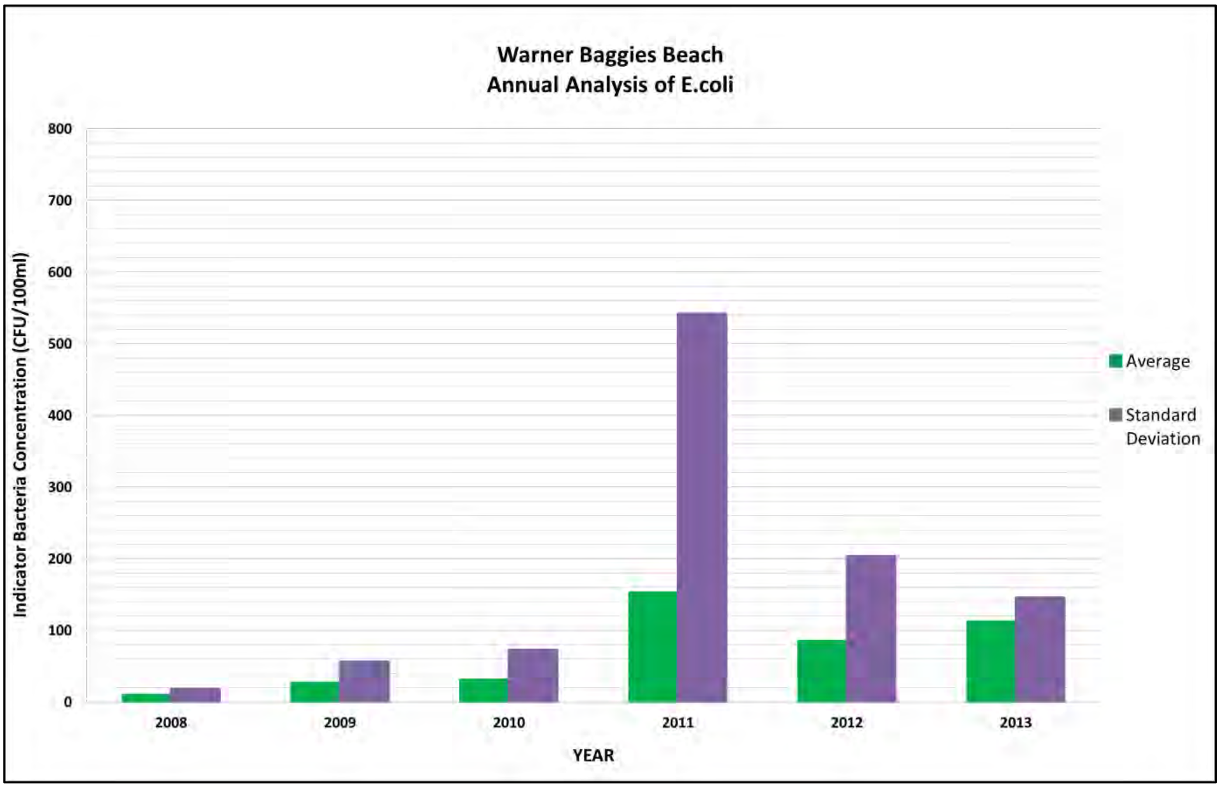


Figure A-112: Annual Analysis of E.coli at Warner Baggies Beach

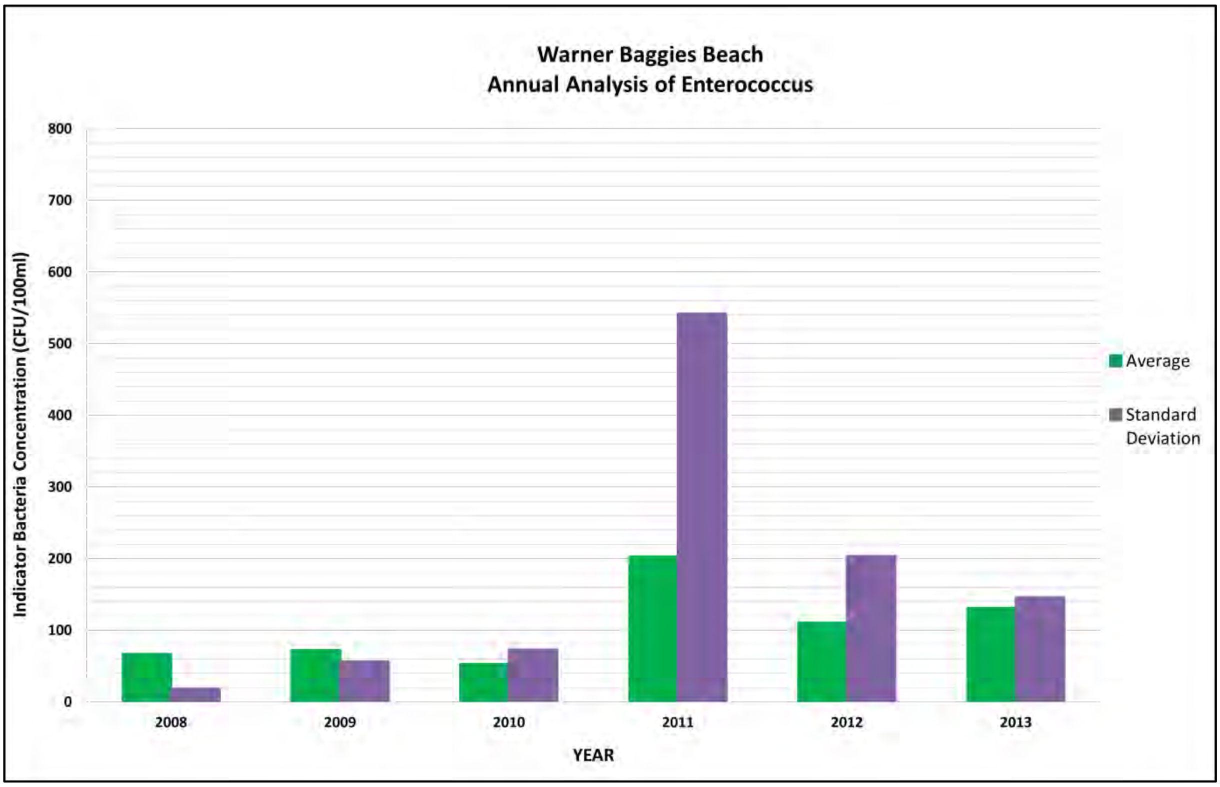


Figure A-113: Annual Analysis of Enterococcus at Warner Baggies Beach

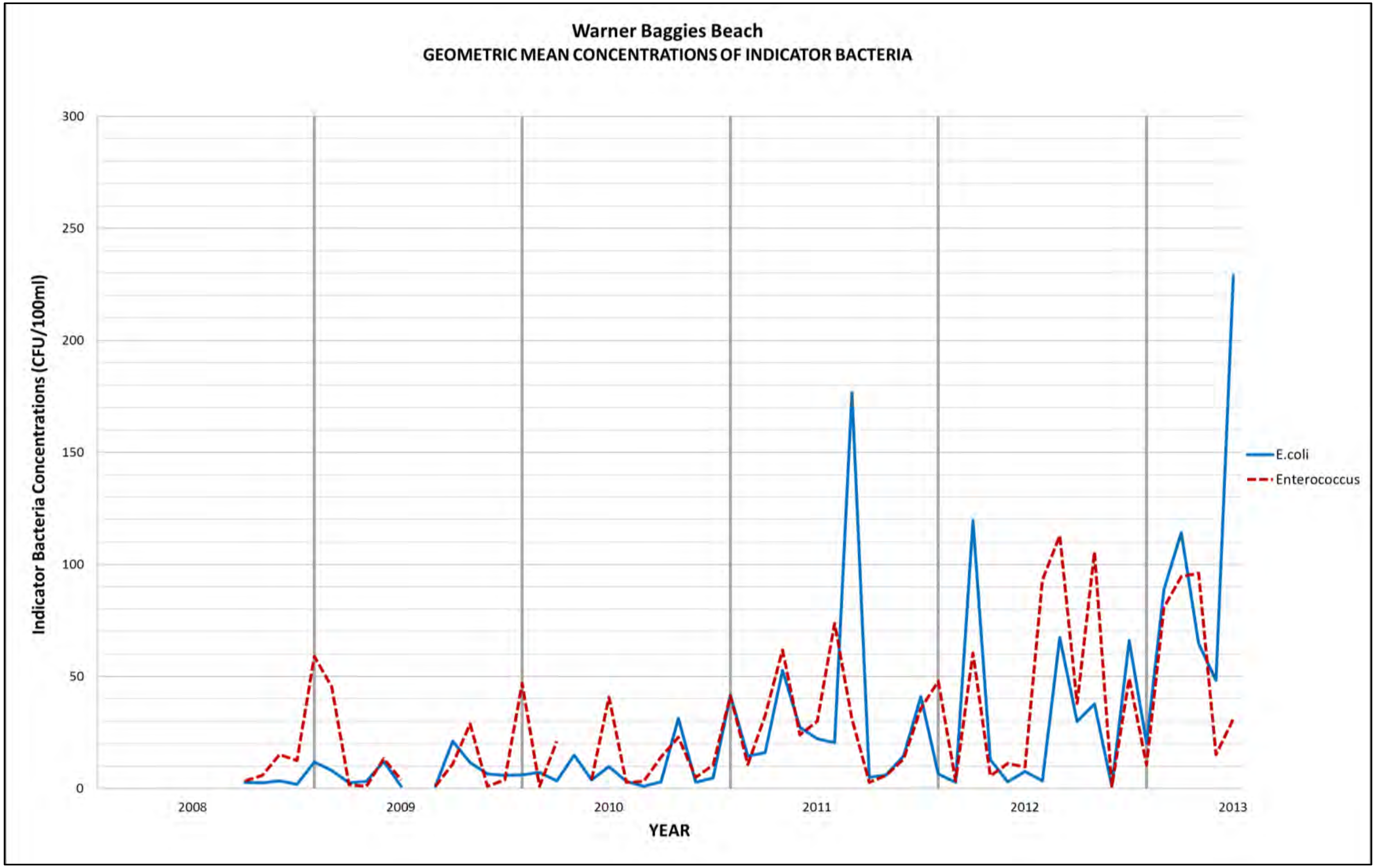


Figure A-114: Warner Baggies – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-114 shows a general increase in both indicator bacteria. Enterococcus exceeded E.coli most often. The two bacteria follow the same patterns of variability for the duration of the study.

- **SAWQ Guidelines**

Table A-151 depicts the microbiological water quality rating based on E.coli. The annual rating at Warner Baggies has been excellent for the first half of the study period and good for the second half. A total of two occurrences of poor are evident throughout the study period. Both incidences occurred in 2011. This corresponds to Figure A-112 which shows the largest average of E.coli in 2011.

Table A-151: Warner Baggies – E.coli Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	E	E	P	G	G
FEB	-	E	E	E	E	E
MAR	-	E	E	E	G	G
APR	-	E	E	G	E	G
MAY	-	E	E	G	E	E
JUN	-	E	E	G	E	G
JUL	-	-	E	G	E	E
AUG	-	E	E	P	G	E
SEP	E	E	E	E	E	E
OCT	E	E	E	E	G	G
NOV	E	E	E	E	E	E
DEC	E	E	G	E	E	E
Annual	E	E	E	G	G	G

Table A-152: Warner Baggies – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	P	P	P	P	E
FEB	-	P	E	P	E	P
MAR	-	E	E	P	G	P
APR	-	E	-	P	E	G
MAY	-	P	G	P	G	E
JUN	-	E	E	P	G	E
JUL	-	-	E	P	P	-
AUG	-	E	E	E	P	-
SEP	G	E	P	G	G	-
OCT	E	P	P	E	P	-
NOV	P	E	E	E	E	-
DEC	G	E	P	P	P	-
Annual	P	P	P	P	P	P

Table A-152 summarises the microbiological water quality rating based on Enterococcus. Annually the waters at Warner Baggies have never been classified as excellent. Ratings have been consistently poor throughout the entire study period. At least a quarter of the year rated poor from 2009 to 2012. In additions, the summer months experienced poor water quality conditions often. When comparing the annual ratings of the two indicators, water quality has not been poor over the study period based on E.coli. In contrast, based on Enterococcus, water quality has been consistently poor.

A.4.8. Winkelspruit

- **Seasonal Trends**

Table A-153 summarises the seasonal averages of E.coli at Winkelspruit beach. Autumn consistently yielded the highest average concentration. From 2010 onward spring consistently produced the second highest average concentration of E.coli. A pattern is evident in the last three years of the study. The seasonal averages of Enterococcus are ranked in Table A-154. No pattern is obvious and there is no link with E.coli.

Table A-153: Winkelspruit – Ranking of E.coli Seasonal Averages

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Autumn	46.7 (2)	**120 (1)**	60.0 (2)	**527 (1)**	**233 (1)**	0.00 (4)	**390 (1)**	3.00 (4)	**615 (1)**	**276 (1)**	**255 (1)**
Winter	6.70 (3)	13.3 (3)	0.00 (3)	0.00 (4)	6.70 (4)	**358 (1)**	80.8 (4)	37.9 (3)	83.6 (3)	121 (3)	59.4 (4)
Spring	**133 (1)**	33.3 (2)	0.00 (3)	6.70 (3)	60.0 (3)	42.7 (3)	99.3 (3)	85.0 (2)	130 (2)	240 (2)	211 (2)
Summer	0.00 (4)	10.0 (4)	**3070 (1)**	33.3 (2)	100 (2)	57.3 (2)	261 (2)	**102 (1)**	75.0 (4)	40.0 (4)	153 (3)

Table A-154: Winkelspruit – Ranking of Enterococcus Seasonal Averages

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Autumn	240 (2)	253 (2)	153 (2)	**433 (1)**	**460 (1)**	40.0 (3)	125 (3)	30.0 (4)	127 (4)	157 (2)	**73.3 (1)**
Winter	166 (3)	**280 (1)**	6.70 (3)	13.3 (3)	53.3 (3)	**100 (1)**	117 (4)	50.3 (3)	**833 (1)**	**227 (1)**	-
Spring	**540 (1)**	100 (3)	0.00 (4)	0.00 (4)	26.7 (4)	88.7 (2)	**194 (1)**	109 (2)	300 (2)	**227 (1)**	-
Summer	60.0 (4)	70.0 (4)	**660 (1)**	40.0 (2)	160 (2)	37.3 (4)	162 (2)	**117 (1)**	249 (3)	57.4 (3)	-

- **Annual Trends**

Figures A-115 and A-116 represent the annual averages and standard deviation for E.coli and Enterococcus respectively. The average concentration of E.coli has varied randomly throughout the study period. A significant increase is clear in 2004 and 2005. These are the highest concentrations with averages reaching up to 15 times that of the lowest at the beginning of the study. Thereafter the concentrations decrease. At the end of the study period the average concentration of E.coli is approximately four times greater than 2003. Extremely large standard deviations are associated with the highest averages in 2004 and 2005. Moreover, large deviations are also noted in 2011 and 2012. The random nature of this bacterium is further supported this.

The average levels of Enterococcus varied slightly with a general decrease up to 2010. Thereafter the averages increased suddenly from 2011 to 2012, and decreased the following year. Significantly large standard deviations are shown in 2011 and 2012; this is a trend shared with E.coli.

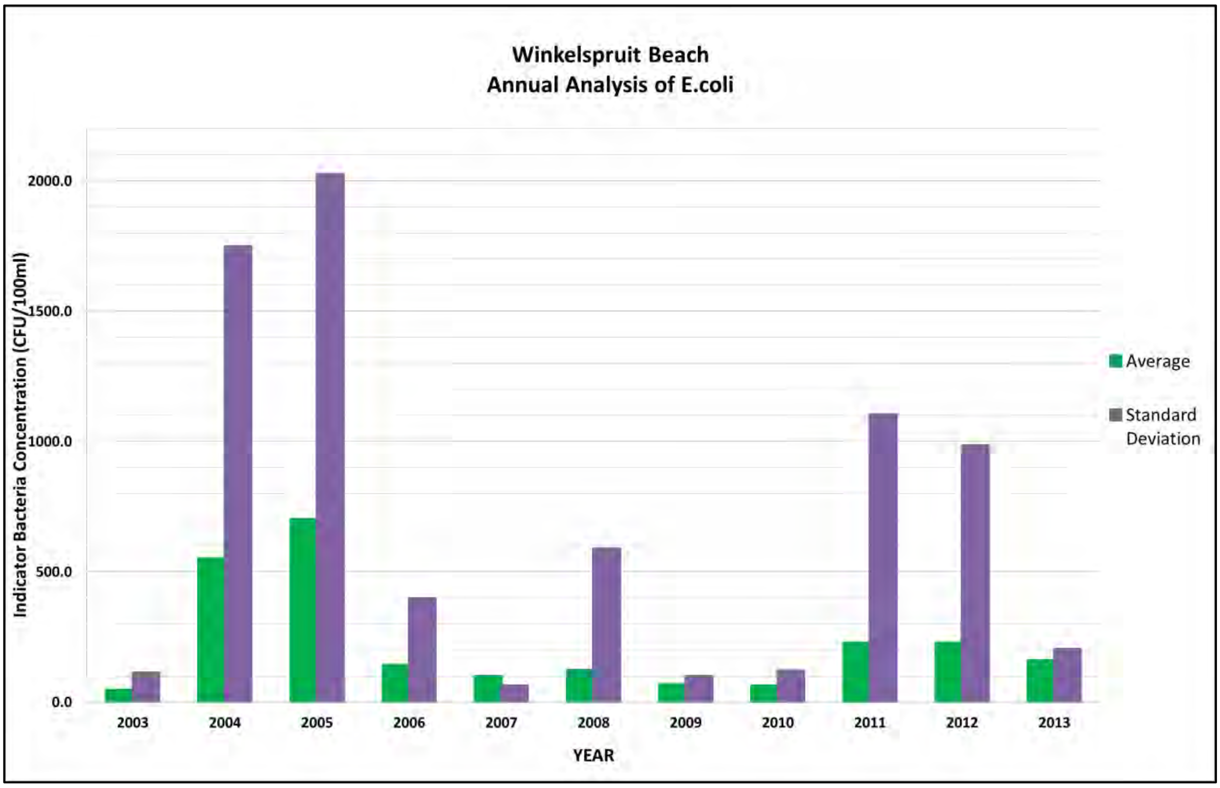


Figure A-115: Annual Analysis of E.coli at Winkelspruit Beach

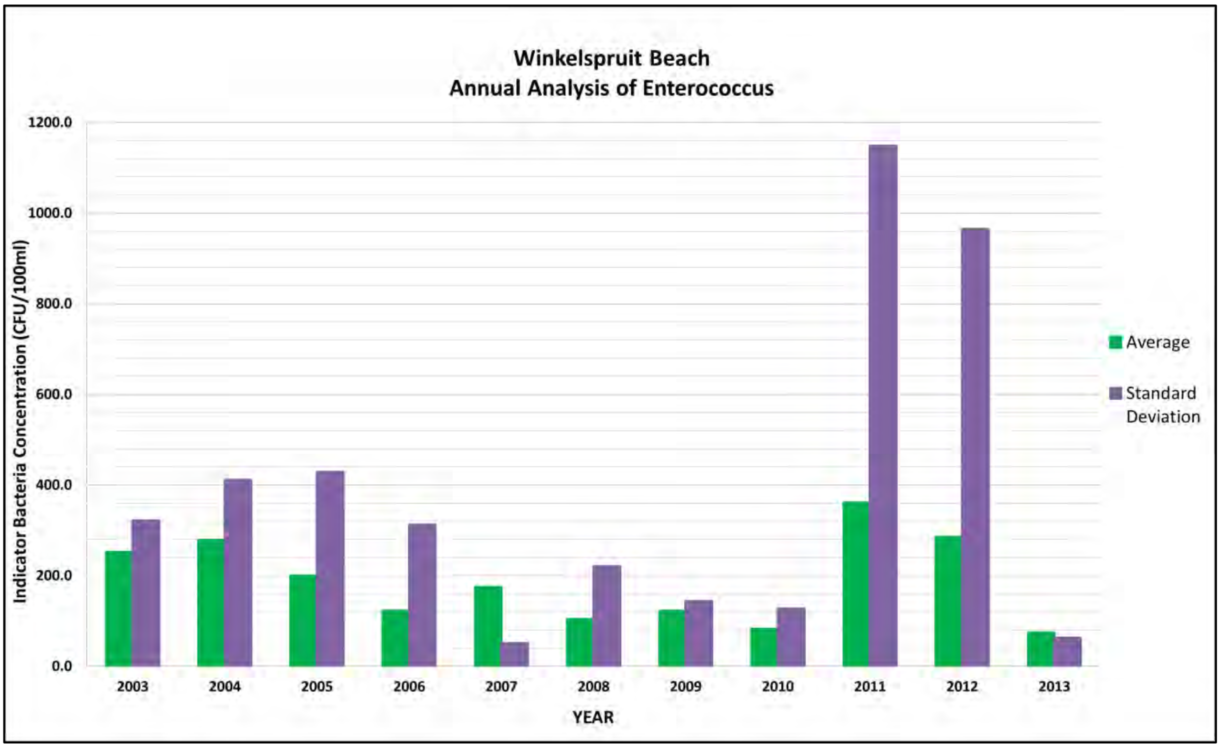


Figure A-116: Annual Analysis of Enterococcus at Winkelspruit Beach

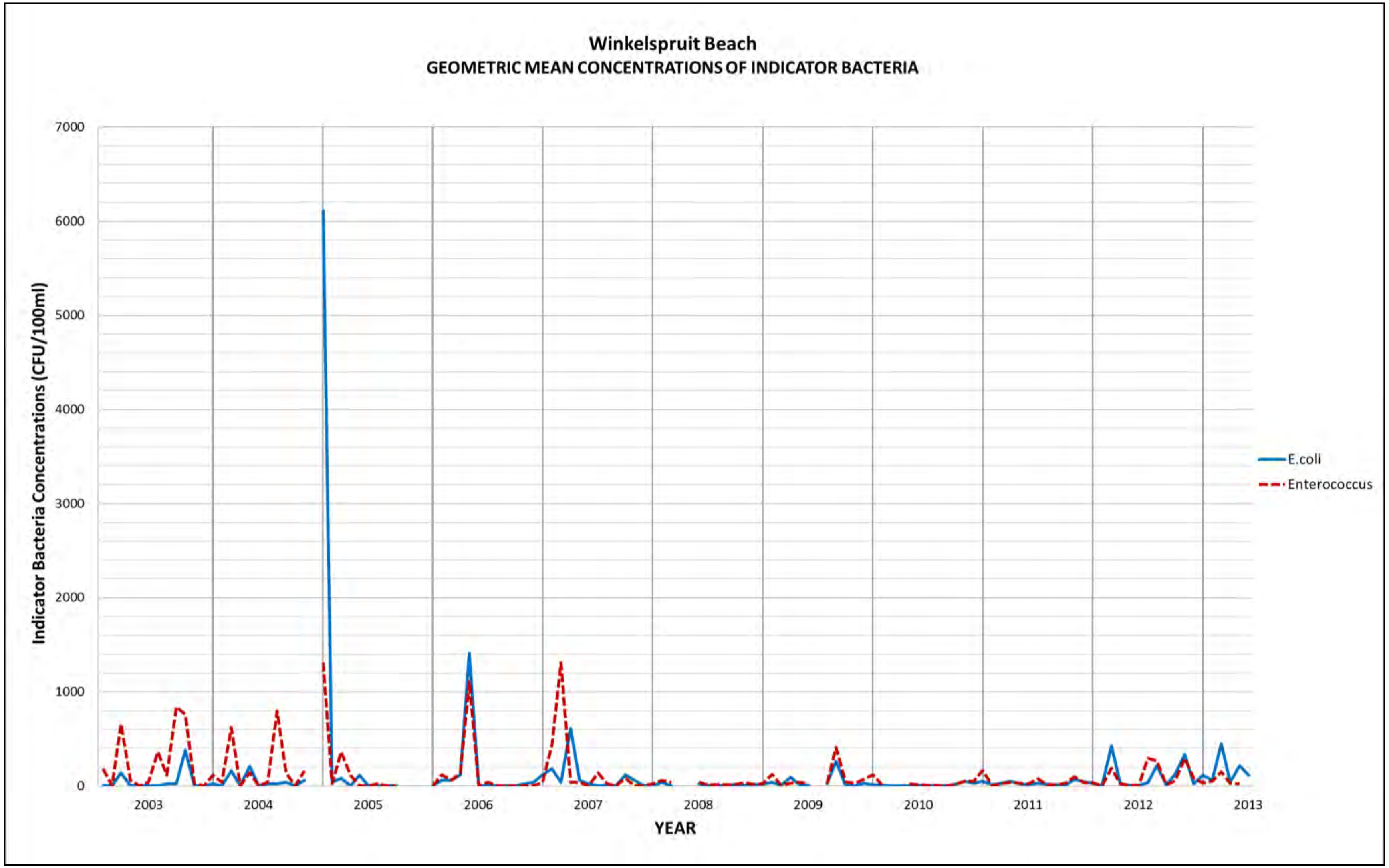


Figure A-117: Winkelspruit – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-117 illustrates the geometric means of E.coli and Enterococcus at Winkelspruit beach. Enterococcus concentrations are shown to be greater than E.coli during first half of the study. Levels of both bacteria correspond with each other and follow the same pattern of variation during second half of the study. Both E.coli and Enterococcus have become less variable.

- **SAWQ Guidelines**

The microbiological water quality rating for E.coli is shown in Table A-155. Generally the levels of E.coli indicate excellent to good water quality conditions, with scattered occurrences of poor water quality throughout the entire study period. A consistently good rating for last four years is clear.

Table A-155: Winkelspruit – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	P	E	E	E	P	G	G	G	G
FEB	E	E	E	E	E	E	G	E	E	E	E
MAR	E	E	E	E	E	E	E	E	G	P	P
APR	E	E	E	E	P	-	P	E	G	G	E
MAY	E	E	E	P	E	-	G	E	G	G	G
JUN	E	E	E	E	E	P	G	E	E	G	E
JUL	E	E	E	E	E	E	-	E	G	E	E
AUG	E	E	E	E	E	E	E	G	G	G	E
SEP	E	E	E	E	E	E	G	E	G	G	P
OCT	G	E	-	E	E	E	E	E	G	G	E
NOV	E	E	-	E	E	E	E	G	P	-	E
DEC	E	-	-	E	E	G	E	G	E	G	E
Annual	E	E	G	G	G	E	E	G	G	G	G

Table A-156: Winkelspruit – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	E	P	E	E	E	P	P	P	P	E
FEB	E	E	E	G	P	E	P	E	E	E	P
MAR	P	P	P	E	P	E	E	P	P	P	P
APR	E	E	E	G	E	-	G	P	P	P	E
MAY	E	G	E	P	E	-	P	E	P	P	E
JUN	E	E	E	E	E	P	P	G	G	P	P
JUL	P	P	E	E	G	G	-	G	P	P	-
AUG	E	G	E	E	E	G	E	P	P	P	-
SEP	P	E	E	E	E	G	G	E	P	P	-
OCT	P	G	-	E	E	G	P	G	P	P	-
NOV	E	P	-	E	E	P	E	P	P	-	-
DEC	E	-	-	E	E	E	P	P	E	P	-
Annual	P	P	P	G	P	G	P	P	P	P	P

Based on Enterococcus the waters at Winkelspruit beach have been poor throughout most of the study period. Annually water quality has never been classified as excellent. From 2009 water quality has consistently been rated poor with at least half of each year experiencing poor water quality conditions.

A.4.9. Karridene

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-157. No pattern is evident as the season which produced the highest average of E.coli at Karridene beach has not been consistent over the course of the study period.

Table A-157: Karridene – Ranking of E.coli Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	0.00 (3)	126 (2)	53.3 (2)	**200 (1)**	**33.3 (1)**	0.00 (4)	34.4 (3)	15.8 (4)	**141 (1)**	164 (2)	**305 (1)**
Winter	**13.3 (1)**	6.70 (4)	0.00 (3)	0.00 (4)	26.7 (2)	**284 (1)**	**237 (1)**	21.2 (3)	128 (2)	140 (3)	25.7 (4)
Spring	0.00 (3)	13.3 (3)	0.00 (3)	13.3 (3)	0.00 (4)	2.90 (3)	15.3 (4)	26.7 (2)	17.8 (4)	**187 (1)**	60.0 (3)
Summer	6.70 (2)	**1200 (1)**	**1800 (1)**	40.0 (2)	13.3 (3)	56.0 (2)	106 (2)	**52.8 (1)**	53.2 (3)	58.9 (4)	96.7 (2)

As with E.coli, there is no clear pattern based on Enterococcus seasonal averages. Furthermore, there is no apparent link between the two bacteria.

Table A-158: Karridene – Ranking of Enterococcus Seasonal Averages

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Autumn	26.7 (4)	113 (4)	153 (2)	213 (2)	**220 (1)**	0.00 (4)	23.9 (4)	30.0 (3)	77.8 (2)	**470 (1)**	**88.3 (1)**
Winter	86.7 (2)	140 (2)	30.0 (3)	**280 (1)**	40.0 (2)	**213 (1)**	**136 (1)**	23.2 (4)	**564 (1)**	196 (3)	-
Spring	**200 (1)**	**266 (1)**	20.0 (4)	46.7 (4)	13.3 (3)	53.1 (2)	63.7 (3)	**69.3 (1)**	54.1 (3)	219 (2)	-
Summer	46.7 (3)	**266 (1)**	**400 (1)**	140 (3)	6.70 (4)	8.00 (3)	78.0 (2)	50.8 (2)	77.8 (2)	81.7 (4)	-

- **Annual Trends**

Figures A-118 and A-119 show the annual averages and standard deviation for E.coli and Enterococcus at Karridene respectively. Over the course of the study period the average concentration of E.coli has varied erratically. A drastic increase is evident in 2004 and 2005.Durign those two years the average concentration of E.coli was determined to be approximately 95 times that of 2003. Subsequent to the drastic increase, the average then dropped and remained mostly consistent. The standard deviations were found to be significant in many cases. Extremely large standard deviations are noted in 2004 and 2005 and are linked to the largest averages. This further supports the erratic behaviour of E.coli at Karridene beach.

Enterococcus has remained consistent over the study period. Slight fluctuations are evident during 2007 through to 2010 where a slight decrease occurred. The average concentration of this bacterium is approximately 1.5 times that of 2003. Large deviations are noted especially in 2011 and 2012.

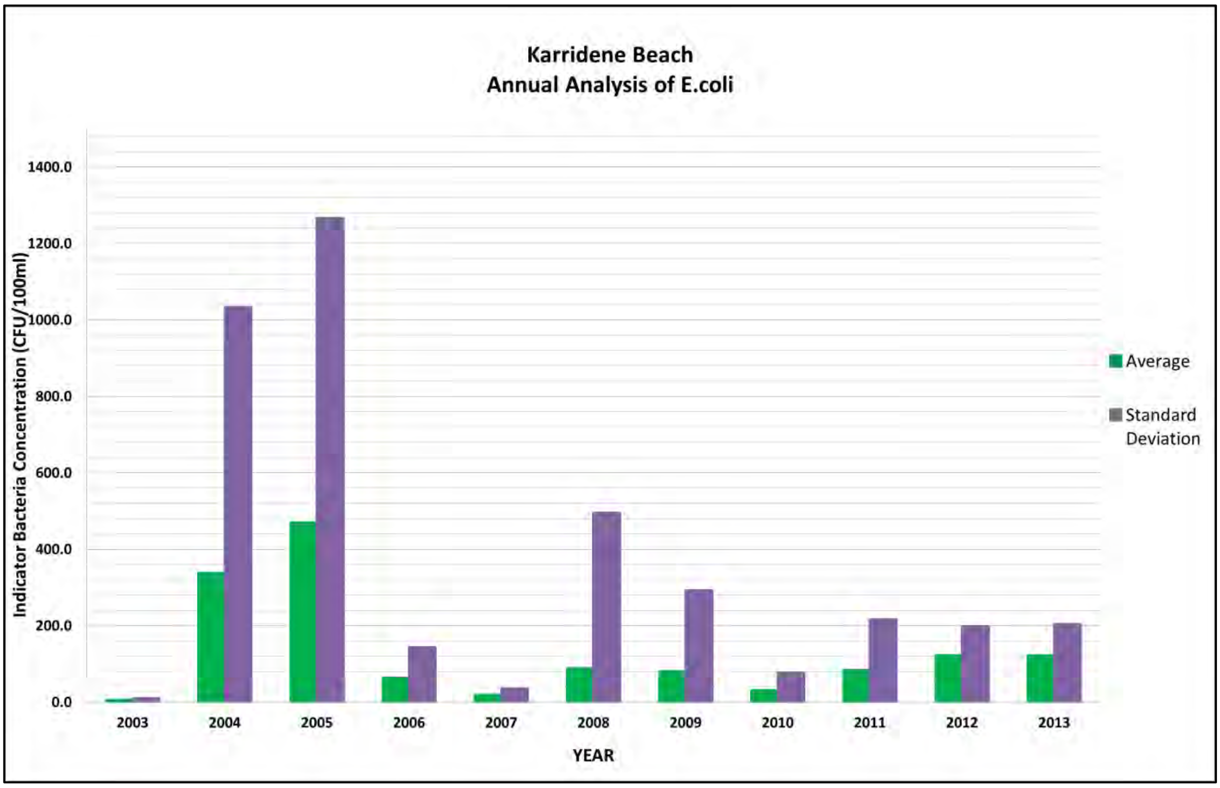


Figure A-118: Annual Analysis of E.coli at Karridene Beach

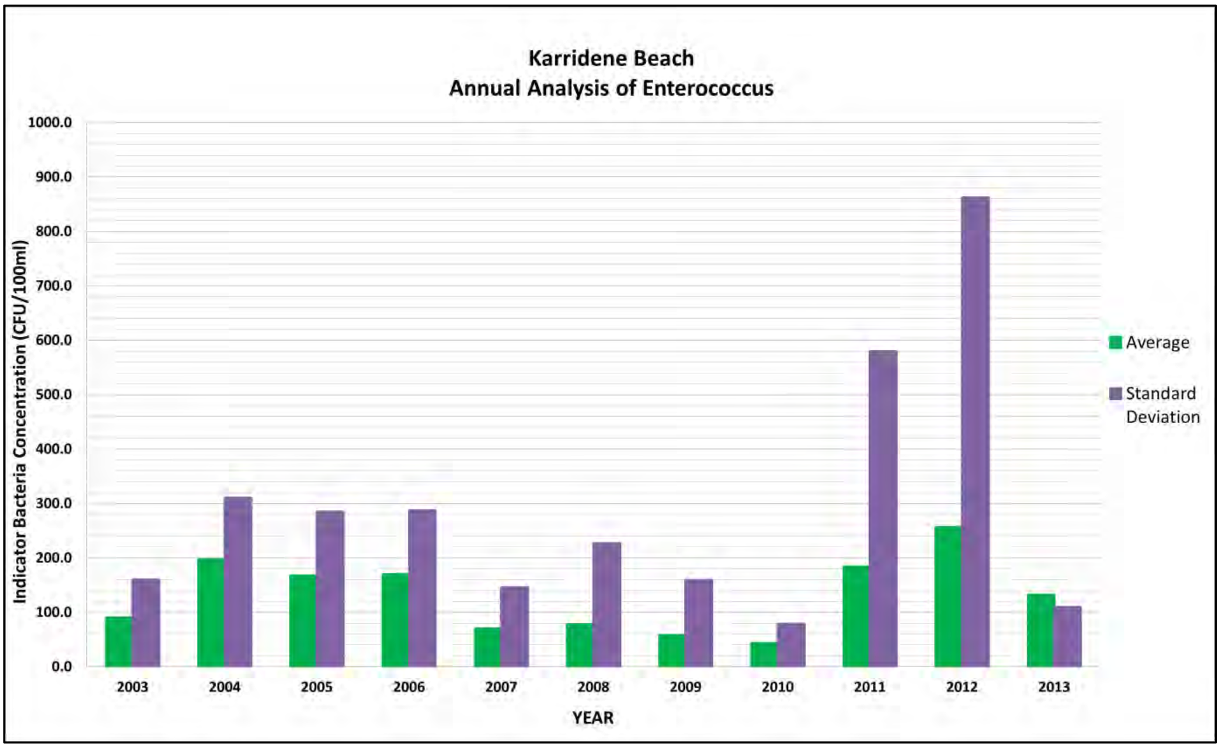


Figure A-119: Annual Analysis of Enterococcus at Karridene Beach

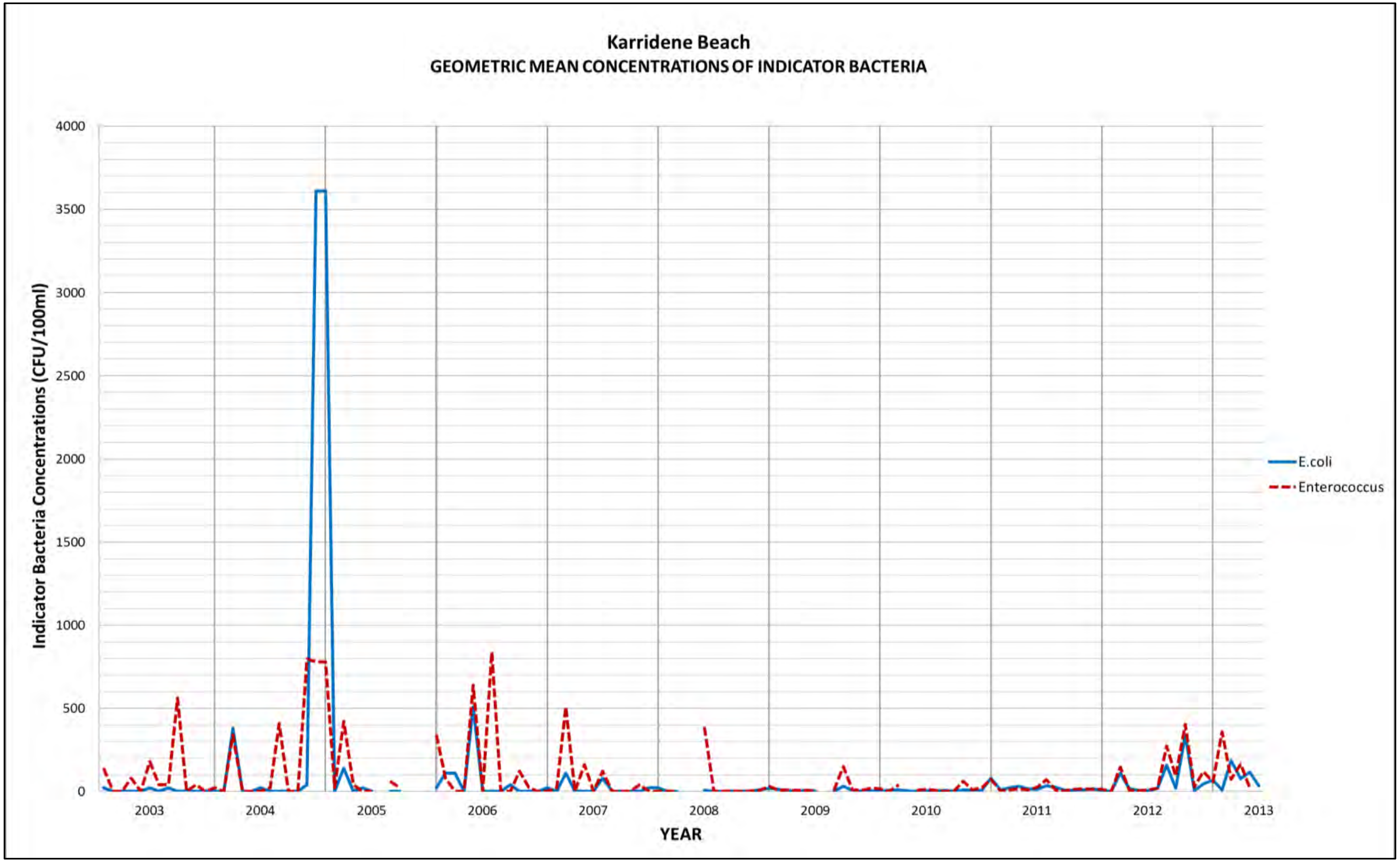


Figure A-120: Karridene – Geometric Mean Concentrations of Indicator Bacteria (2003-2013)

Figure A-120 illustrates the geometric means of E.coli and Enterococcus at Karridene beach. Enterococcus concentrations are shown to be greater than E.coli on most occasions during first half of the study. Levels of both bacteria correspond with each other and follow the same pattern of variation during second half of the study. Both E.coli and Enterococcus have become more consistent.

- **SAWQ Guidelines**

Tables A-159 and A-160 show the microbiological water quality ratings based on E.coli and Enterococcus respectively. Generally the annual rating has been excellent and good. Poor water quality occurred randomly and infrequently and ultimately had little marginal effect on the overall water quality ratings.

Table A-159: Karridene – E.coli Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	E	E	P	E	E	E	P	E	E	G	G
FEB	E	E	E	E	E	E	E	G	E	E	E
MAR	E	G	E	E	E	E	E	E	P	G	P
APR	E	E	E	E	E	-	E	E	G	E	G
MAY	E	E	E	G	E	-	G	E	E	G	P
JUN	E	E	E	E	E	G	P	E	E	E	E
JUL	E	E	-	E	E	E	-	E	P	G	E
AUG	E	E	E	E	E	E	E	E	P	G	E
SEP	E	E	E	E	E	E	E	E	E	G	E
OCT	E	E	-	E	E	E	E	E	E	G	G
NOV	E	E	-	E	E	E	E	E	E	E	E
DEC	E	G	-	E	E	G	E	E	E	E	E
Annual	E	G	G	G	E	E	G	E	G	E	G

Table A-160: Karridene – Enterococcus Microbiological Water Quality Rating

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
JAN	G	E	P	P	E	E	P	G	P	P	G
FEB	E	E	E	E	E	E	E	E	E	E	P
MAR	E	P	G	E	P	E	E	E	P	P	G
APR	E	E	E	E	E	-	E	-	P	E	P
MAY	E	E	E	P	G	-	G	E	G	P	E
JUN	G	E	E	E	E	P	P	G	G	P	-
JUL	E	E	-	P	G	E	-	E	P	P	-
AUG	E	P	E	E	E	E	-	E	P	P	-
SEP	P	E	E	E	E	E	E	E	E	P	-
OCT	E	E	-	G	E	E	G	G	G	P	-
NOV	E	P	-	E	E	P	G	G	P	E	-
DEC	E	P	-	E	E	E	E	P	E	P	-
Annual	G	P	G	P	G	G	E	G	P	P	P

Based on the presence of Enterococcus in Karridene‟s waters, the annual water quality rating has been poor consistently for the last three years of the study. Initially incidences of poor water quality were random and infrequent. The most frequent and consistent incidences of poor water quality are shown to be in 2011 and 2012.

A.4.10. Umgababa

Sample data for both indicator bacteria at Umgababa Beach was only provided for 2008 to 2013. Data for E.coli was from September 2008 to December 2013 and data for Enterococcus was from September 2008 to June 2013.

- **Seasonal Trends**

The E.coli seasonal averages are ranked in Table A-161. Autumn is shown to be the highest consistently for the last three years from 2011 to 2013. No other seasonal trends are noted at Umgababa based on E.coli.

Table A-161: Umgababa – Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	32.0 (2)	14.7 (3)	**95.7 (1)**	**176 (1)**	**246 (1)**
Winter	-	7.50 (4)	6.30 (4)	74.9 (2)	99.7 (4)	39.4 (4)
Spring	4.00 (2)	**129 (1)**	**39.0 (1)**	41.9 (4)	129 (2)	60.0 (3)
Summer	**120 (1)**	20.0 (3)	27.8 (2)	46.6 (3)	103 (3)	95.0 (2)

From 2008 to 2010 the highest average counts of Enterococcus occurred during spring. Due to insufficient data no other trends can be determined.

Table A-162: Umgababa – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	62.7 (2)	18.0 (3)	85.6 (2)	**412 (1)**	**93.3 (1)**
Winter	-	10.0 (3)	18.0 (3)	**337 (1)**	156 (2)	90.0 (2)
Spring	**53.4 (1)**	**145 (1)**	**57.0 (1)**	45.1 (4)	136 (3)	-
Summer	24.0 (2)	62.7 (2)	40.6 (2)	75.7 (3)	113 (4)	-

- **Annual Trends**

The annual averages and standard deviations for E.coli and Enterococcus are depicted in Figures A-121 and A-122 respectively. The average levels of E.coli have clearly increased, with the average in 2013 increasing four fold when compared to 2008. Although a trend of increase is clear, the average concentration of E.coli has remained below 150CFU/100ml. The standard deviations are shown to be significant. Although the general average has not been large, standard deviations more than double the average indicate that levels of E.coli have varied significantly during each year.

A general increase in Enterococcus concentrations is evident. Like with E.coli, the average in 2013 increased fourfold when compared to 2008. Average concentrations exceeded 150CFU/100ml just once. The highest average is noted in 2012. The standard deviations were found to be marginal in most cases.

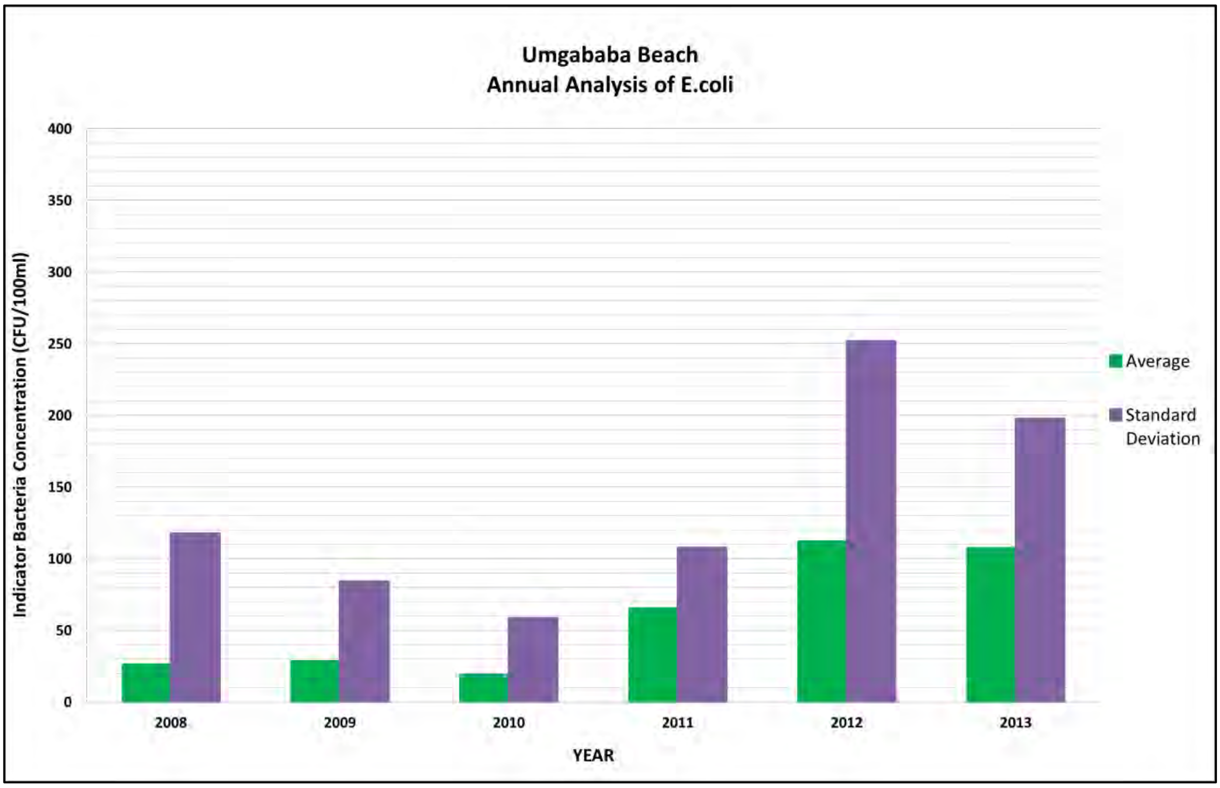


Figure A-121: Annual Analysis of E.coli at Umgababa Beach

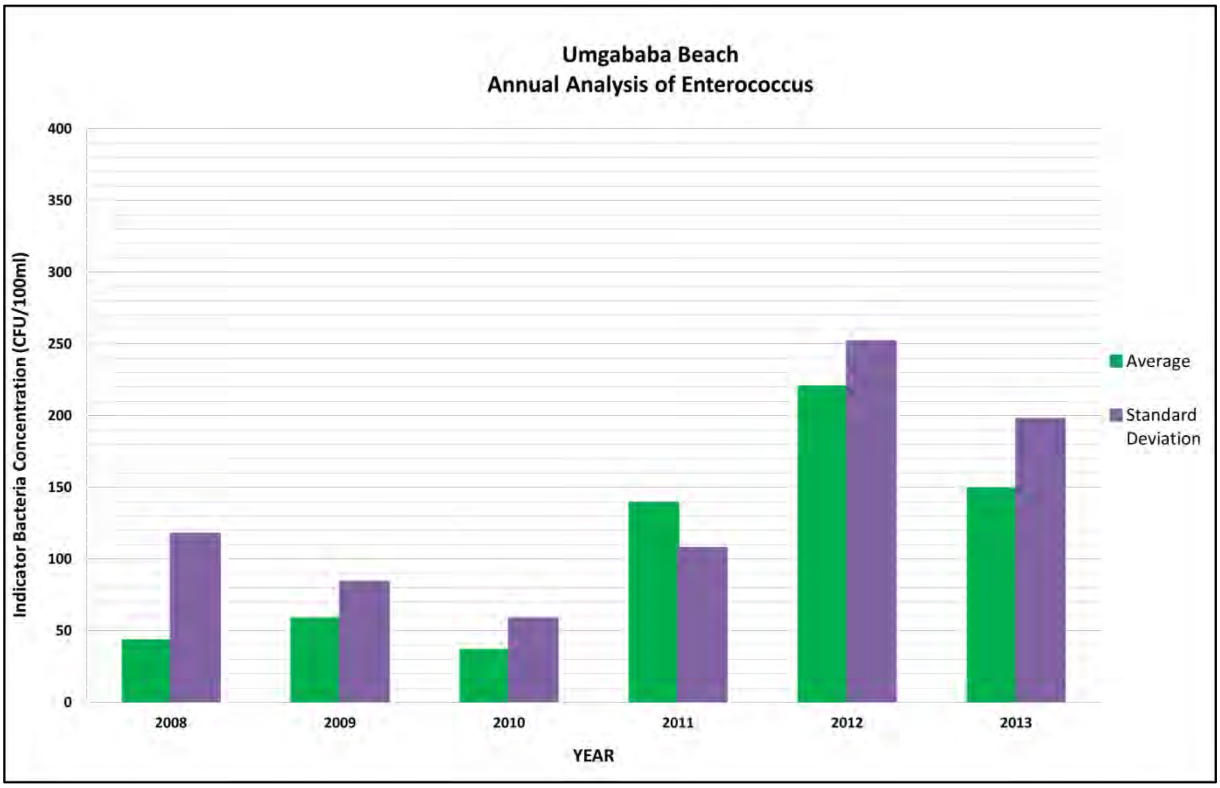


Figure A-122: Annual Analysis of Enterococcus at Umgababa Beach

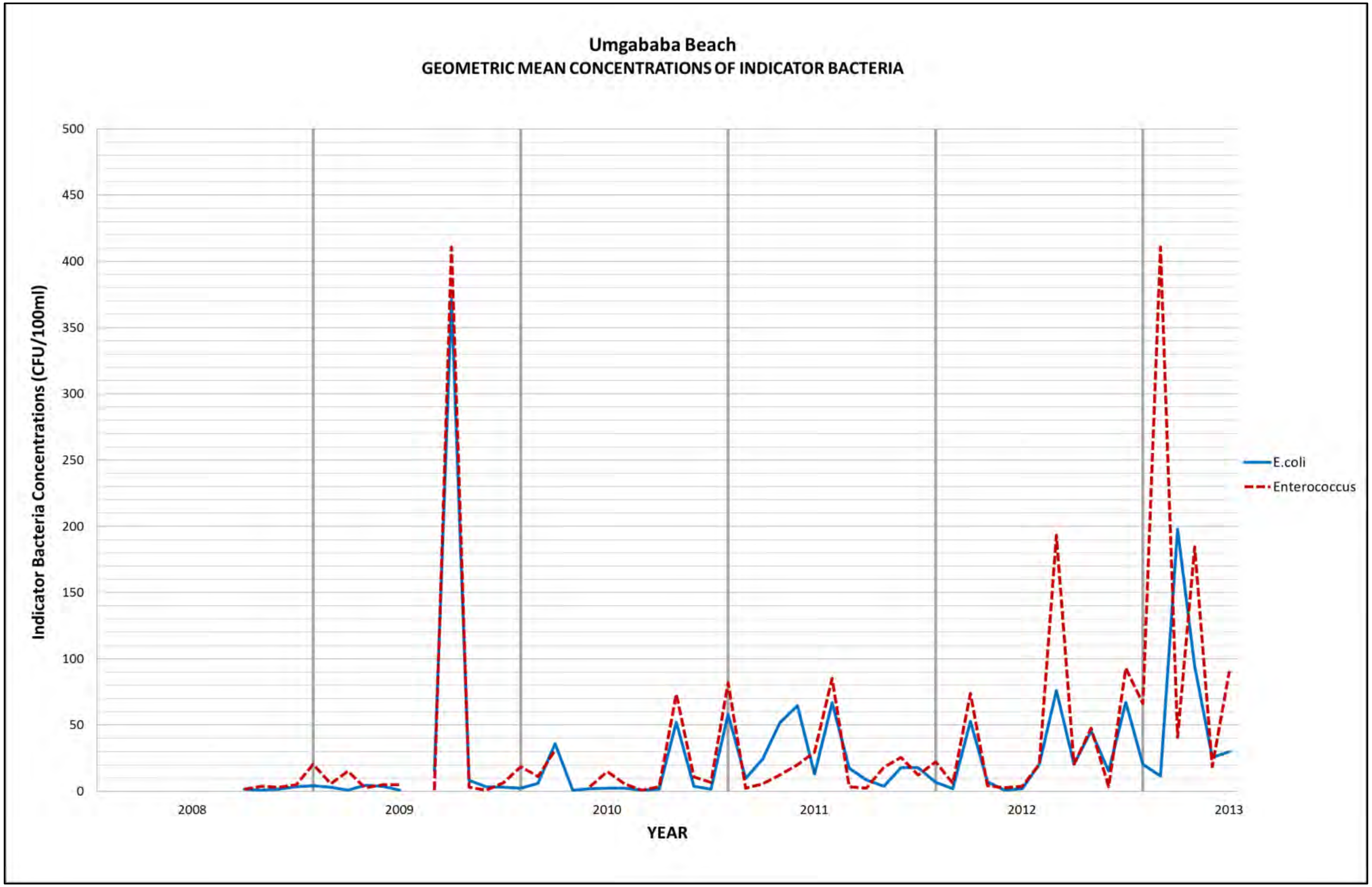


Figure A-123: Umgababa – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-123 compares the geometric means of E.coli and Enterococcus at Umgababa beach. With exception to the peak in 2009, a general increase in both indicator bacteria is shown. Enterococcus exceeded E.coli most often over the course of the study. The two bacteria follow the same patterns of variability for the duration of the study, fluctuating in unison.

- **SAWQ Guidelines**

The annual rating at Umgababa beach has been excellent for the first half of the study period and good for the second half. Only one occurrence of poor are evident throughout the study period.

Table A-163: Umgababa – E.coli Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	E	E	E	E	G	G
FEB	E	E	G	E	E	E
MAR	E	E	E	E	G	P
APR	E	G	E	G	E	G
MAY	E	E	E	G	E	E
JUN	E	E	E	E	E	E
JUL	E	-	E	G	G	E
AUG	E	E	E	E	E	E
SEP	E	G	E	E	G	E
OCT	E	E	E	E	E	E
NOV	E	E	E	G	E	E
DEC	G	E	E	E	G	E
Annual	E	E	E	G	G	G

The annual water quality ratings are shown to deteriorate from excellent to good, and then poor. The last three years received a poor rating consistently. Poor water quality is shown to occur consistently during the summer months throughout most of the study. The most frequent occurrences of poor water quality is evident in 2012. This is linked to Figure A-122 which shows the highest average concentration in that same year.

Table A-164: Umgababa – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	E	P	P	P	P	G
FEB	E	E	E	E	E	P
MAR	E	P	E	P	G	G
APR	E	E	-	P	E	P
MAY	E	G	E	G	E	E
JUN	E	E	E	G	E	E
JUL	E	-	E	E	P	-
AUG	E	E	E	E	P	-
SEP	E	P	E	E	P	-
OCT	E	E	G	G	P	-
NOV	P	E	G	G	E	-
DEC	E	E	E	P	P	E
Annual	E	G	G	P	P	P

A.4.11. Umkomaas

Sample data for both indicator bacteria at Umkomaas Beach was only provided for 2008 to 2013. Data for E.coli was from September 2008 to December 2013 and data for Enterococcus was from September 2008 to June 2013.

- **Seasonal Trends**

Seasonal averages of E.coli are ranked in Table A-165. Summer is ranked the highest during the first three years of the study then second highest for the next three. Autumn then yielded the highest average for the last two years of the study.

Table A-165: Umkomaas – Ranking of E.coli Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	146 (3)	60.3 (2)	131 (3)	**323 (1)**	**225 (1)**
Winter	-	179 (2)	25.8 (4)	**422 (1)**	121 (4)	145 (3)
Spring	25.8 (2)	55.8 (4)	37.3 (3)	108 (2)	243 (3)	76.7 (4)
Summer	**52 (1)**	**323 (1)**	**124 (1)**	108 (2)	256 (2)	201 (2)

Summer produced the highest average of Enterococcus from 2008 to 2010. Thereafter, based on available data, the highest average level is shown to occur during the winter months. There is no correlation between E.coli and Enterococcus.

Table A-166: Umkomaas – Ranking of Enterococcus Seasonal Averages

	2008	2009	2010	2011	2012	2013
Autumn	-	174 (2)	153 (2)	168 (3)	136 (4)	370 (2)
Winter	-	95.0 (3)	64.4 (3)	**1026 (1)**	**248 (1)**	**800 (1)**
Spring	107 (2)	52.5 (4)	28.0 (4)	121 (4)	228 (3)	-
Summer	**396 (1)**	**346 (1)**	**161 (1)**	730 (2)	236 (2)	-

- **Annual Trends**

Figures A-124 and A-125 show the annual analysis of E.coli and Enterococcus respectively. E.coli has varied at Umkomaas beach with average concentrations fluctuating but ultimately increasing. In 2012 the average increased more than 5 fold since the start of the study period. Large standard deviations are noted, especially in 2009 and 2011. Generally the higher averages are linked with larger deviations.

Enterococcus follows a similar trend as E.coli. Average concentrations of this bacterium fluctuated but at the end of the study the average increased by more than double that at the start of the study. The lowest average is evident in 2010, thereafter the highest average is shown in 2011. The average in 2011 is almost six times that of the previous year. The standard deviations also fluctuated from extremely low to significantly high. This further highlights the variable nature of Enterococcus at Umkomaas beach. As with E.coli, the largest deviations occurred in 2009 and 2011. E.coli and Enterococcus appear to follow similar patterns of increase based on averages.

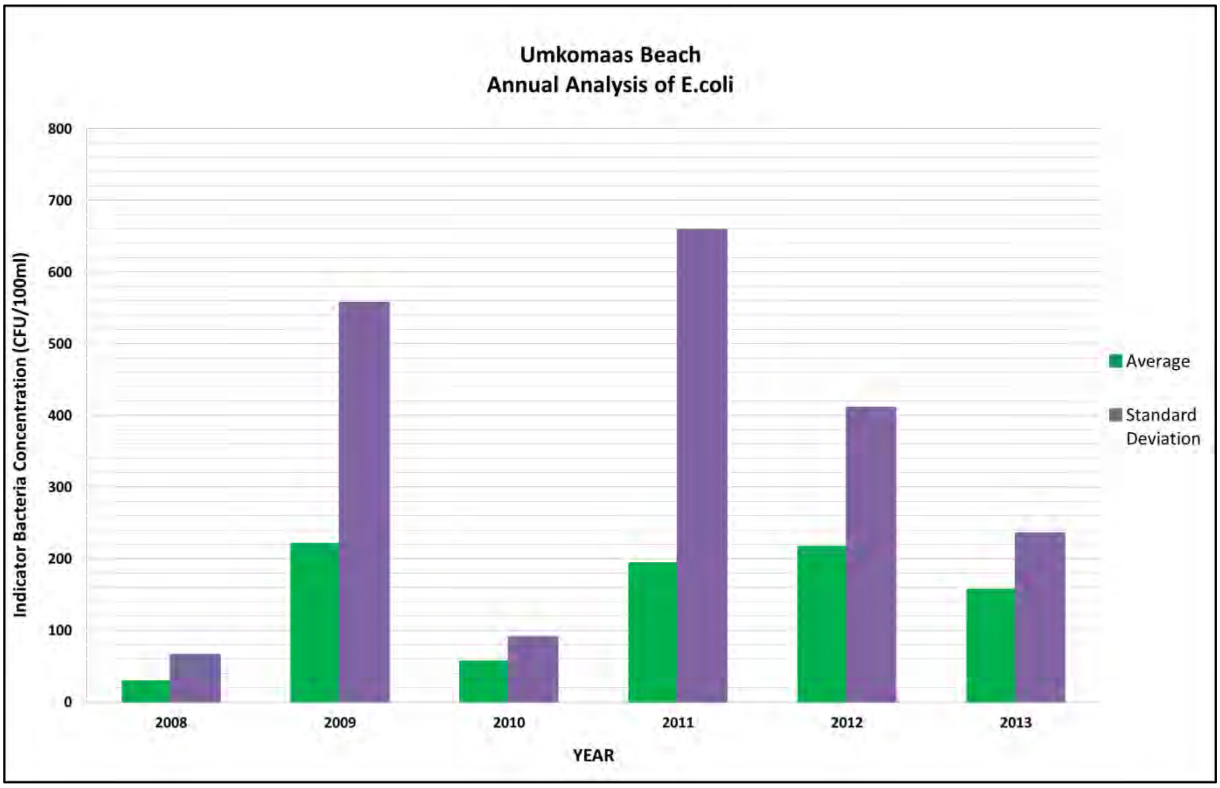


Figure A-124: Annual Analysis of E.coli at Umkomaas Beach

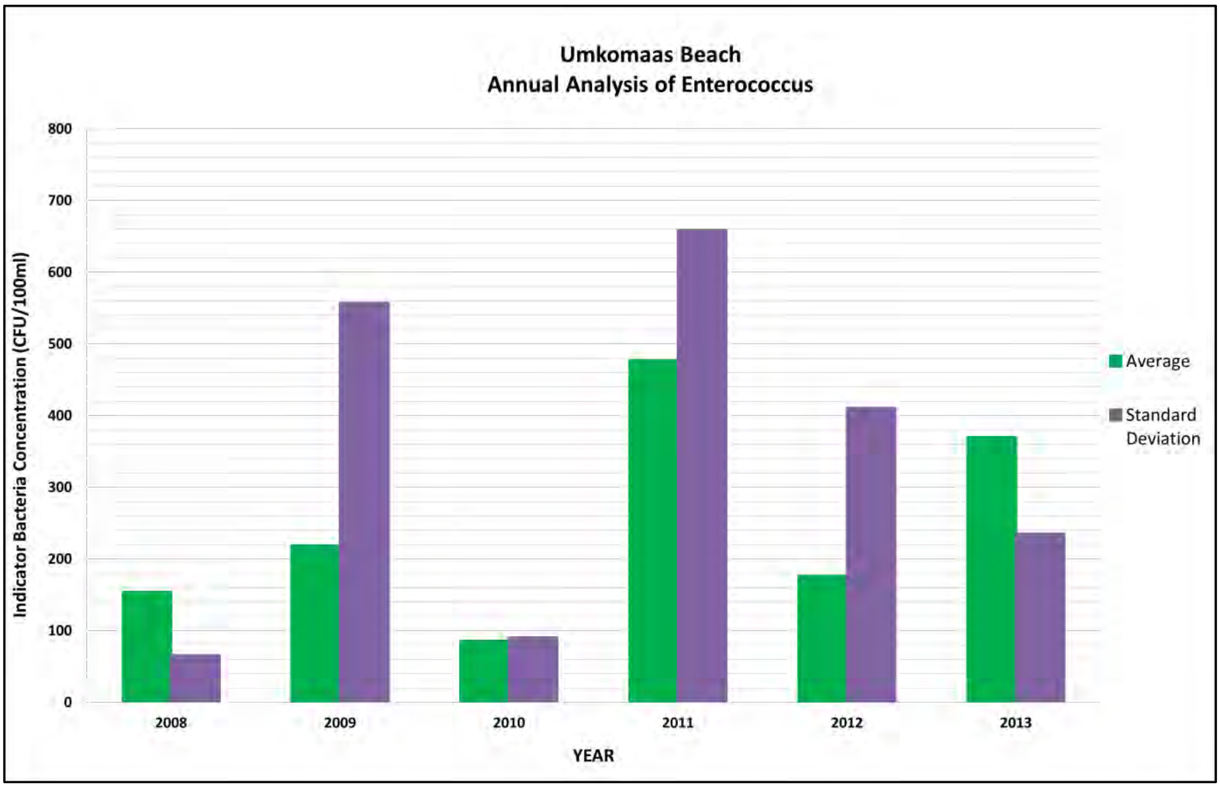


Figure A-125: Annual Analysis of Enterococcus at Umkomaas Beach

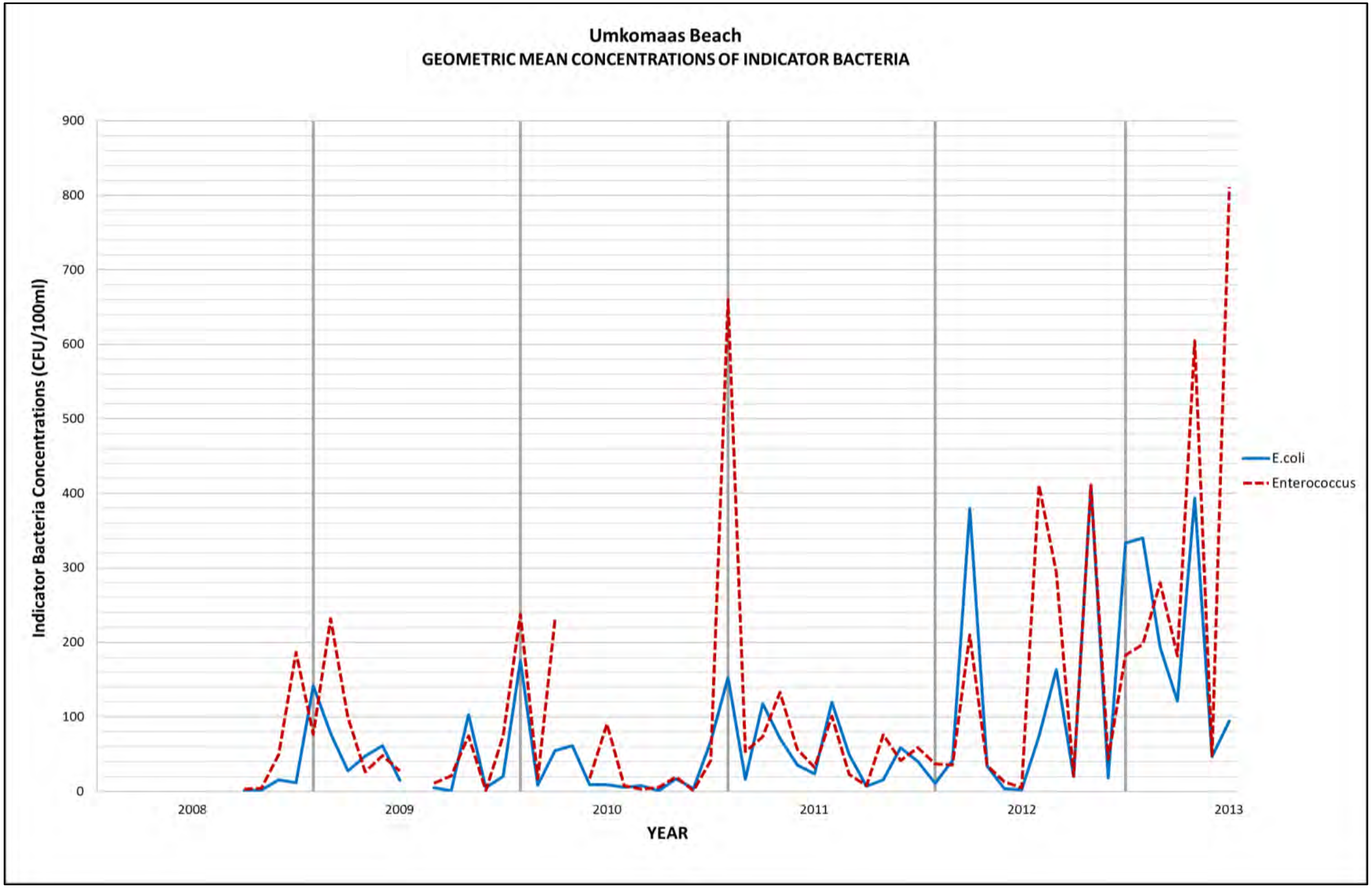


Figure A-126: Umkomaas – Geometric Mean Concentrations of Indicator Bacteria (200A-2013)

Figure A-126 shows a general increase in the geometric mean concentrations for both indicator bacteria. Enterococcus exceeded E.coli most often during the study period. The two bacteria follow the same patterns of variability. Although the actual geometric mean concentrations differed for each bacterium, E.coli and Enterococcus mirrored each other.

- **SAWQ Guidelines**

Table A-167 summarises the microbiological water quality rating based on E.coli at Umkomaas. Overall the water quality was classified as mostly good. Poor water quality conditions never occurred during the study period.

Table A-167: Umkomaas – E.coli Microbiological Water Quality Rating

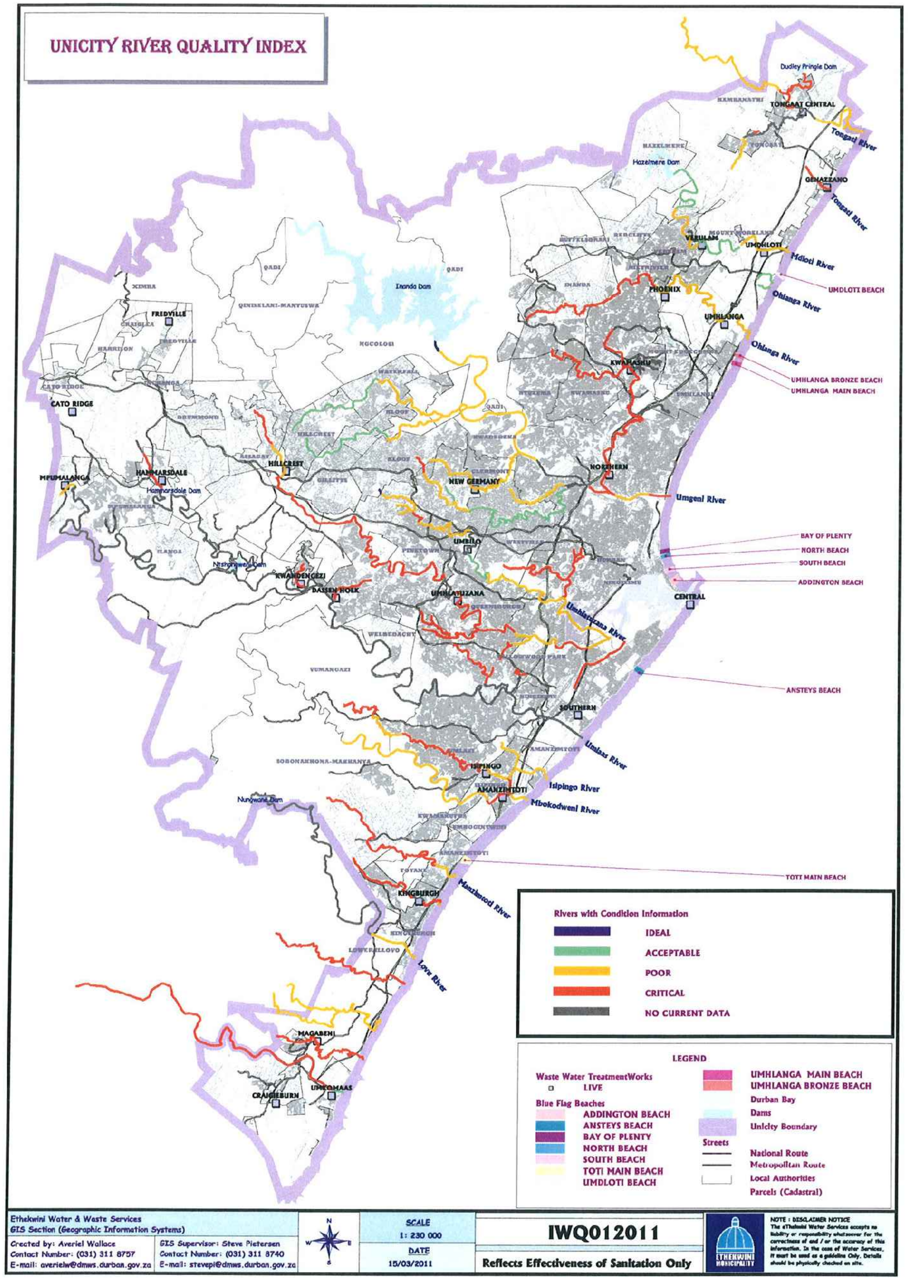
	2008	2009	2010	2011	2012	2013
JAN	-	G	G	G	G	G
FEB	-	G	E	E	E	G
MAR	-	E	E	G	G	E
APR	-	E	E	G	G	G
MAY	-	G	E	E	E	E
JUN	-	G	E	G	E	G
JUL	-	-	E	G	E	E
AUG	-	E	E	G	G	E
SEP	E	E	E	E	G	E
OCT	E	G	E	G	G	E
NOV	E	E	E	G	E	G
DEC	E	E	G	E	G	E
Annual	E	G	E	G	G	G

Table A-168 shows the microbiological rating for Enterococcus. The annual ratings show the water quality at Umkomaas based on Enterococcus has been good for the first half of the study, and poor for the second half. Occurrences of poorer water quality are shown to be consistently in the summer months. The highest incidences of poor water quality conditions are evident in 2012.

Table A-168: Umkomaas – Enterococcus Microbiological Water Quality Rating

	2008	2009	2010	2011	2012	2013
JAN	-	P	P	P	P	G
FEB	-	G	G	G	G	P
MAR	-	P	G	P	G	G
APR	-	G	-	P	G	P
MAY	-	G	G	G	E	G
JUN	-	G	G	G	E	G
JUL	-	-	E	G	P	-
AUG	-	E	E	E	P	-
SEP	G	E	G	G	P	-
OCT	G	G	G	G	P	-
NOV	P	E	E	G	E	-
DEC	G	G	G	P	P	-
Annual	G	G	G	P	P	P

APPENDIX B: River Quality Indices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Inanda Dam
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UMHLANGA
Ohlanga River
UMHLANGA BRONZE BEACH
UMHLANGA MAIN BEACH
KWAMASHU
FREDVILLE
CATO RIDGE
HAMMARSDALE
Hammarsdale Dam
HILLCREST
NEW GERMANY
NORTHERN
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SOUTH BEACH
ADDINGTON BEACH
Nshongweni Dam
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Umhlatuzana River
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SOUTHERN
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ISIPINGO
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MAGABENI
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UMKOMAAS
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Local Authorities
Parcels (Cadastral)
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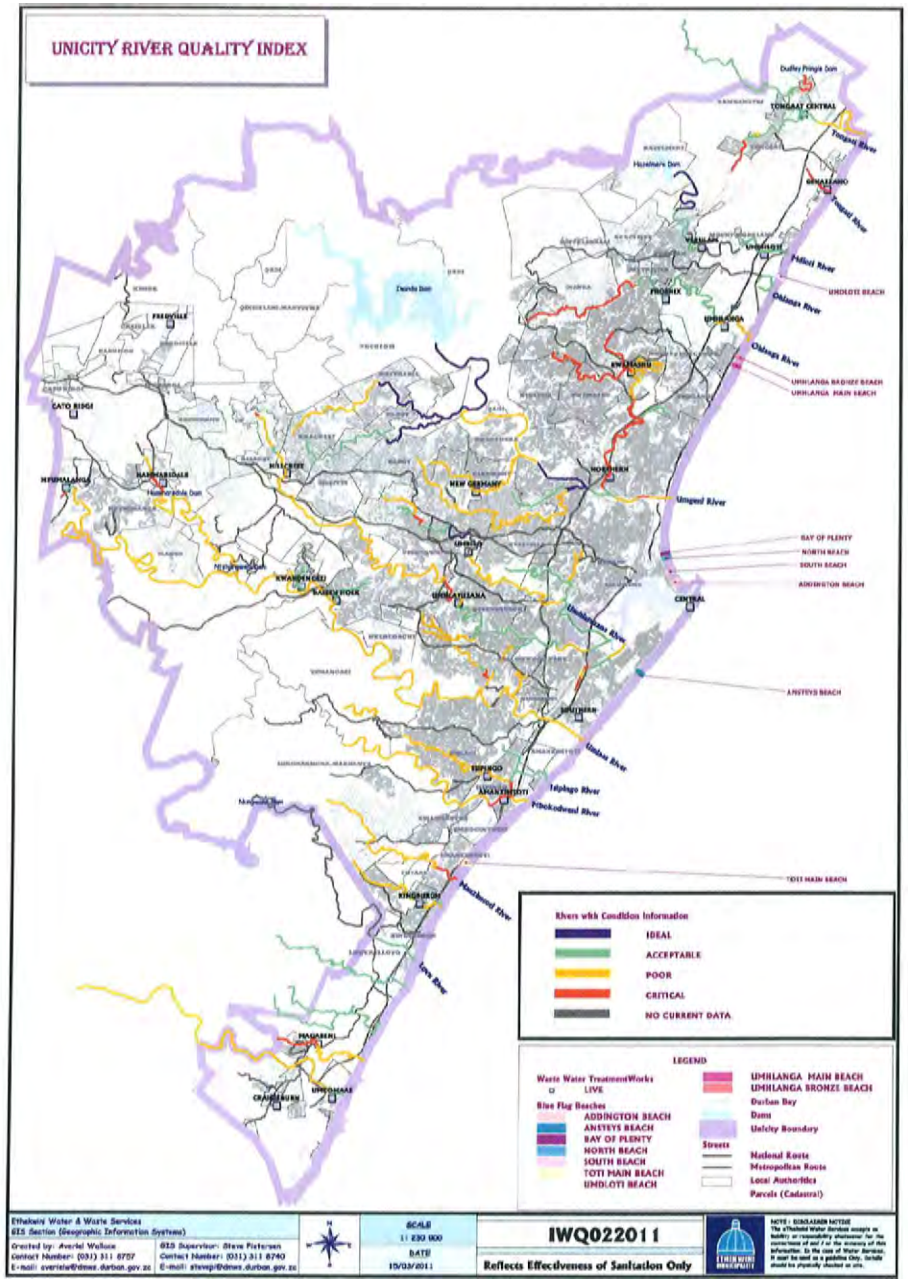
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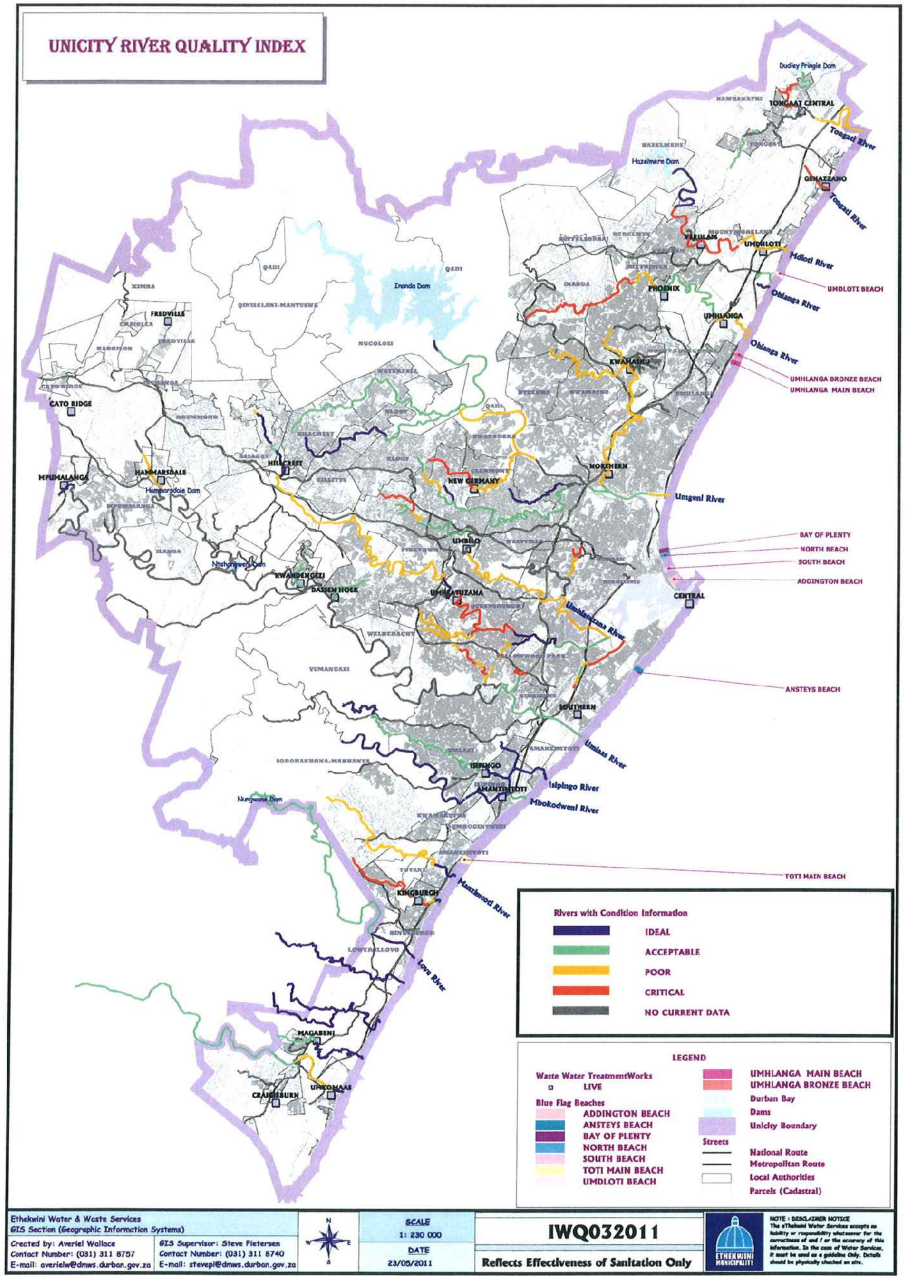
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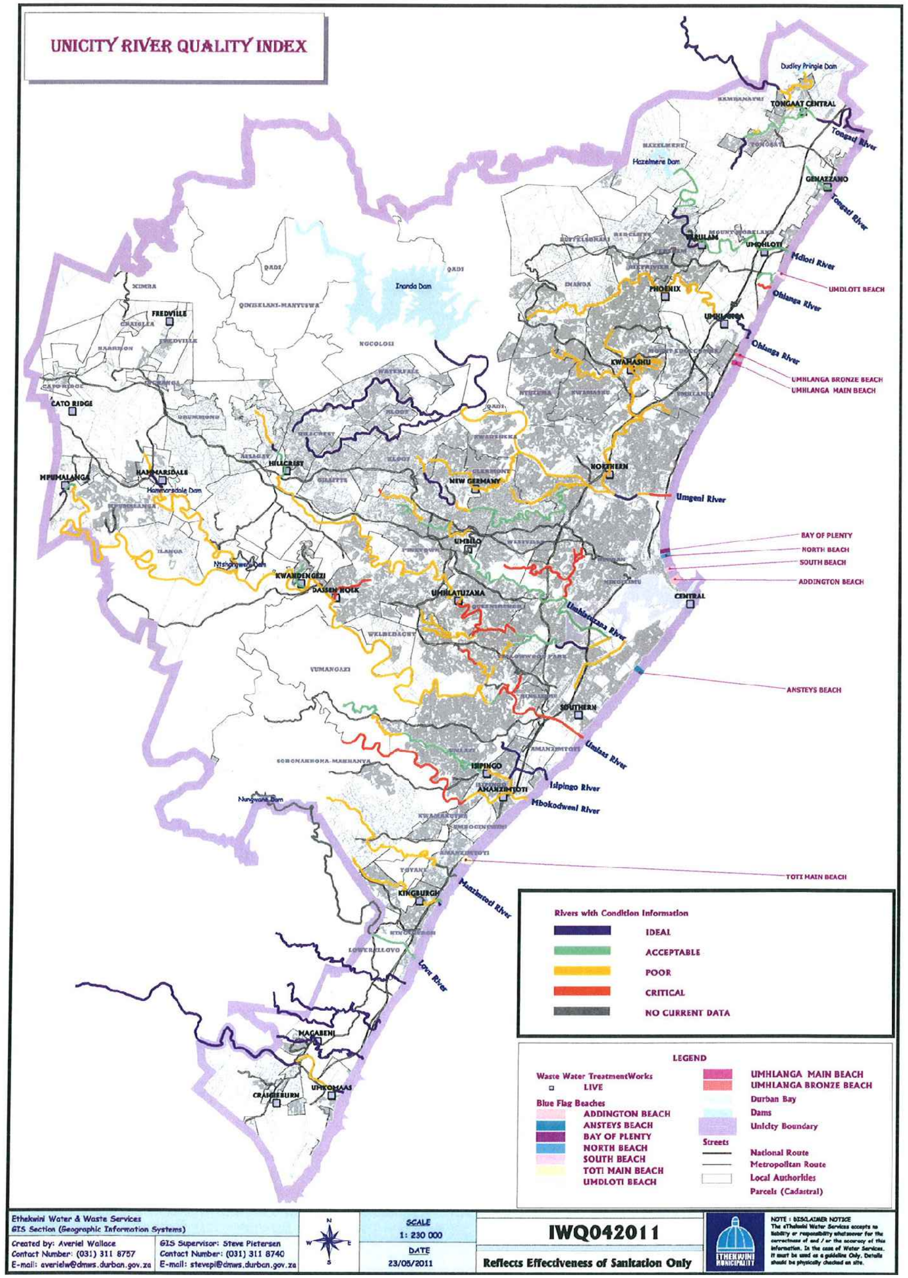
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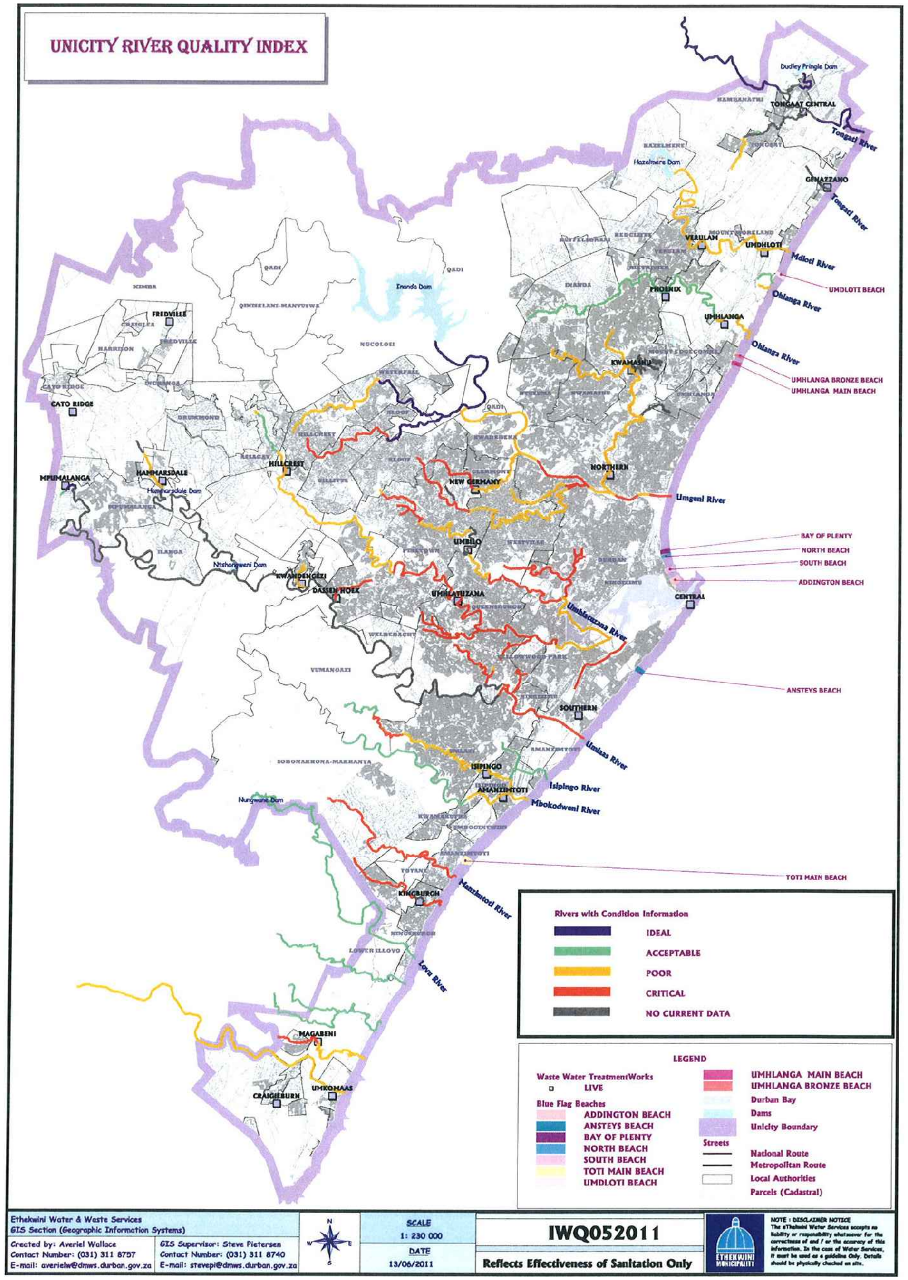

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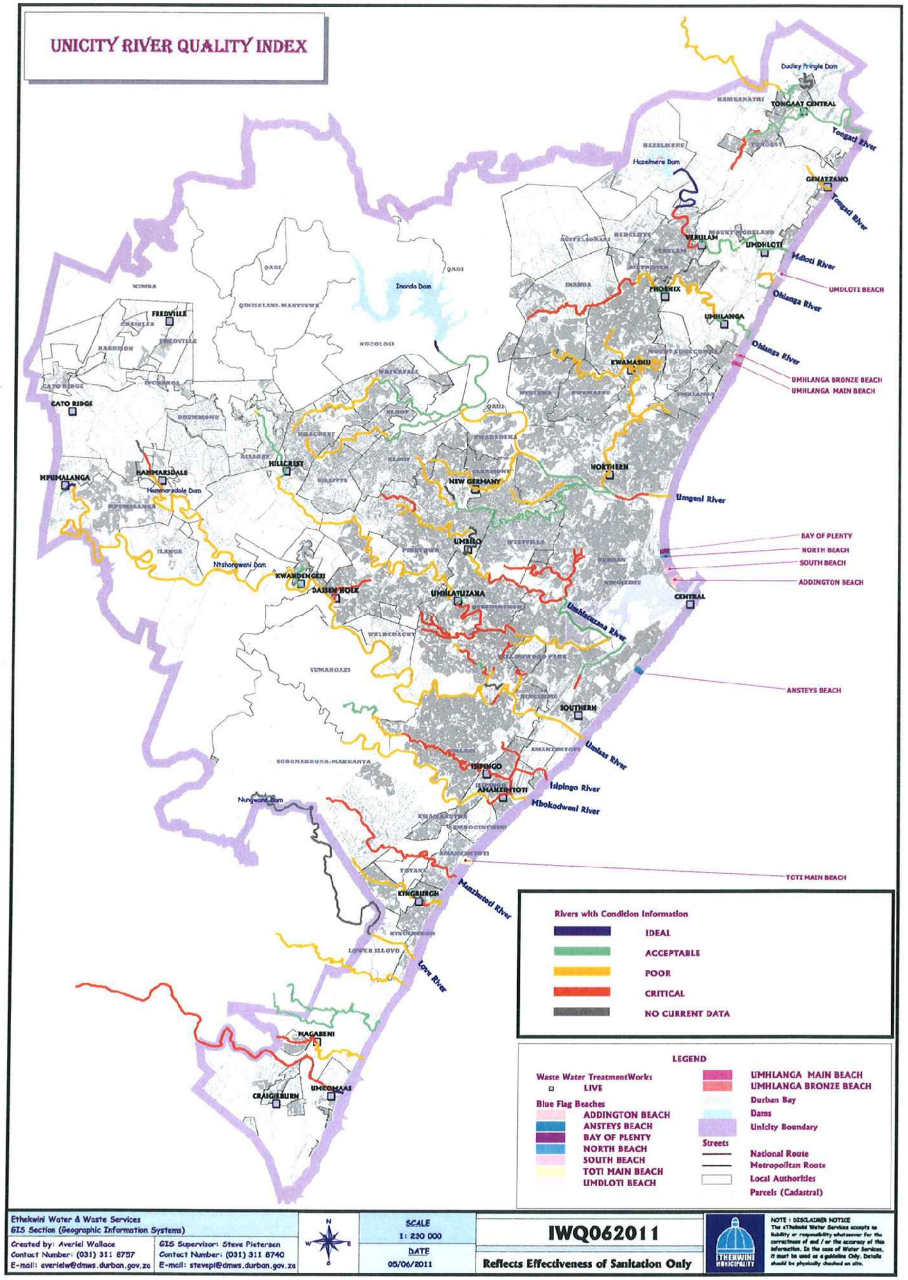

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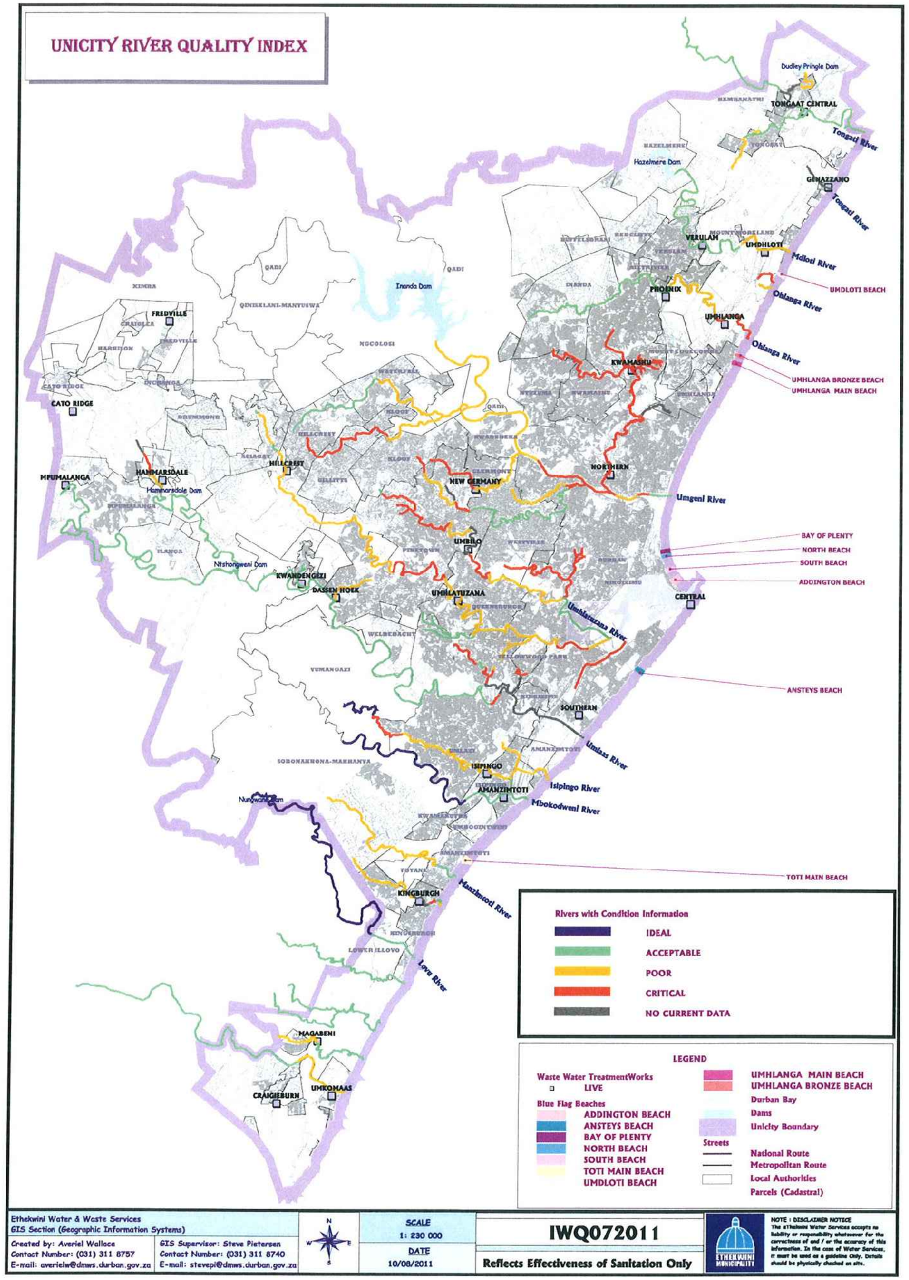
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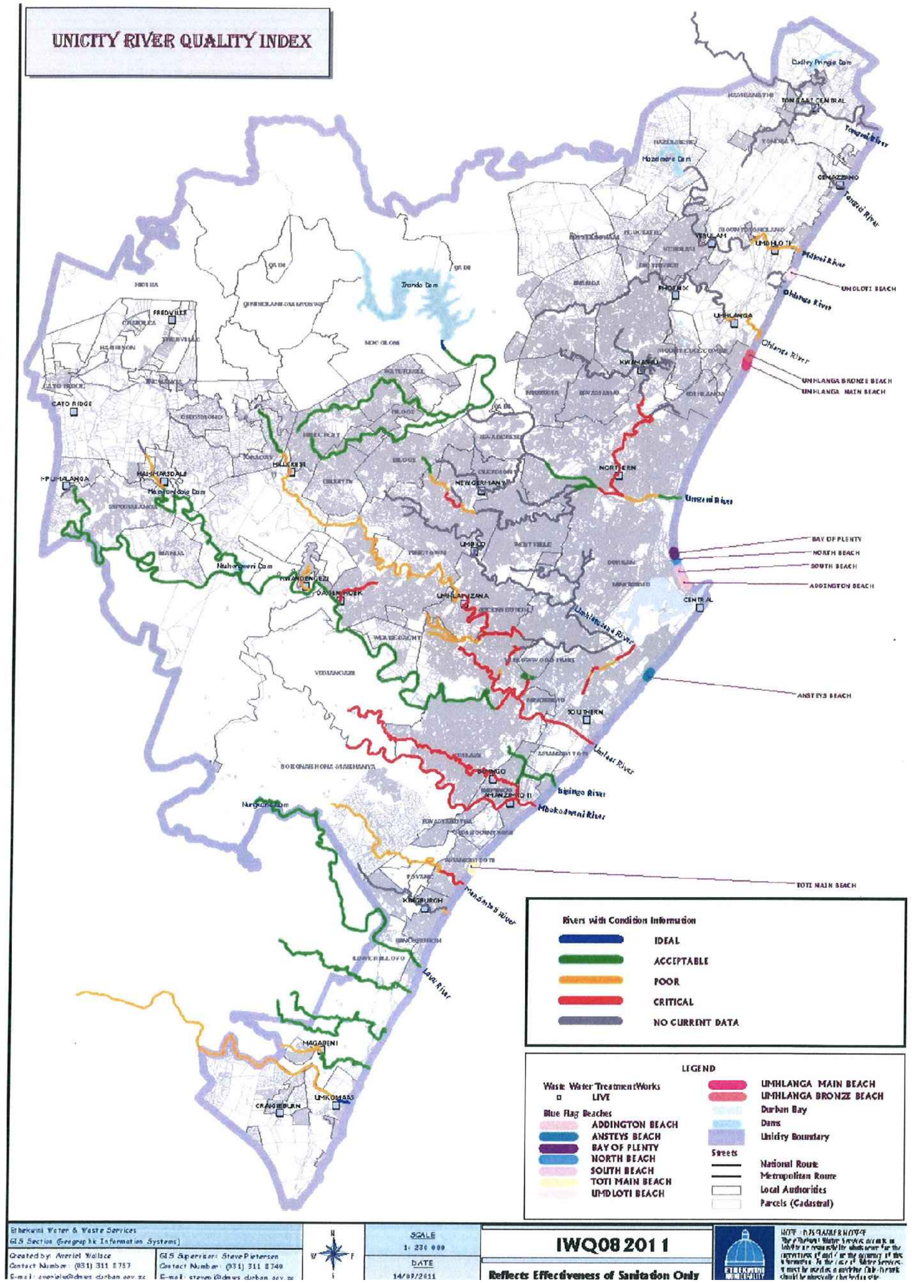
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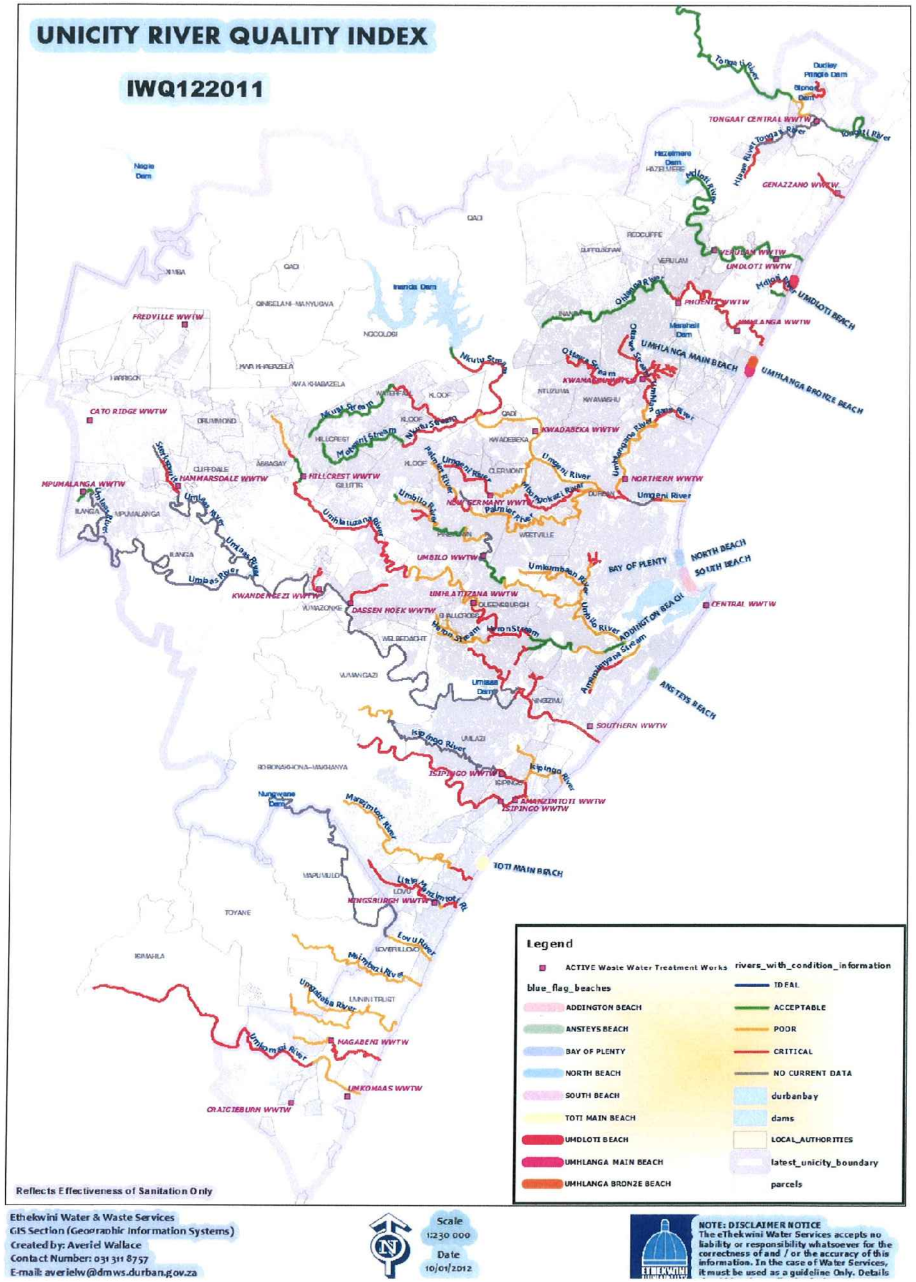
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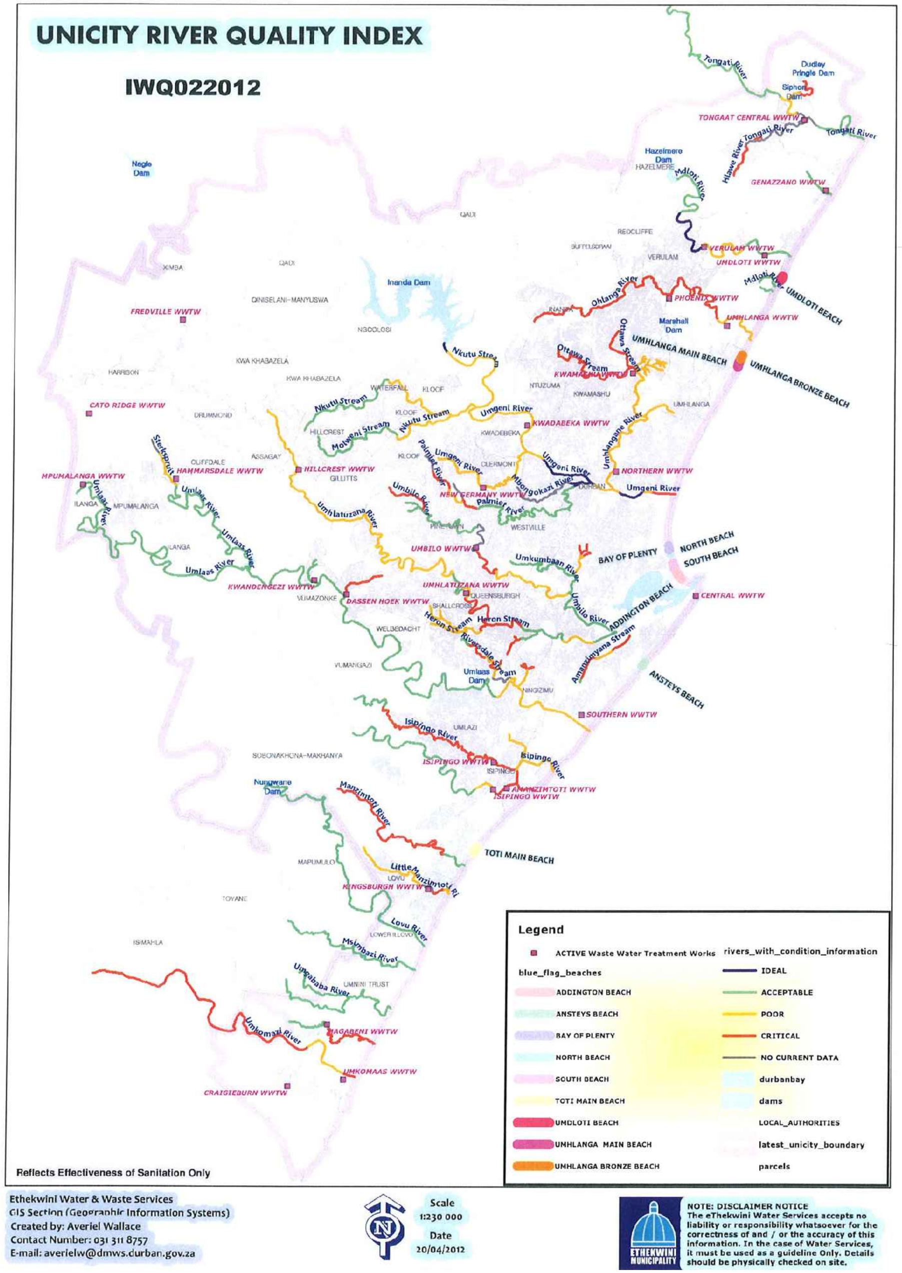
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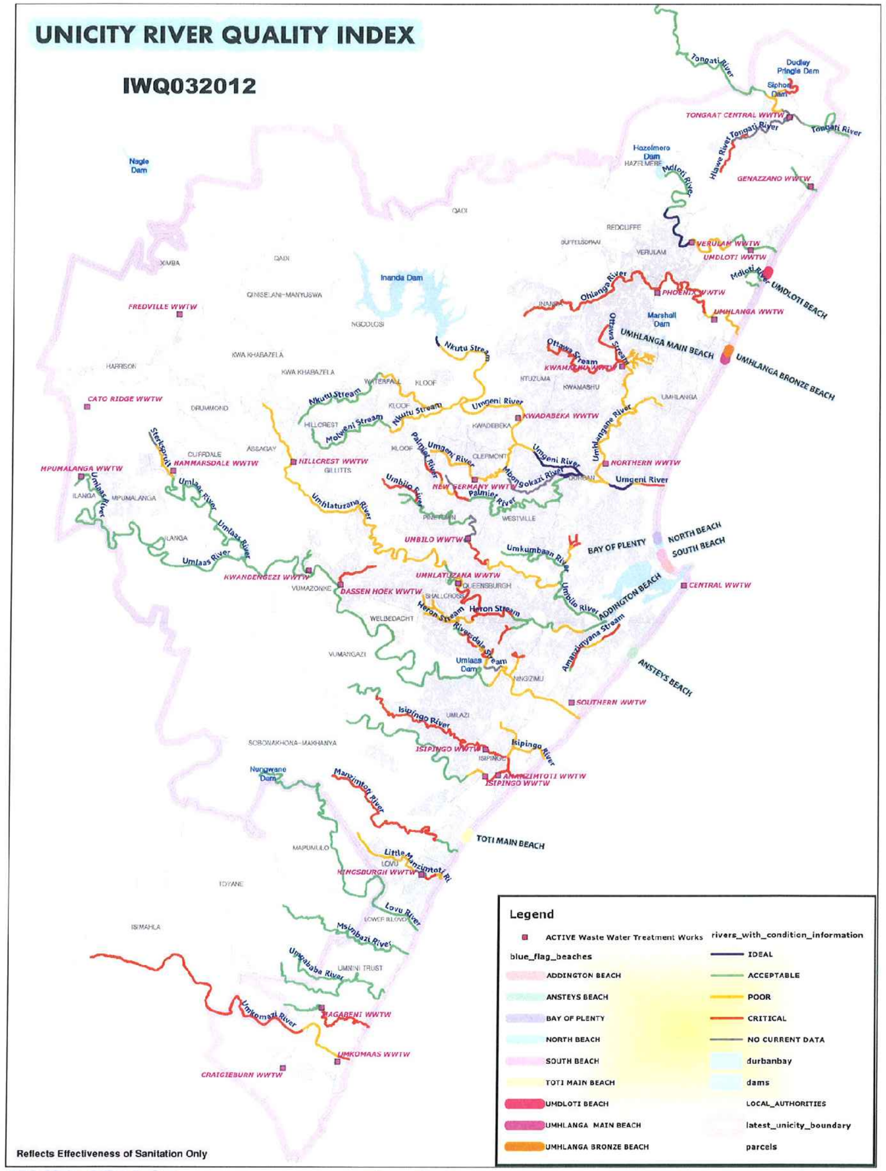

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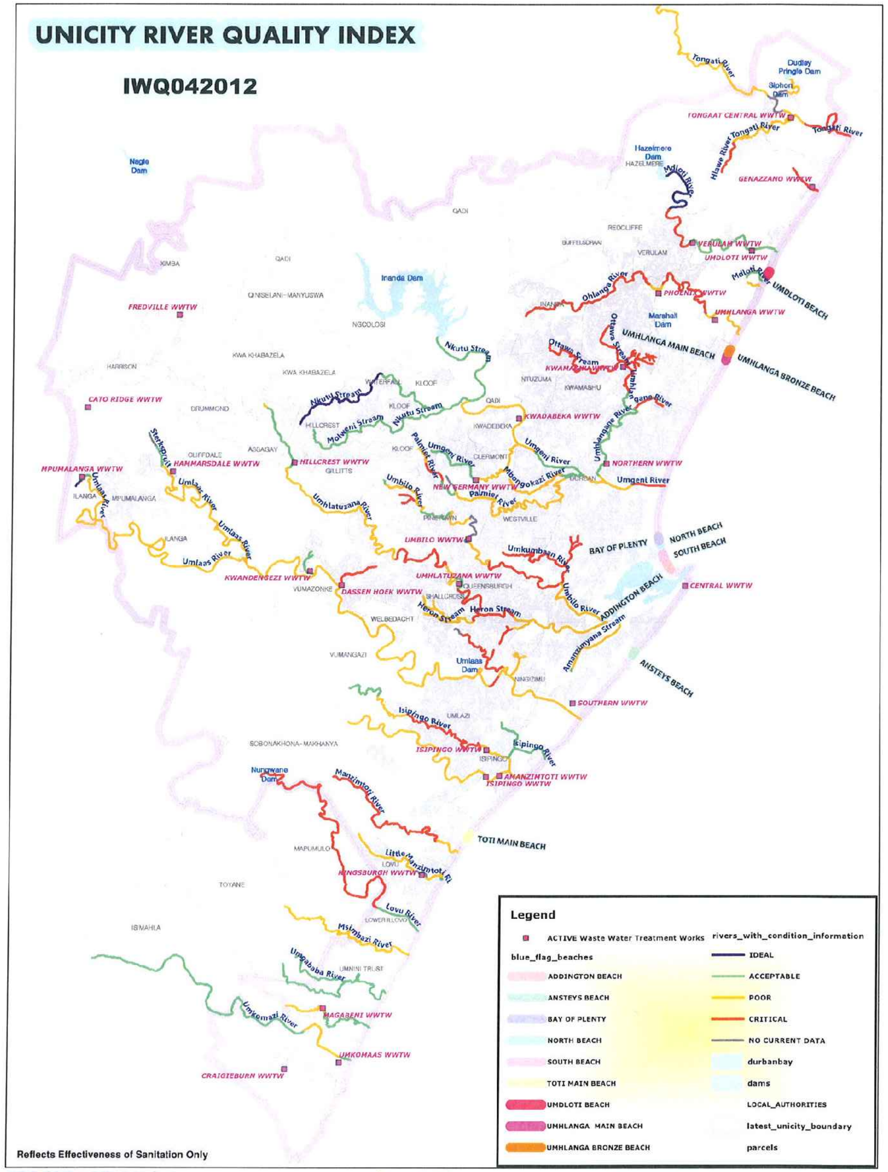

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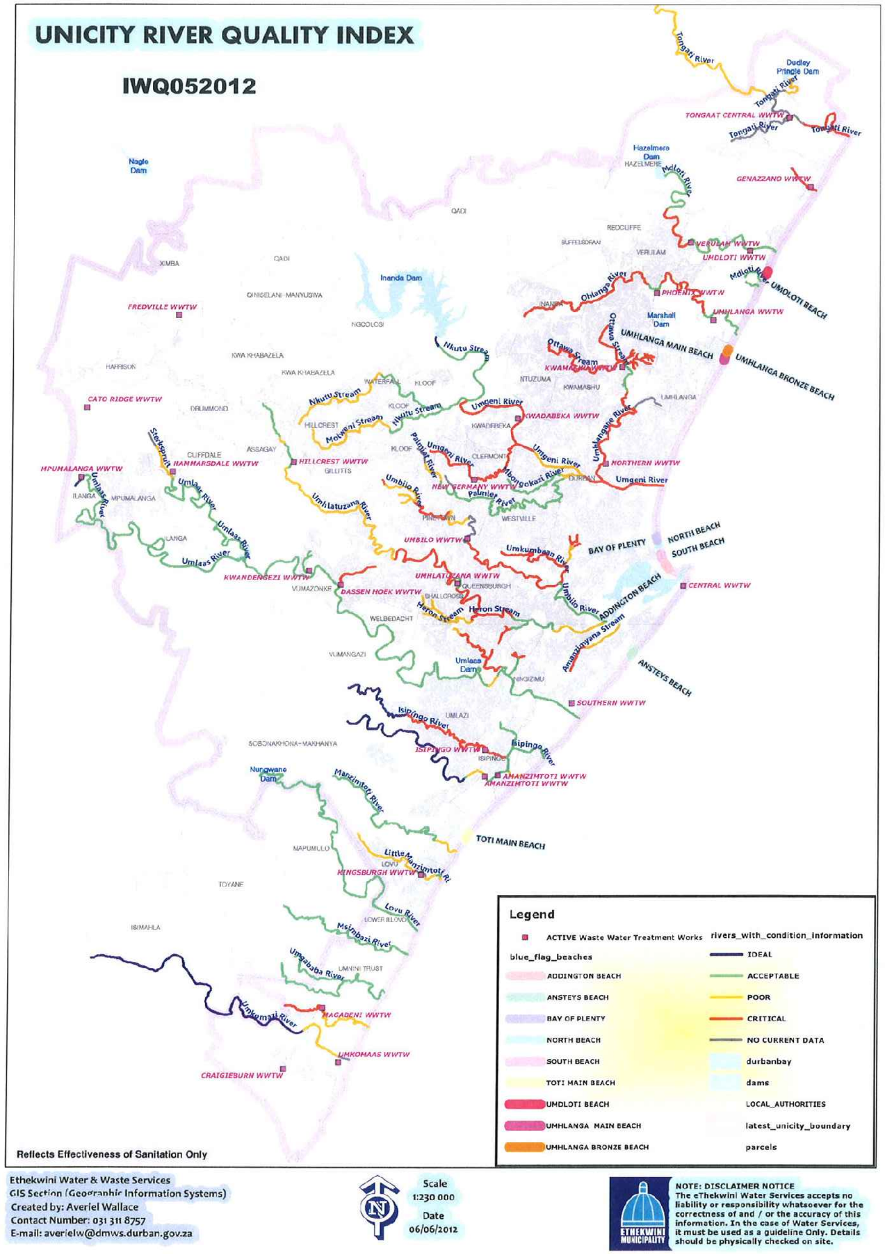

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Inanda Dam
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CATO RIDGE WWTW
KWADABEKA WWTW
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Lovu River
Msimbazi River
MAGABENI WWTW
UMKOMAAS WWTW
CRAIGIEBURN WWTW
Ethekwini Water & Waste Services
GIS Section (Geographic Information Systems)
Created by: Averiel Wallace
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E-mail: averielw@dmws.durban.gov.za
Scale 1:230 000
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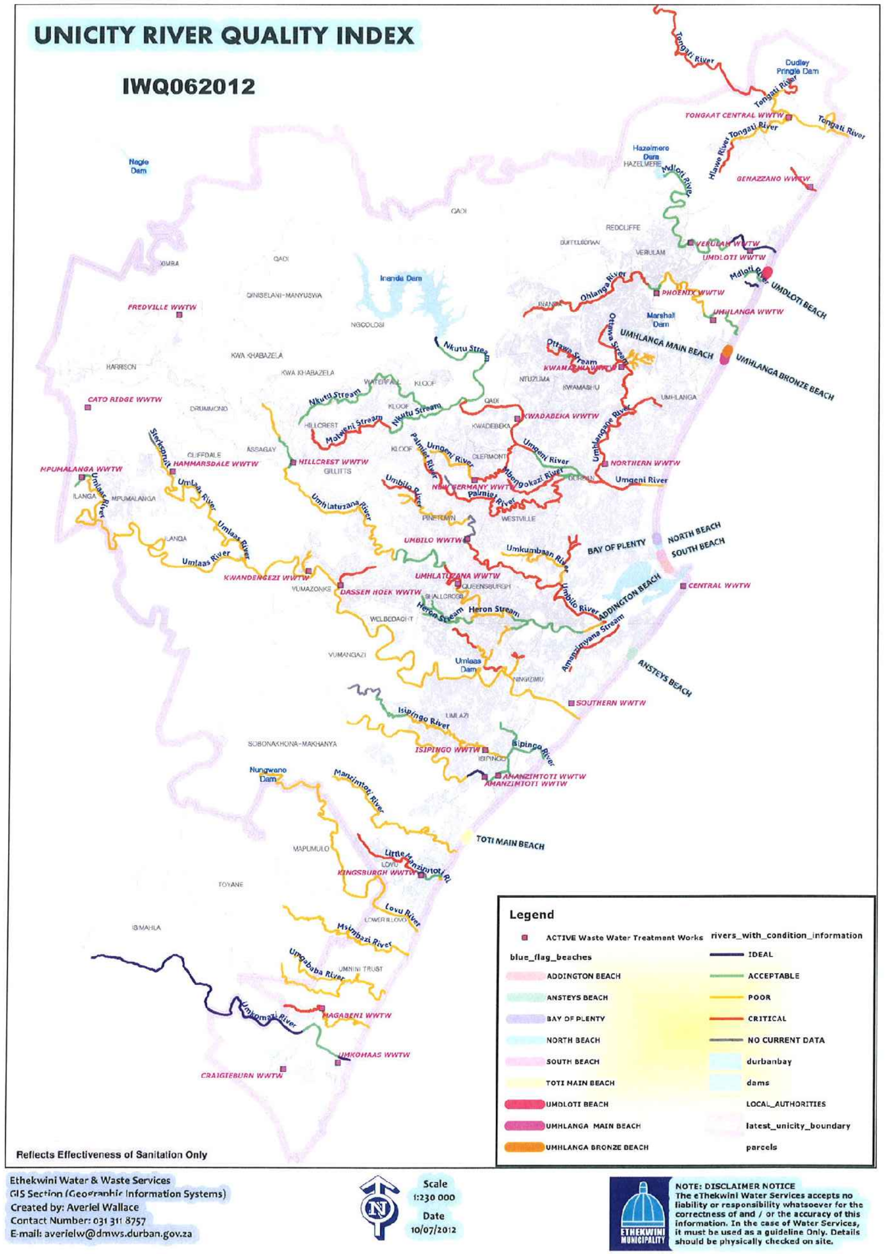

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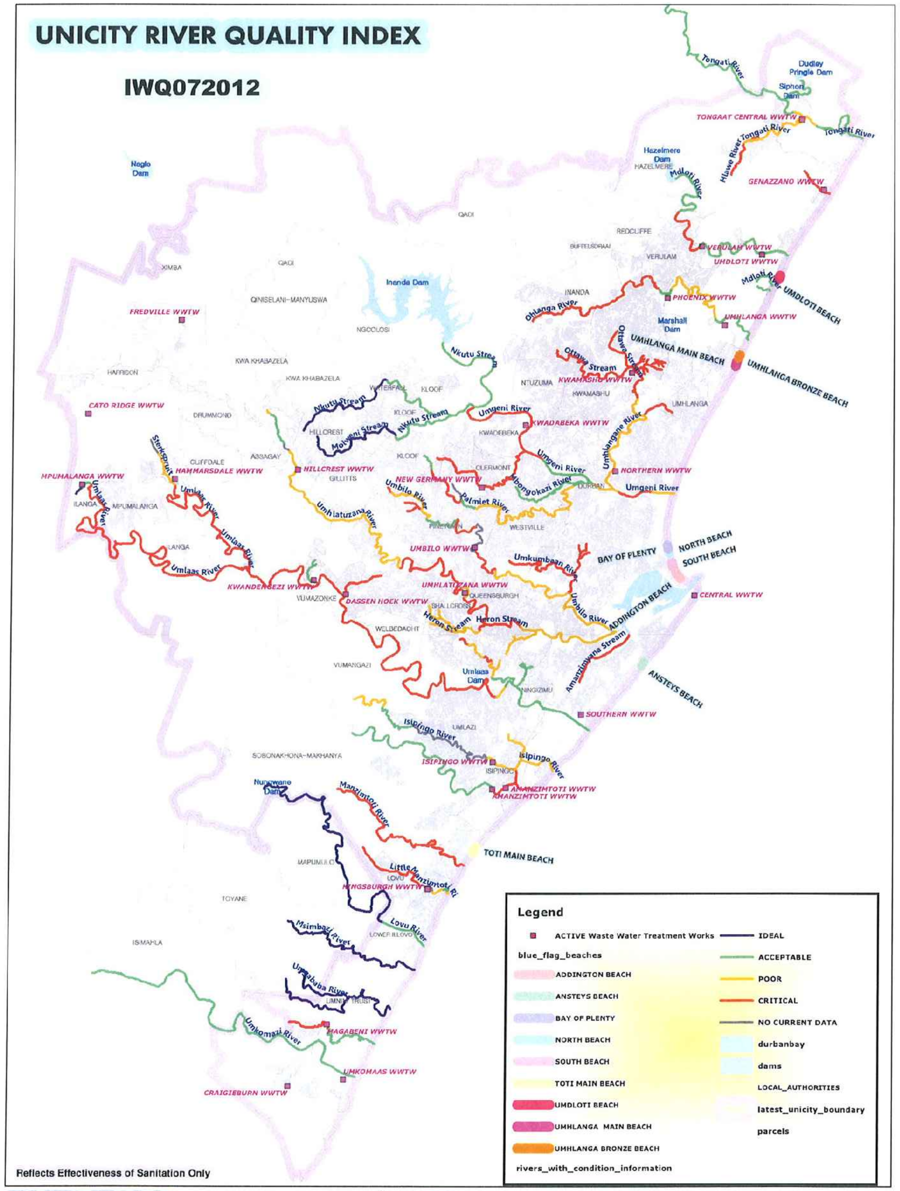

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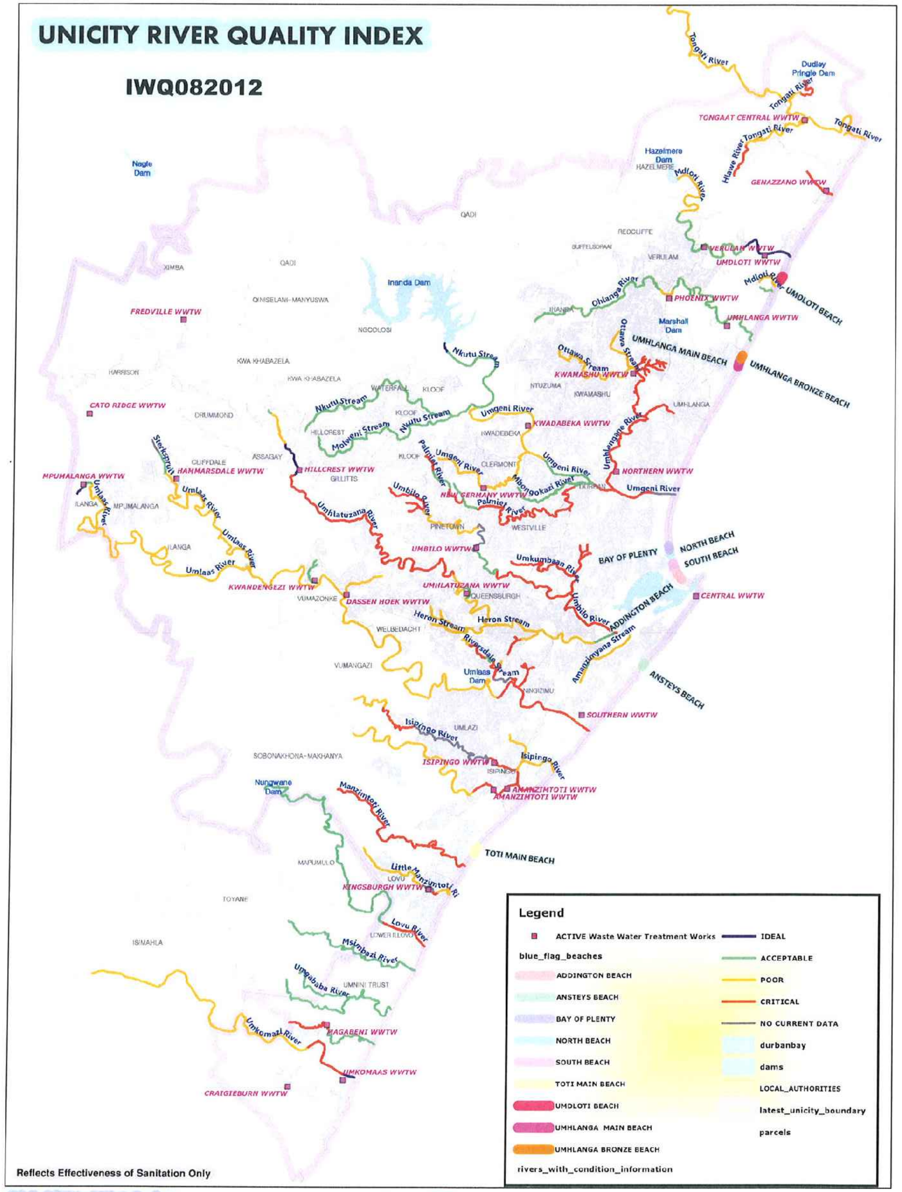

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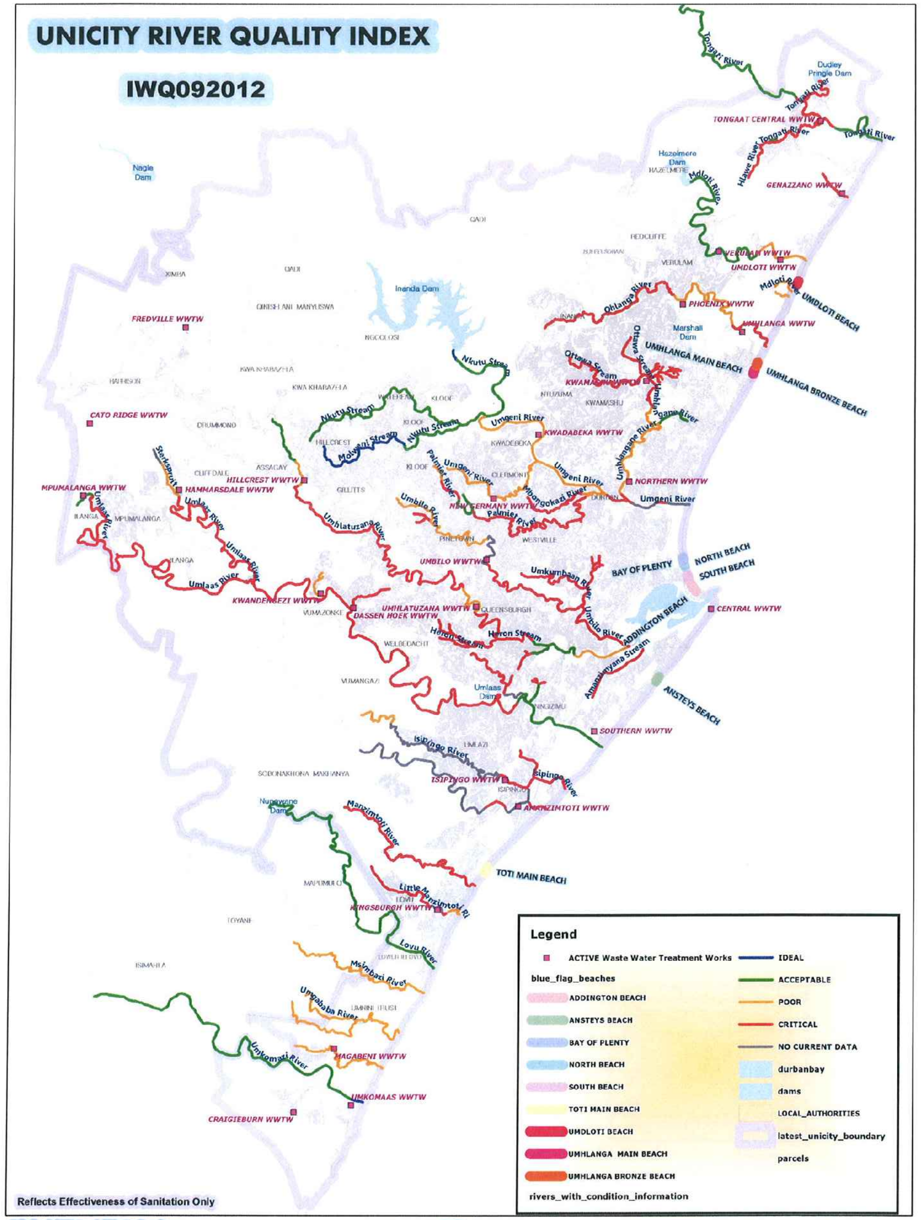

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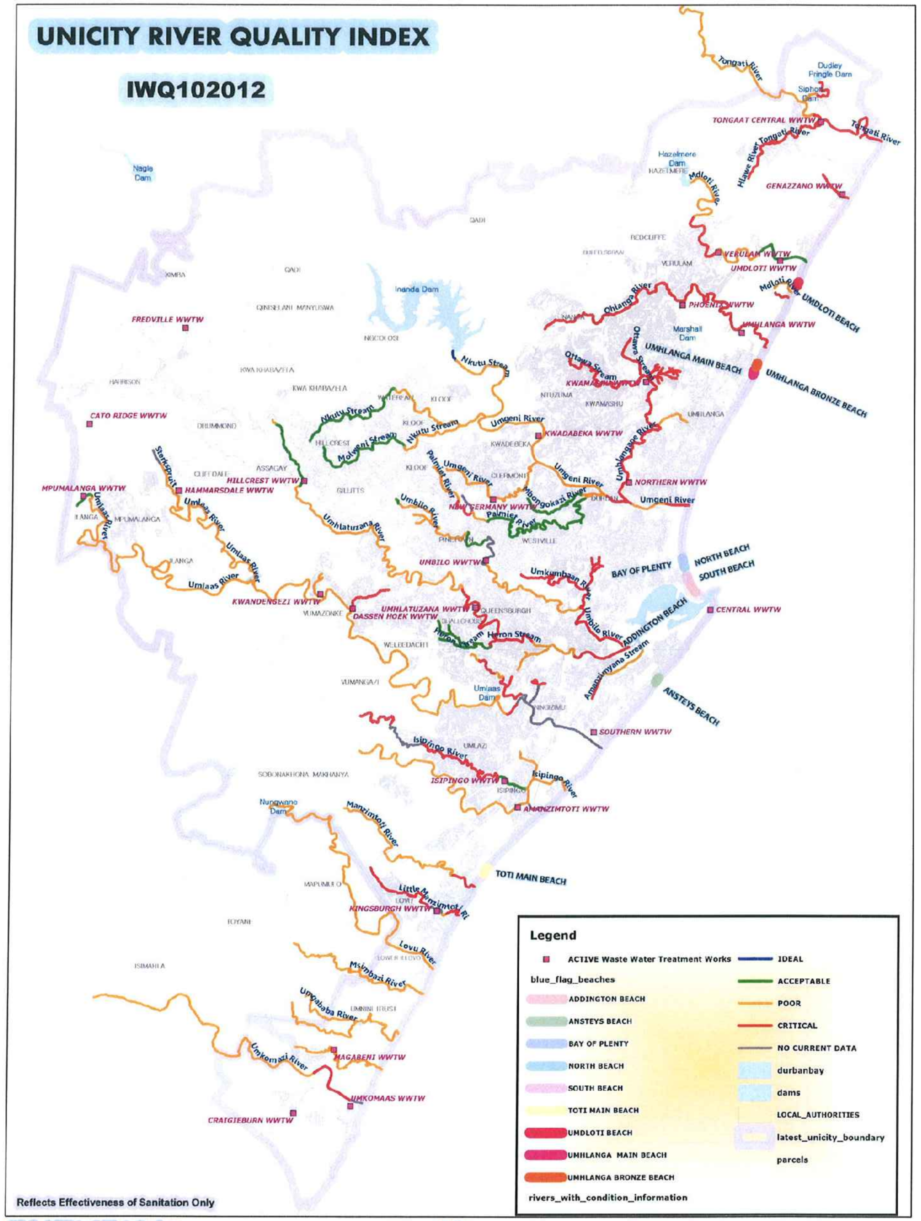

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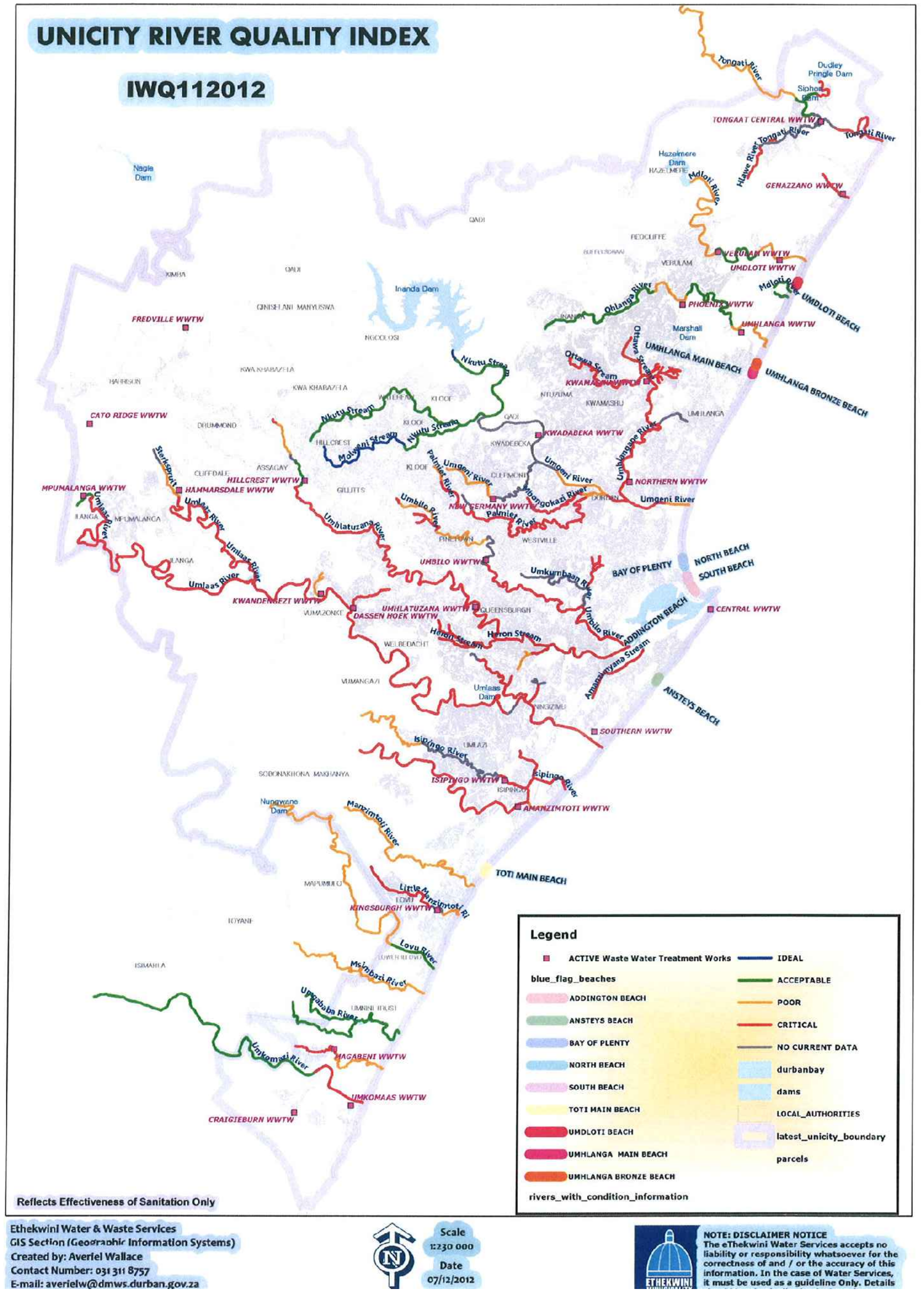
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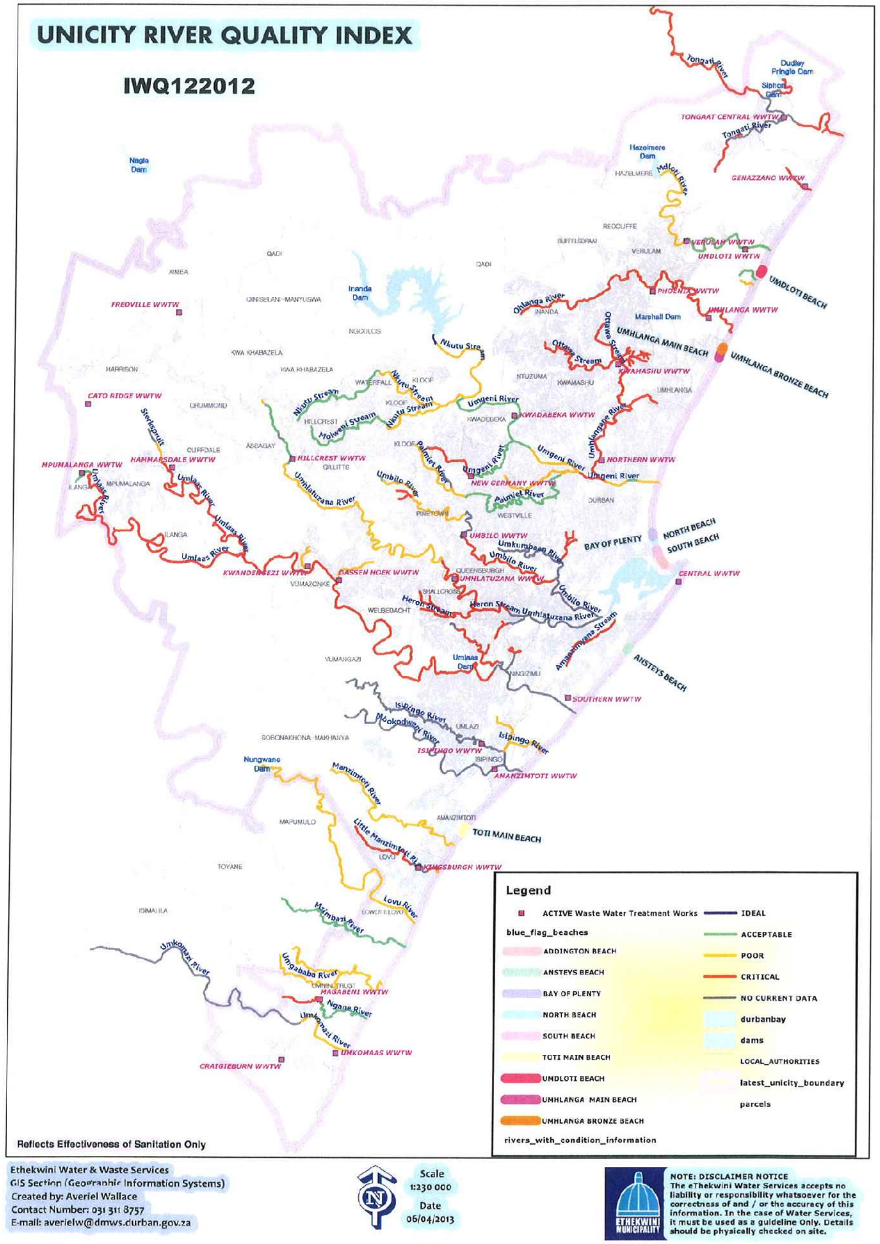
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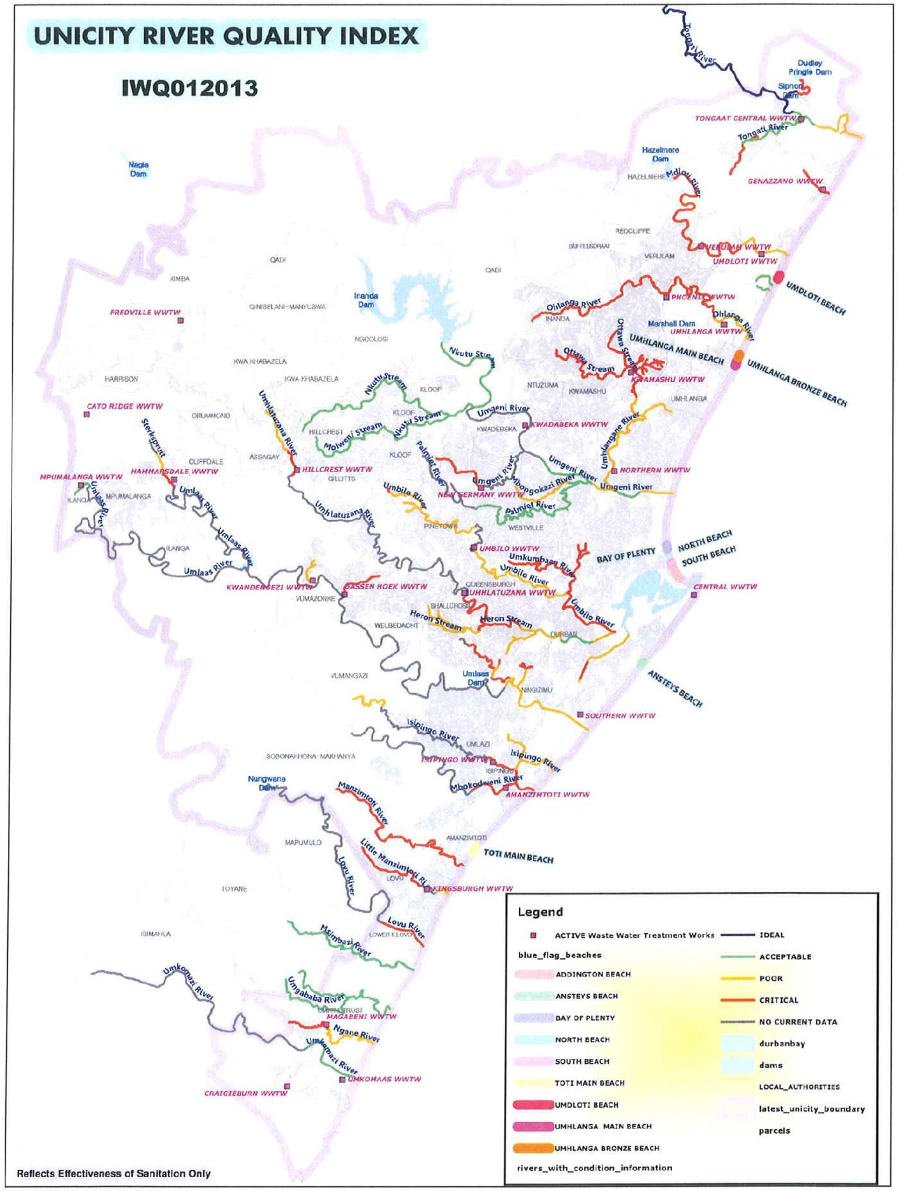

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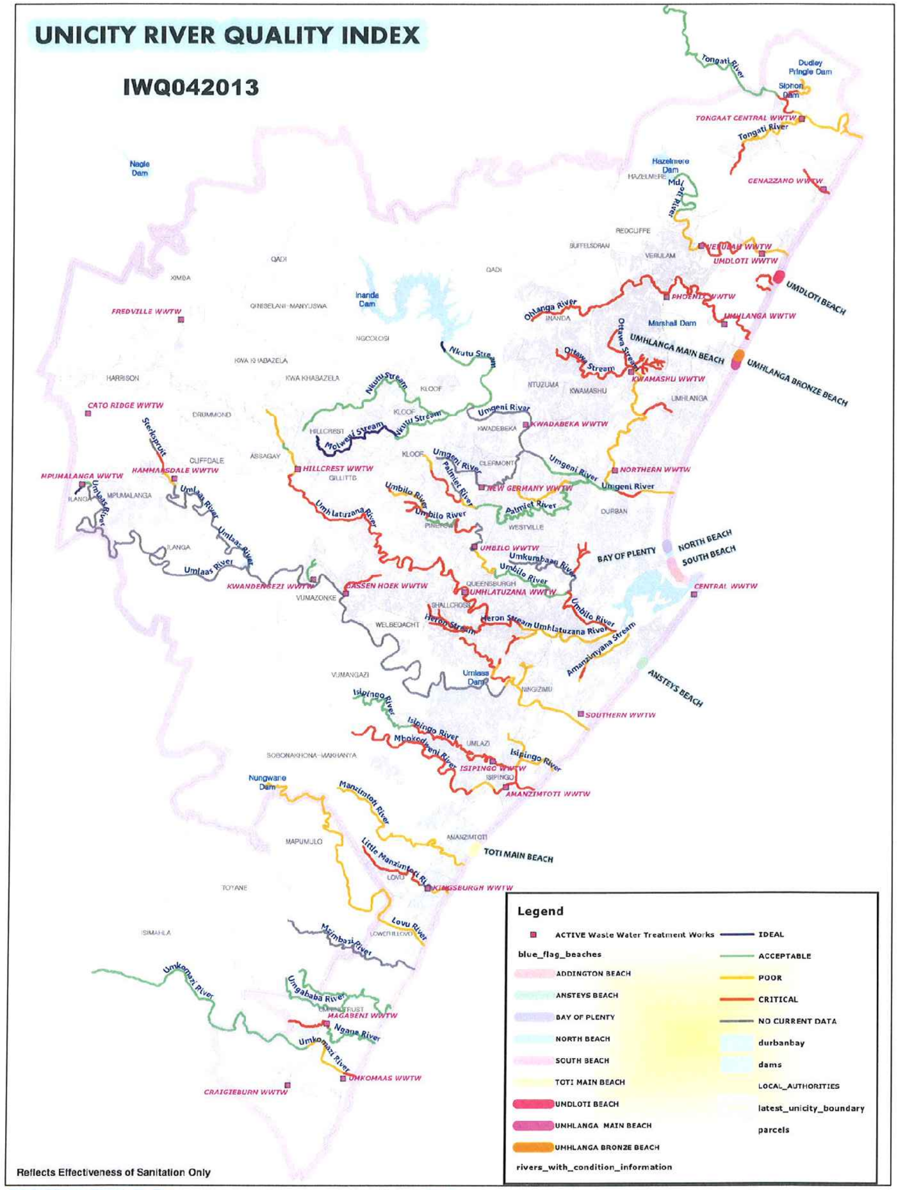

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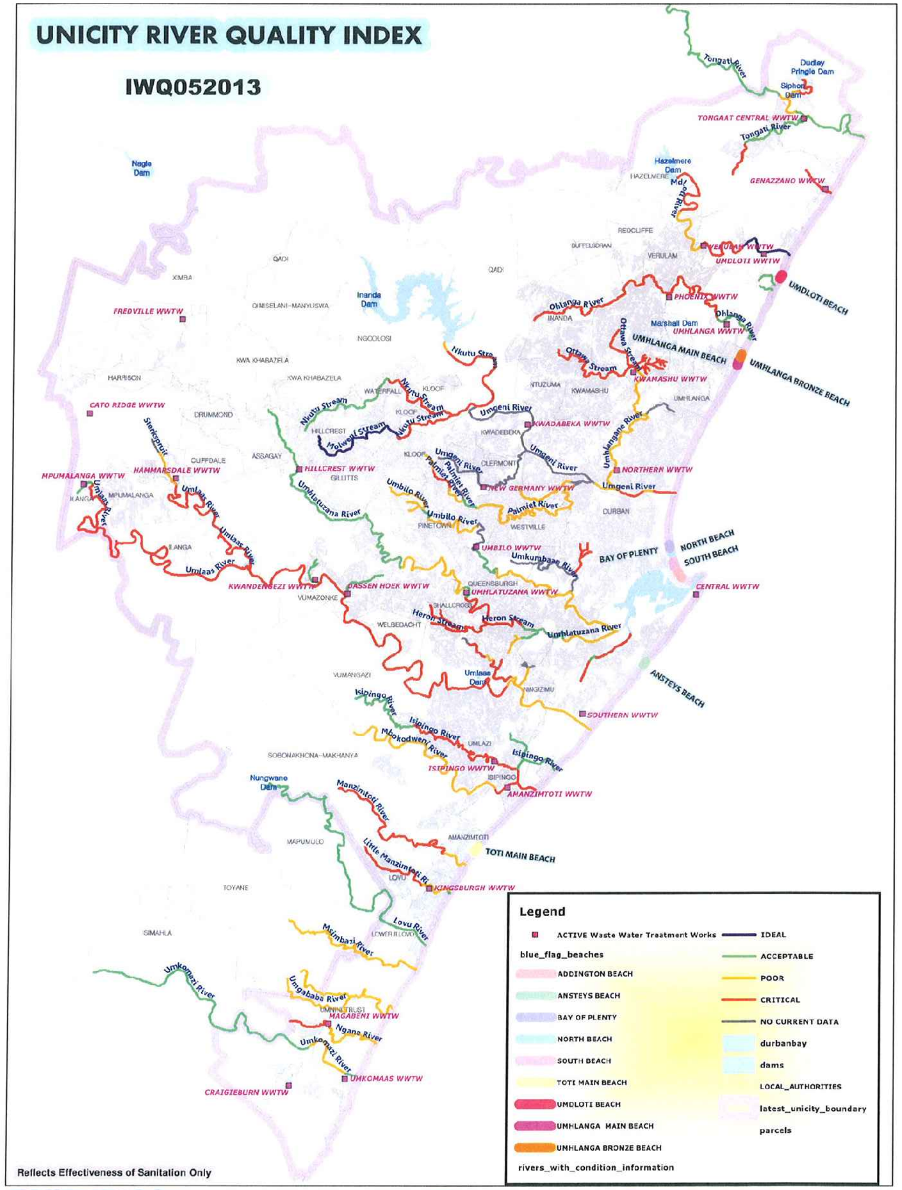

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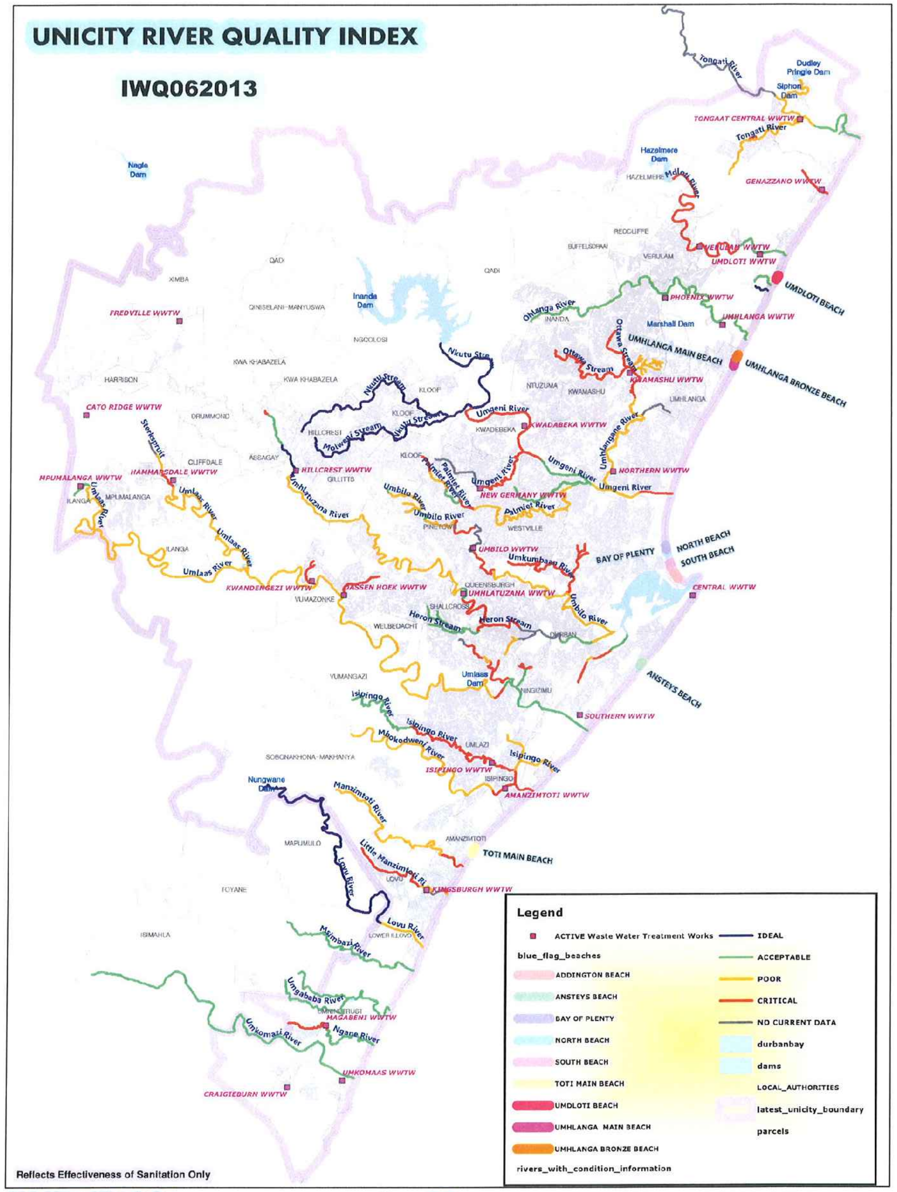

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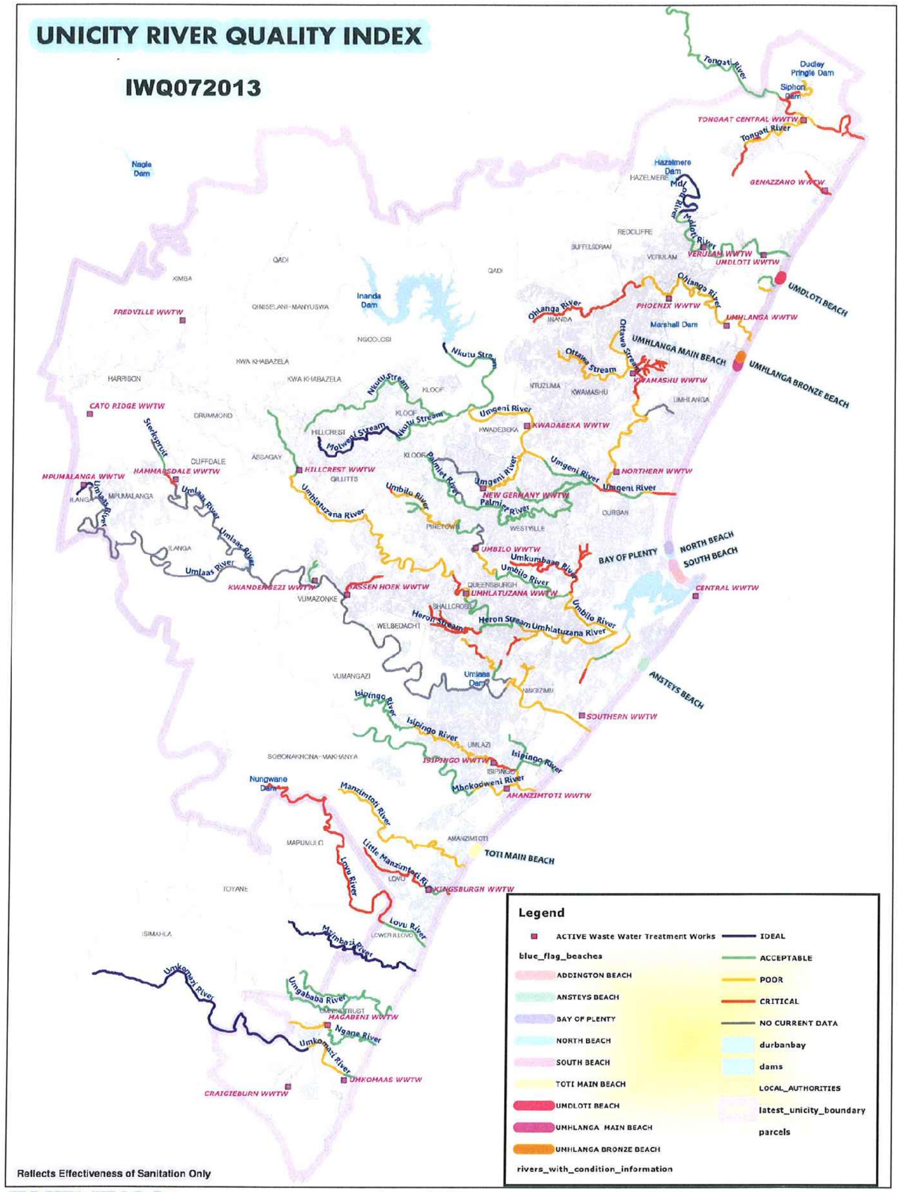

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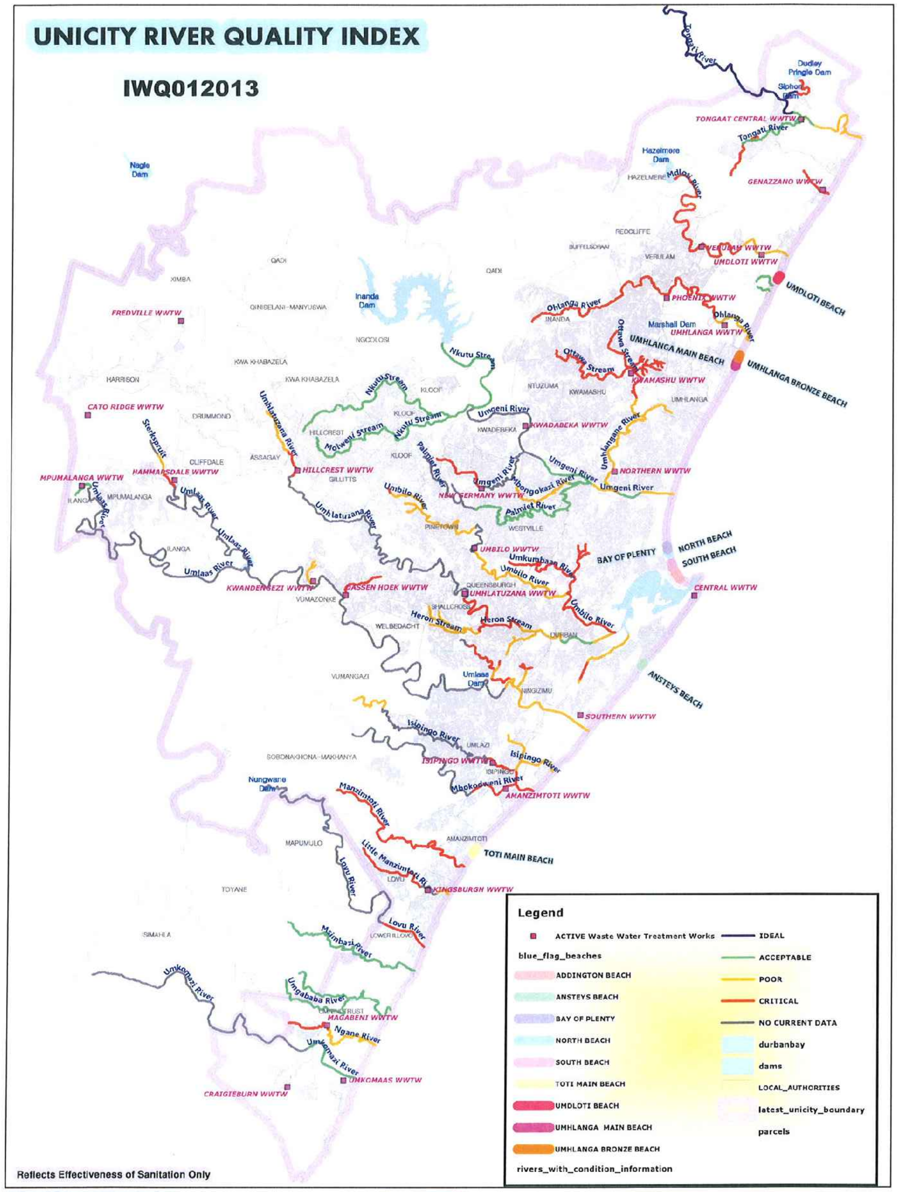

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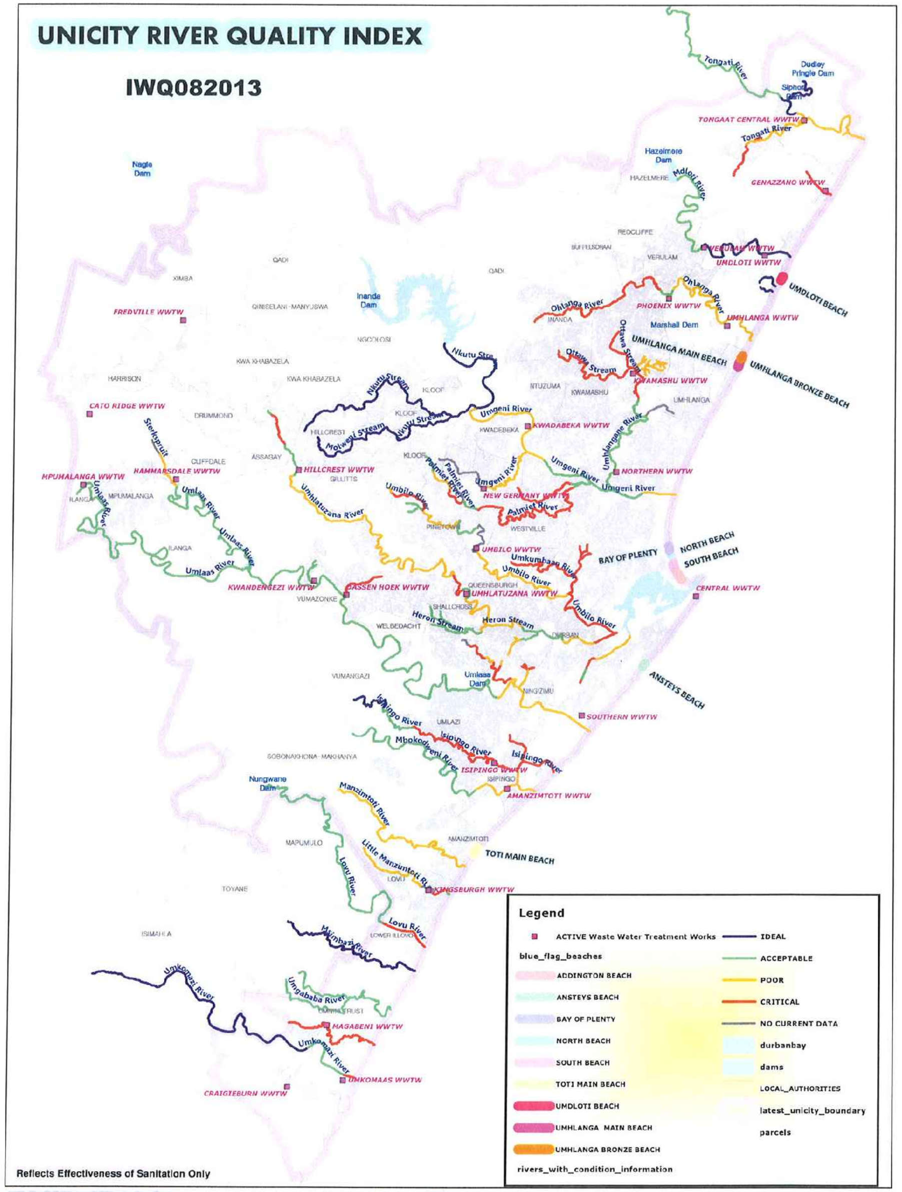

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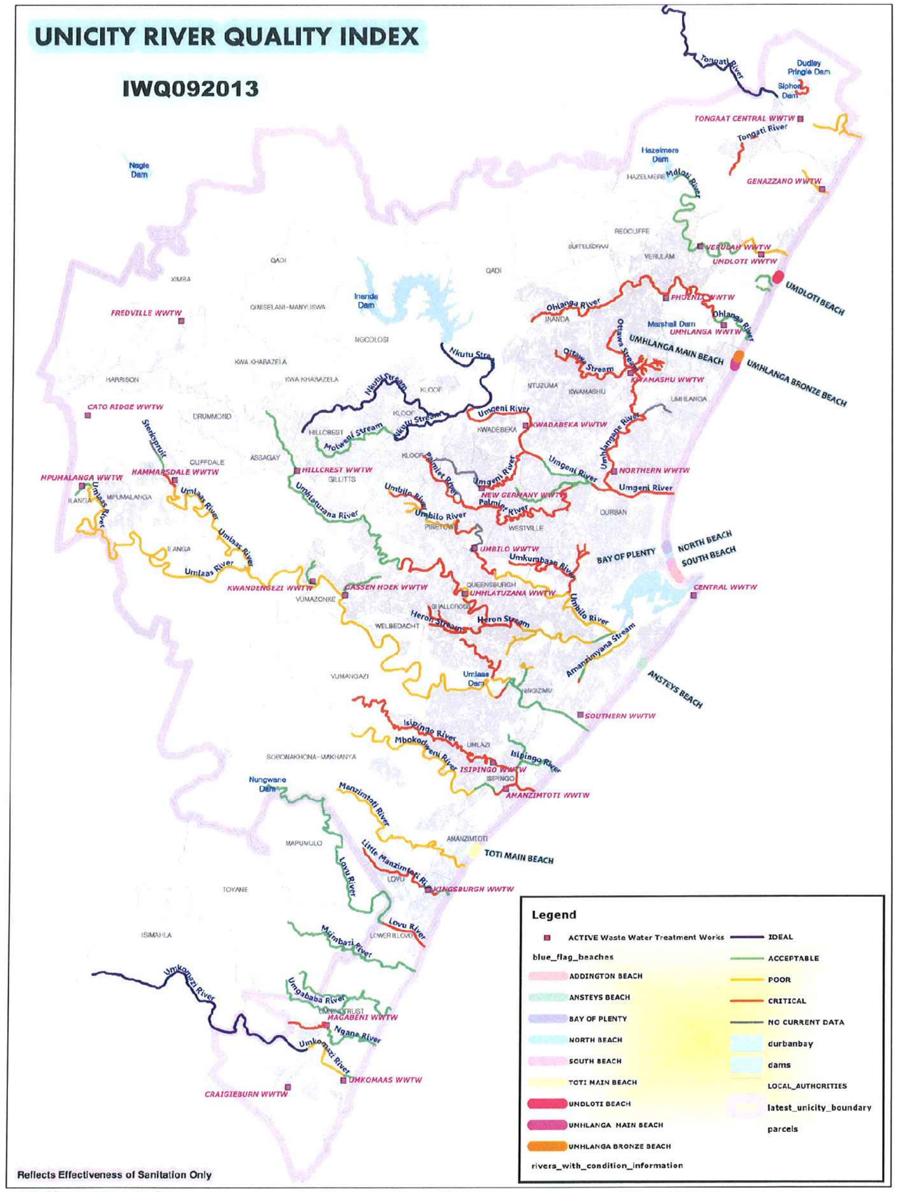

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APPENDIX C: Newspaper Articles and Publications

eThekwini to re-apply for Blue Flags

The Democratic Alliance in eThekwini is delighted that the City Manager has done an about turn on the municipality belonging to the Blue Flag accreditation scheme.

Durban was the first city in South Africa to introduce the international Blue Flag system in 2001. Dr Sutcliffe (then city manager) and previous mayor Obed Mlaba, 'posed' on South Beach with the Blue Flag.

By 2008 eThekwini had 10 Blue Flag beaches. However, Mike Sutcliffe withdrew from Blue Flag in favour of his own Sutcliffe System, which he claimed was more rigourous and easier for the public to use. The Blue Flag scheme involves looking up at the flag, if it is flying, you know that the beach is safe, the sea water quality is good, there are trained lifeguards on duty, there are managed ablution facilities and there is environmental information displayed.

If the flag is not flying - none of the above is guaranteed. Sutcliffe's system – has no obvious indicator, but beachgoers are able to access the internet for water quality results, and then select which beach to use. For a supposedly tourist friendly municipality, it makes sense to use the Blue Flag scheme. Even in this technological age, not too many people check out the internet before going to the beach!

Tourism Minister, Marthinus van Schalkwyk says Blue Flag beaches are becoming the beach of choice for holiday makers. "As the number of Blue Flag beaches increases in South Africa, domestic visitors are increasingly exercising their choices in which beaches they visit." Over 40 countries are currently participating in the programme, with a total of 3489 beaches and marinas awarded the Blue Flag status in 2012.

National and Provincial Government is keen for eThekwini to re-join Blue Flag, so the city manager's U-turn is good news for tourism and the people.

The Democratic Alliance has been at the forefront of efforts to return Durban's status as the premier South African beach tourism destination. We have been proposing that Durban applies for a few beaches next year, and slowly increase them each year. Durban is famous for its beaches, and we should be advertising these assets as clearly as possible.

Cllr Geoff D A Pullan
DA eThekwini Spokesman on Beaches

Berea Mail, Dec 2012

Water off Durban beaches 'not safe'

MHLABA MEMELA | 19 November, 2012 00:03

In February, bacteria ate into a surfer's foot and some experts fear that vibrio vulnificus will be lying in wait for unsuspecting holiday-makers
Image by: TEBOGO LETSIE

With only weeks to go before thousands of holiday-makers travel to KwaZulu-Natal, experts have warned that the water off many Durban beaches contains toxic chemicals.

South Durban Community Environmental Alliance activist Priya Pillay described Durban's beaches as unsafe and unfit for holiday-makers.

"The tests carried out by the eThekwini municipality's water and sanitation department revealed high levels of E.coli and Enterococcus bacteria, which cause cholera and gastro-intestinal illnesses," she said.

The city tested beaches around Durban in the past year, ending in July, and the results revealed that the quality of the beach water did not meet South African water standards.

Pillay cited heavy pollution from industries in the city, as well as pollution from informal settlements as the cause.

"Beaches, including Anstey's and Brighton, are among those affected," she said.

In February, the bacterium Vibrio vulnificus was found at a Durban beach after a local doctor contracted it while surfing.

This bacterium, which might cause blistering and inflammation, had eaten through the tissue on Dr Peter Breedt's foot, leaving an open wound.

He was among several people who became sick after swimming or surfing off city beaches.

Over the years, the city has prided itself on its pristine beaches being better than others around the country.

But the disposal of toxic chemicals, fuel-pipe leaks and human waste spilling into the sea have gradually destroyed the quality of the city's seawater.

The popular spots for holiday-makers are now overflowing with rubbish and have become breeding ground for fleas.

But city officials yesterday assured visitors that Durban was more than ready to host its festive season holiday-makers.

Thabo Mofokeng, eThekwini municipal spokesman, said it would be "all systems go" at most tourist hot-spots and there was nothing for visitors to worry about.

He said festive season plans were already in place and ready for implementation.

"Our planning started some time ago and involves all municipal units such as the metro police and the SAPS. The plans include beach safety, traffic management and a number of events to entertain visitors," he said.

Mofokeng said the city was expecting a bumper festive season and thousands of holiday-makers would choose Durban as their destination.

"We are satisfied with the quality of the water at our beaches and they are safe for bathing. Water quality is constantly monitored to ensure the safety of bathers, especially during the rainy season," he said, adding that most beaches would be open except for parts of Blue Lagoon which is being upgraded.

"Development is progressing well and is expected to be complete by March."

Andrew Layman, CEO of the Durban Chamber of Commerce and Industry, said local businessmen were concerned about several matters relating to the beach-front.

"We are always striving for the achievement of a high standard with respect to the cleanliness of the beach and the public amenities, as well as the security of visitors," he said.

A few years ago the city had 10 beaches with the internationally recognised Blue Flag status but it pulled out of the programme in 2008 after several of its beaches failed to meet the scheme's standard for seawater quality**. – Sunday Times**

Durban's blue flags to fly again

June 14 2013 at 11:39am
By Tony Carnie and Bernadette Wolhuter

FILE PHOTO: The City of Cape Town officially kicked off the Blue Flag season during a special event at the Muizenberg Pavilion. Picture: David Ritchie

Durban - Five years after pulling out of the international Blue Flag beach excellence scheme, Durban has done an about-turn and rejoined the programme.

The decision, announced by mayor James Nxumalo on Thursday night, has been widely welcomed and is expected to go a long way towards restoring confidence among local bathers and tourists about the cleanliness of sea water on the Golden Mile.

Initially, the city is hoping to retrieve blue flags at four local beaches (uShaka, eMdloti tidal area, eMdloti main and Umgababa) and, at a later stage, the main beach at uMhlanga Rocks and Westbrook on the North Coast.

However, before the flags can be hoisted, the first four beaches will have Blue Flag “pilot status” for a year until the city can demonstrate that the city complies with all 33 quality criteria required by Blue Flag International, which currently recognises 3 850 beaches and marinas in 48 countries across Europe, South Africa, Morocco, Tunisia, New Zealand, Brazil, Canada and the Caribbean.

The Blue Flag scheme dates from 1985, when several French coastal municipalities were awarded the flags for complying with sewage treatment and bathing water quality criteria after mounting concern about the deterioration of water quality at several Mediterranean beaches.

The scheme is run by an NGO, the Foundation for Environmental Education, and effectively provides an independent guarantee that beaches comply with strict criteria on water quality, environmental education, lifeguard training, safety, and other issues.

Durban pulled out of the scheme in 2008, during the tenure of former city manager Michael Sutcliffe, who argued that Blue Flag administrators were applying "double standards" when comparing the cleanliness of sea water in Durban with that in Europe.

However, if Sutcliffe had not pulled out of the scheme in a huff, it is likely that all of Durban's formerly accredited beaches would have ended up losing their blue flags, because of the high levels of sewage contamination in several areas.

Problems emerged in 2006, when four local beaches failed to comply with sewage pollution standards.

Blue Flag also stipulates that an independent laboratory should be responsible for testing all sea water samples. Sutcliffe insisted that the city's own laboratory technicians should do the tests.

Now, however, it is understood that all samples will be analysed by the CSIR, rather than the city, to meet the requirement for independent tests.

Nxumalo said that since Durban pulled out of the scheme in 2008, there had been a number of calls from the public, hospitality and business entities, as well as the provincial and national governments, for the eThekwini Municipality to re-enter the programme.

In January, the council resolved to re-enter the Blue Flag scheme this year, and it is believed that city officials formally submitted an application to re-enter the scheme on a pilot basis two weeks ago.

"Our biggest challenge is undoubtedly the state of our water quality at our beaches," Nxumalo said.

"A critical review of the city's water quality results has narrowed the potential pilot Blue Flag beaches to six candidates."

Durban Chamber of Commerce chief executive Andrew Layman expressed his delight at the news, and offered the municipality his full support.

"We feel very strongly that some, if not all, of Durban's beaches should have their Blue Flag status reinstated," Layman said.

"As an international symbol, Blue Flag status indicates to tourists the quality of both the water and the amenities at our beaches."

The head of Umhlanga Tourism, Peter Rose, said re-entering the programme was a step in the right direction and he supported it. But he questioned whether Blue Flag status was recognised by US tourists, who he said made up the second-largest group of tourists to the country.

Blue Flag was mainly recognised in Europe, and Durban had established itself as a premier tourist destination before Blue Flag had begun.

"Having Blue Flag beaches is not the be all and end all," he said, "but I would still rather we had them than not."

The Mercury

Three more DBN beaches on Blue Flag track

October 9 2014 at 08:01am
By Leanne Jansen

Umhlanga main, pictured, and Westbrook on the North Coast will be eligible to boast full world-class quality status should they consistently meet Blue Flag standards. Picture: Philip Wilson

Durban - Durban's return to the Blue Flag beach programme has seen it being rewarded with another three beaches certified as having "pilot" Blue Flag status this year.

Ansteys (Bluff), Umhlanga main and Westbrook on the North Coast will be eligible to boast full world-class quality status should they consistently meet Blue Flag standards.

eThekwini now has seven beaches with pilot Blue Flag status. The first four were announced last October: uShaka, eMdloti main, eMdloti tidal pool and Umgababa.

It has been a slow but welcome return for Durban to the programme, following former city manager Michael Sutcliffe's controversial decision to withdraw from it in 2008.

Many of eThekwini's Blue Flag beaches had been unable to comply with the stringent Blue Flag criteria because of high readings of sewage bacteria in the water.

The list of South Africa's 45 Blue Flag beaches for this year was announced in Knysna earlier this week, and included KZN newcomers Pennington (under the Umdoni municipality) and Blythedale (KwaDukuza municipality) – both of which were awarded full Blue Flag status.

Ted Knott, the coastal programme manager of the Wildlife and Environmental Society of SA (Wessa), which manages the programme, said that apart from it playing a strong role in promoting environmental education and biodiversity conservation, it was of national significance to tourism.

"The Blue Flag has become a symbol of quality recognised by tourists and tour operators. It is able to provide holiday-makers world-class beaches offering safe, clean and well-managed facilities," he said.

Each KZN coastal municipality is now involved in the programme, with either full or pilot status.

To achieve Blue Flag status, as many as 33 criteria spanning four aspects of coastal management must be met: water quality, environmental education and information, environmental management and safety and services. Last year, The Mercury reported that eThekwini officials were taking a slow and progressive approach in re-entering the programme, to ensure that all beaches participating were able to comply with the strict standards.

This year, eThekwini did not apply for full status for any of its beaches. Knott said the pilot status might apply for up to two years.

A total of 26 KZN beaches were awarded either full or pilot status, and Wessa has committed to working closely with the municipalities of the pilot-status beaches to help them achieve full status next year.

Phillip Sithole, the head of Durban Tourism, said the awarding of Blue Flag pilot status came on the back of Durban gaining a number of bragging rights – including being named one of the top 10 most underrated cities in the world by CNN.

Durban had become a destination of choice for international visitors, particularly for its beaches. More affluent tourists were particularly "picky". Umhlanga was a major local attraction for the latter.

The Mercury

Half of Durban's rivers okay

Posted by: Saving Water SA (Cape Town, South Africa) – partnered with Water Rhapsody conservation systems – 28 July 2011

Ninety out of 175 rivers in the Durban area have very good or fair water quality, eThekwini's water and sanitation department says.

The water classification at 90 river sites in the eThekwini municipal area were either "near natural" or "good" or "fair" following an aquatic bio-monitoring programme to determine the state of the health and integrity of rivers.

Those involved in the programme studied the state of living organisms in the water.

"We are looking at life in the water… which is an indication of water quality," said project executive Selva Mudaly.

The water quality in Umdloti river, north of Durban, was "good to near natural", while Umgeni and Umlazi rivers both had good water quality. Out of the 175 sites tested, 85 rivers had either "fair", "poor" or "very poor" classifications. Mudaly said the worst affected rivers were Isipingo, Umkhumbane and Umhlangane rivers. The water quality was bad, mainly because of the rivers being near industrial areas or informal settlements with a lack of proper sanitation, and waste water taps running into rivers. Mudaly said the best way to fix the problem would be re-housing the areas and ensuring people had access to proper sanitation. But he said eThekwini was also in the process of moving people away from the rivers because often pit latrines would be built on the riverbanks, causing sewage to leak into the water. **– Sapa**

Umgeni River ‘one of dirtiest’ in SA

June 7 2013 at 03:30pm
By Tony Carnie

Durban - The Umgeni River is one of the dirtiest rivers in the country, with recent studies showing proof of cholera, shigella, salmonella and other harmful viruses and bacteria at every sampling point between the Inanda Dam and Blue Lagoon in Durban.

A new study by the Water Research Commission says water samples show that these viruses could infect people throughout the year from drinking untreated water, cooking with water or irrigating food crops from the river, or washing clothes, swimming or playing in the Umgeni, downstream of Inanda Dam.

“These observations may have serious health care implications,” University of KwaZulu-Natal researchers Johnson Lin, Atheesha Ganesh and Moganavelli Singh warn in a report submitted to the commission.

The release of the study comes as the city’s health unit has raised the alarm over a suspected outbreak of diarrhoea in Durban after two children died and more than 150 people were hospitalised in the past three months.

Although most cases of the illness were reported in Inanda, Amaoti, Ntuzuma, Mayville and KwaMashu, health officials say people living in other suburbs could also be infected.

While conservation and environmental pollution are often seen as “luxury” issues for wealthy people, the researchers say that nearly 2.5 percent of all deaths in South Africa are related to unsafe water, poor sanitation or hygiene, and that 50 percent of acute gastrointestinal sickness is suspected to be caused by viral infection.

They also recall that 395 people died and more than 120 000 became sick in the cholera epidemic in South Africa between 2000 and 2003.

The researchers say that to save costs, most routine testing of South African river water quality is restricted to looking for E.coli and other sewage bacteria that are easy to detect, whereas it is almost impossible to test regularly for up to 100 different viruses coming from human faeces.

In this study, however, the researchers did one of the first comprehensive studies on human disease-causing germs and viruses in the Umgeni River.

It was based on samples collected in winter, autumn, summer and spring between March 2011 and January last year at five sampling points – Blue Lagoon, Reservoir Hills, New Germany wastewater works, Krantzkloof nature reserve and Inanda Dam.

Every sampling point failed to meet water quality targets for drinking or recreation, with the most bacterially polluted water found at the mouth of the Umgeni River and next to an informal settlement in Reservoir Hills.

They also found cholera, salmonella and shigella pathogens at every sampling point, along with adenoviruses, enteroviruses, rotaviruses and hepatitis B viruses.

“These results strongly indicate the potential of viruses in the water samples (especially from the lower catchment areas) to infect human hosts throughout the year. These observations may have serious health care implications.

“Although river water is never managed to achieve drinking water quality, the results would also raise concerns for those who consume water directly from the river without any form of treatment.”

The results also suggested that the Umgeni should be tested more frequently to monitor actual virus levels rather than simply monitoring E.coli and other easily detectable sewage bacteria.

Though they do not pinpoint the exact pollution sources, the researchers suggest that the most likely source of the viruses and bacteria in the Umgeni is inadequate municipal sewage treatment and runoff from informal houses close to the river.

“In such areas (in many parts of the country) no wastewater treatment is provided and raw sewage enters the rivers and streams directly. Because of lack of infrastructure in these settlements, the residents are often forced to inhabit river banks… people living in these areas often utilise the contaminated surface water for crop irrigation, recreation and domestic personal use such as washing, drinking and cooking without prior treatment.”

In their background comments, the researchers say diarrhoea can be caused by viruses, bacteria, parasites and toxins, but it was only during the past two decades that viruses had been firmly established as a cause of acute gastroenteritis.

Although many rivers have yet to be studied intensively, the UKZN researchers suggest that the Umgeni River is among the most heavily contaminated, along with the Vaal, Crocodile and Olifants rivers.

The 230km Umgeni River had been chosen for the study because it was the primary source of water for more than 3.5 million people in an area which generated almost 65 percent of the provincial gross domestic product. **- The Mercury**

Durban warns of sewage spill in rivers

December 3 2014 at 01:10pm

By Kamini Padayachee

Durban - The eThekwini Municipality has issued an urgent health warning for people to stay away from the Isipingo and Mbokodweni rivers and the estuary which have been contaminated by a sewage spill.

In a statement yesterday, the municipality said the spill was caused by damaged pipes, and “emergency repairs” were being carried out.

The city urged residents to refrain from drinking, swimming, fishing or using the water.

The warning was until further notice.

Municipal spokeswoman Tozi Mthethwa said the spill was caused by suspected metal theft which caused a sewerage pipe from the Avenue East pump station to collapse.

She said the collapsed pipe was replaced and the blockage had been fixed.

Mthethwa said the affected rivers were being “aerated” and water quality tests were being conducted to minimise the health impact of the spill.

“The municipality has staff dedicated to repairing, replacing and upgrading sewers, who have been working around the clock to ensure the contaminated rivers are cleaned.”

Yesterday, there was a strong stench on the banks of the Mbokodweni River where it flows through the Athlone Park golf course, between Prospecton and eManzimtoti.

At the nearby Dakota Beach boys were swimming in a lagoon that is fed from the Mbokodweni River, unaware of the spill.

South Durban Community Environmental Alliance co-ordinator Desmond D’Sa said the municipality needed to “clean up their act”.

“The municipality spent millions on infrastructure like the soccer stadium, but forgot about maintaining the sewer systems. They also give the excuse of metal theft, but then they should take action against illegal scrapyards and prosecute the perpetrators,” D’Sa said.

Di Dold, chairwoman of marine watchdog group Coastwatch KwaZulu-Natal, said there needed to be a concerted effort to deal with the polluting of rivers.

“It is ridiculous. There have been several sewage spills into the Isipingo River - it keeps happening.”

She said sewage spills were taking place all along the coastline.

“The rivers are under incredible strain and the marine life is suffering because of it, but the national departments of environmental affairs or water affairs are deathly silent.”

The spill comes after sewage flowed into the Umhlanga River in August, caused by a fault in the Waterloo pump station which the municipality also linked to metal theft.

In January this year, dead fish were found floating near the Isipingo River mouth. The city said the cause was a sewage leak from its Joyner Road pump station and pollution from the nearby industrial area.

The Mercury

APPENDIX D: Blue Flag Guidelines for Water Quality

A.7 Blue Flag Campaign

i. Approach and methodologies

The Blue Flag campaign is an international initiative which was started in the mid 1980s to encourage local authorities to provide clean and safe beaches for local populations and tourists (UNEP, 1996). It is a voluntary and non-punitive scheme and is targeted at local authorities, the general public and the tourism industry. The main objectives of the Blue Flag campaignare to improve understanding of the coastal environment and to promote the incorporation of environmental issues in the decision-making processes of local authorities and their partners.

In essence, beaches that meet specific criteria are annually awarded a Blue Flag, which can be used as part of the local tourism marketing strategy (FEE, 2004). Areas for which specific criteria are assigned are:

i) Water quality (typically the area that is addressed in water quality guidelines for recreational waters)

ii) Beach management and safety; and

iii) Environmental information and education.

Although not legally required, South Africa (through its Department of Environmental Affairs) initiated the Blue Flag Campaign to encourage socio economic development and to improve coastal livelihoods through better management of marine and coastal related resources. Detailed criteria differ slightly from one region to another. Specific criteria that currently apply to water quality in South Africa are presented in Table B.10.

TABLE B.10: *Summary of water quality criteria for Blue Flag beaches in South Africa*

PARAMETER	ENVIRONMENTAL QUALITY TARGETS
Microbiological indicators	*Faecal coliform (E. coli) per 100ml: <100 in 80% of samples (guideline)* *Faecal coliform (E. coli) per 100ml: <2000 in 95% of samples (imperative)* *Faecal streptococci (Enterococci) <100/100ml in 80% of samples (imperative)* *Faecal streptococci (Enterococci) <50/100ml at 75% compliance (guide)*
Aesthetics	*Oil: absent in 95% of samples* *"Floatables" – presence should not be noted*
Physico-chemical variables	*pH between 6-9 in 95% of samples*

ii. Implementation Practice

In terms of water quality a beach must comply with the bathing water quality requirements in the previous Blue Flag seasons in order to be eligible for the Blue Flag award (i.e. during the season prior to that for which the application is being submitted, this been changed to the prior four seasons for beaches new to the system).

Where thermotolerant coliform (*E. coli*) counts exceed the 2 000/100ml the Blue Flag must be temporarily withdrawn and a further sample taken immediately. The second (follow-up) sample cannot be considered an additional sample for calculating statistical compliance (i.e. in % of samples). Only the results on this second sample shall be used to assess compliance with the bacteriological standards.

If the compliance with the guideline and imperative values cannot be met during a Blue Flag season, the Flag must immediately be withdrawn. The bacteriological results must be displayed in the Water Quality display on the beach Notice Board (in South Africa icons is used with smiling and frowning faces to indicate water quality), as well as the date of the sampling. The water quality data must be sent through to the National Coordinator as soon as it is available.

iii. Monitoring frequency and analysis

The first sample must be taken within 5-17 days before the beginning of the Blue Flag season. During the season, sampling must be carried out at least once in 28 days. The last sampling of the season must be taken within a fortnight of the last date of the Blue Flag season. Samples should be taken where the daily average density of bathers are highest. If the beach is long and/or there are possible sources of pollution (e.g. storm water outlets), additional samples must be taken at such locations. Samples should be taken 30 cm below the surface of the water on an incoming tide.

An accredited laboratory must undertake all sample analyses. Copies of all laboratory reports must accompany applications for the next season. It is the responsibility of the local authority to ensure that the integrity of the sample is not compromised during transit to the laboratory.

NOTE: **Proposed new global standards for Blue Flag *(Alison Kelly, National Blue Flag Coordinator, pers. comm.)***

The Foundation for Environmental Education (FEE) Programme is in the process of revising BluFlag standards for microbiological indicators. The proposed standards are as follows:

Limit values for E. coli – 100 (95 percentile)
Limit value for intestinal enterococci – 56 (95 percentile)
Sampling frequency – 28 days per interval
Sampling history – 3
Bathing water profile – Yes
Sampling calendar - Yes skin, and upper respiratory infections, [illegible] that may be transmitted from swimmer to swimmer).