CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

KNOW YOUR COAST, 2023

Frequently asked questions and information relating to Cape Town's coastline.

Making progress possible. Together.

With acknowledgement to Dr Brent Newman for his contribution on the section “Pharmaceuticals, you, and the environment”, Professor Neil Armitage from the University of Cape Town (UCT) for his contribution on the history of stormwater drainage systems and the implications for homeowners (originally provided in the 2021 report), and Dr Grant Pitcher from the University of Cape Town for his contribution on algal blooms.

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1. INTRODUCTION

With the increase in public awareness and interest in coastal water quality in Cape Town, the City receives an ever-increasing number of queries and questions by the public, interest groups and stakeholders. These queries are often similar in nature and have highlighted the need for the City to provide a general coastal water quality education and awareness document.

For the 2023 coastal water quality monitoring period, the City was unable to collect sufficient enterococci data due to unforeseen challenges that prevented Scientific Services from analysing enterococci for a significant portion of 2023. It is worth noting that enterococci were consistently monitored for the Blue Flag (BF) beaches, in compliance with the international BF standards, as it is conducted by an independent laboratory.

The absence of sufficient data resulted in the City not being able to make any statistical analysis based on percentile non-parametric index ranking, and ultimately was not able to generate the categories of 'poor', 'sufficient', 'good' or 'excellent' for each of its sampling locations (and which the City normally reports on) for the annual Know Your Coast Report for the period December 2022 to November 2023. While raw data reflecting current and available enterococci continue to be uploaded onto the **City's coastal water quality web page**, we have chosen to use the opportunity of this year's annual Know Your Coast Report to present an educational and awareness document in the form of frequently asked questions to build wider understanding of coastal water quality in Cape Town.

These FAQs cover general coastal water quality monitoring and management in Cape Town as well as information on the City's three marine outfalls. This report also concludes with three sections on wider aspects relating to coastal water quality. These include the findings of a study led by Dr Brent Newman from the CSIR to assess the presence of pharmaceuticals in coastal waters of Cape Town, a contribution from Professor Neil Armitage on Cape Town's stormwater system and the dos and don'ts surrounding the system, and finally a section by Dr Grant Pitcher on algal blooms, the causes of algal blooms, and the human health and environmental impacts of these blooms.

Lastly, when the term 'wastewater' is used throughout this document, it is taken to include sewage, water from any domestic use, i.e. water generated from showering and bathing, water from basin use, water from dish washing and clothes washing machines, etc. Wastewater also includes water that may be used and discharged by commercial, agriculture and industrial facilities. All these sources of wastewater enter the sewage system. Therefore any spill – whether it be from a failed sewer pump station, a broken sewer line, etc. – contains water from all of the aforementioned sources and is therefore referred to as wastewater as the technically correct term.

2. GENERAL INFORMATION ON COASTAL WATER QUALITY IN CAPE TOWN

Q: WHY DOES THE CITY MONITOR AND REPORT ON COASTAL WATER QUALITY (CWQ)?

A: The City monitors CWQ for the following reasons:

- **Public health and safety:** A key priority for the City is to ensure that coastal waters at recreational nodes are safe for recreational activities. Monitoring water quality at recreational nodes where people swim, surf, and engage in other water-based activities helps the City undertake necessary actions to limit risk to the public. This is especially the case in instances where poor water quality may persist at specific locations and which requires public health and safety warning signage.

- **Public information and education:** Reporting on water quality allows the public to make informed decisions as to where there is pollution risk when recreating in our coastal waters. It also aids in greater understanding of the coastal water quality dynamics, the wastewater system and what work the City is doing to address CWQ.

- **Monitoring urban pollution of our coastal waters:** Monitoring CWQ allows the City to monitor levels, trends and changes in pollution of our coastal waters from urban sources (wastewater, contaminated stormwater, etc.) and is also expanding into chemicals of emerging concern, marine ecosystem health and marine biodiversity indicators. By continuously monitoring changes in water quality over time, the City can also identify trends in coastal water quality, and in instances where poor coastal water quality persists, the City can investigate both causes and possible solutions to improve coastal water quality in such areas.

- **Informing decision makers:** Coastal areas contribute significantly to local economies through tourism, recreation, and fishing industries. Maintaining high water quality standards enhances the attractiveness of coastal destinations, promotes tourism, and supports economic activities reliant on the coastline. Monitoring CWQ ensures that decision makers are aware of the urban pollution challenges.

- **Empowerment of the public and associated decision making:** Monitoring CWQ over many years and making these data – inclusive of the trends in CWQ – available to the public on the City's Coastal Water Quality website are intended to empower the public's decision making as it relates to recreating at City beaches.

3. COASTAL WATER QUALITY: SAMPLING, ANALYSIS AND INTERPRETATION

Q: FROM HOW MANY SITES DOES THE CITY TAKE SAMPLES FOR THE PURPOSES OF COASTAL WATER QUALITY MONITORING?

A: The City currently samples 99 coastal sites from within the City's area of jurisdiction, spanning a total length of approximately 307 km of coastline. Sample sites are categorised into recreational sites or as coastal monitoring sites. **Monitoring sites are those sites that are in close proximity to known pollution sources, i.e. rivers, canals and stormwater outlets and which are located away from popular recreational nodes.** Recreational categories are thus not calculated for coastal monitoring sites. Recreational nodes are defined as popular swimming and water recreational use areas. The City tests all 99 sites for indicator bacteria, either internally or at an external laboratory.

Q: HOW IS COASTAL WATER SAMPLING CONDUCTED?

A: Sampling is conducted by trained staff members from both the Scientific Services Department as well as district environmental health staff. Staff visit each of the 99 sampling sites every two weeks. Samples of seawater are placed in sterilised bottles as provided by Scientific Services and are labelled. Once the samples are collected, the sample bottles are kept on ice and returned to the City's Scientific Services for processing after a chain of custody form has been completed. Here the samples are tested for enterococci, either in-house or are outsourced to accredited external laboratories.

Q: WHAT ARE *E. COLI* AND ENTEROCOCCI?

A: *E. coli* (*Escherichia coli*) and enterococci are types of bacteria commonly found in the intestines of humans and animals. These bacteria play important roles in maintaining a healthy balance of bacteria in the intestines, which is crucial for digestion and overall gut health. They help break down food, produce certain vitamins, and prevent harmful bacteria from colonising the intestines.

While most strains of *E. coli* are harmless, some can cause illness, especially if ingested through contaminated food or water. Enterococci are also typically harmless in healthy individuals but can sometimes cause infections, particularly in people with weakened immune systems. Both *E. coli* and enterococci are often used as indicators of water quality, as their presence in water bodies can suggest faecal contamination and the potential presence of other harmful pathogens. The higher the number of the indicator species, the higher the possibility of a pathogen also being present in the water. To reduce the risk of illness, it is important to pay attention to water quality advisories and coastal pollution signs and avoid swimming in areas where contamination levels are high to reduce the risk of illness.

Q: WHY DOES THE CITY USE ENTEROCOCCI FOR DETERMINING COASTAL WATER QUALITY?

A: For many years, *E. coli* has been commonly used as an indicator bacterium for assessing water quality, including coastal waters. However, there are limitations to using *E. coli* as the primary indicator (WHO, 2021):

- **Non-specificity:** *E. coli* is a common bacterium found in the intestines of warm-blooded animals, including humans and mammals. Its presence in water bodies can indicate faecal contamination, but it does not exclusively originate from human faeces. Other sources such as animal waste or environmental reservoirs can also contribute to *E. coli* levels, leading to potential misinterpretation of contamination sources. An example of an environmental reservoir would be beach-cast kelp, which is known to support colonies of *E. coli*.

- **Health risk assessment:** No statistical relationship has been established for *E. coli* that can support a dose-response guideline value. Although *E. coli* presence can suggest the potential presence of harmful pathogens associated with faecal contamination, it does not directly measure the risk to human health. Different strains of *E. coli* vary in pathogenicity, and the presence of non-pathogenic strains may not necessarily pose a health risk to swimmers. In short, it is not a very reliable indicator of risk to humans in coastal waters.

- **Enterococci:** The preferred global standard for assessing water quality – in recent years, enterococci have emerged as the preferred indicator bacterium for assessing coastal water quality. The reasons for this are as follows:

- **Specificity:** Enterococci are a group of bacteria predominantly found in the intestines of warm-blooded animals, including humans. Their presence in water bodies is primarily associated with faecal contamination from human sources, making them more specific indicators of recent sewage or faecal pollution events.

- **Correlation with health risks:** Enterococci levels in recreational waters have been found to correlate more closely with the risk of swimming-associated illnesses, including gastrointestinal, skin, and respiratory infections. Monitoring enterococci levels provides a more accurate assessment of the potential health risks posed by contaminated water compared to *E. coli*.

- **Standardisation:** Enterococci-based water quality standards and guidelines have been adopted by many regulatory agencies and organisations worldwide – including the World Health Organization – providing a standardised approach to assessing recreational water quality and ensuring public health protection.

In summary, while *E. coli* has been traditionally used for assessing coastal water quality, its limitations have led to the adoption of enterococci as the preferred global standard (WHO, 2021).

Q: HOW IS COASTAL WATER QUALITY CATEGORISED AND WHAT DO THESE CATEGORIES MEAN?

A: Water quality is assessed by comparing the number of enterococci in the water samples to the South African Water Quality Guidelines for Coastal Marine Waters for recreational use (see table 1).

It is for this reason that the City applies a risk-adjusted approach, whereby measurements are taken and assessed over an extended period of time to determine a realistic representation of coastal water quality. This approach is internationally accepted as the most appropriate means to determine realistic and informative risk levels as it relates to recreational coastal water quality. This risk-adjusted approach is critical to both informing and empowering citizens to make decisions in terms of recreating along Cape Town's coastline. It is important to note that this approach does not reflect real-time coastal water quality. Currently, there are no systems in place internationally that can reliably and accurately provide real-time data as required for coastal water recreational use. Instead, many samples are required over a 365-day rolling period to determine a realistic representation of risk as it relates to coastal water quality for a specific site. Further, results for a 365-day period are compared against a five-year period to determine longer-term trends. This approach is internationally accepted as the most appropriate means to determine realistic and informative risk levels and trends as it relates to recreational coastal water quality (WHO, 2021).

The South African Water Quality Guidelines for Coastal Marine Waters are based on research into whether people swimming in waters with different numbers of faecal indicator bacteria developed gastrointestinal illness. They define a 'tolerable risk' instead of no risk at all. For most healthy people, water quality that meets the targets will pose little risk to their health, and any illness they might develop will usually be minor and short-lived. This is because humans can usually tolerate exposure to low numbers of pathogens. Toddlers, the elderly, people with weakened immune systems, as well as those who have not previously been exposed to the pathogens are more at risk. People who participate in high-exposure activities such as long-distance swimming and surfing are also at a higher risk, as they are likely to swallow more water than the ordinary person. The number of bacteria in a water sample is counted as colony-forming units per 100 mℓ of the sample ('the count'). Percentiles of counts measured in many water samples collected over time are used to rate water quality as 'excellent', 'good', 'fair' or 'poor' by comparing them to the guidelines below listed in table 1. The minimum grade for South African coastal waters for recreation is 'sufficient'.

TABLE 1: RISK CRITERIA FOR RECREATIONAL USE OF COASTAL WATERS IN SOUTH AFRICA

Grade	Estimated risk of illness per exposure*	Enterococci (cfu**/100 mℓ)	Escherichia coli (cfu/100 mℓ)
Excellent	<2,9% gastrointestinal (GI)	< 100 (95 percentile)	< 250 (95 percentile)
Good	<5% GI illness risk	< 200 (95 percentile)	< 500 (95 percentile)
Fair	<8,5% GI illness risk	< 185 (90 percentile)	< 500 (90 percentile)
Poor	> 8,5% GI illness risk	> 185 (90 percentile)	> 500 (90 percentile)

* Exposures are defined as 10 minutes of swimming with three head immersions.
** Colony-forming units

The City of Cape Town follows the South African Water Quality Guidelines for Coastal Marine Waters Volume 2: Guidelines for Recreational Use,[1] available at:
https://resource.capetown.gov.za/documentcentre/Documents/Procedures,%20guidelines%20and%20regulations/South_African_Recreational_Water_Quality_Guidelines.pdf.pdf

[1] Republic of South Africa, Department of Environmental Affairs (2012). South African Water Quality Guidelines for Coastal Marine Waters. Volume 2: Guidelines for recreational use.

Q: WHAT DOES 'POOR' WATER QUALITY MEAN?

A: A minimum set of data is required over a 365-day rolling period to determine a realistic representation of risk related to coastal water quality for a specific site. Results for a 365-period are then compared against a five-year period to determine longer-term trends. Based on this approach, water quality is rated 'poor' if the number of enterococci bacteria colonies in water samples exceeds the targets of the South African Water Quality Guidelines for Coastal Marine Waters for recreational use. This method works to rank the available data for a site, and then determines the value at which 90 and 95 per cent of the values are below. These values are called the 90th and 95th percentiles. These are then matched to the risk criteria values to determine the recreational category.

If the 95th percentile (calculated using the Hazen method) of the data over a specific period is ≤100, water quality is rated 'excellent'; if ≤200, it is rated 'good', and if the 90th percentile over the period is ≤185, it is rated 'sufficient'. If none of these targets are met, the water quality is rated 'poor'. This does not mean that the number of bacteria colonies in the water is consistently high, however. As few as two water samples with a high number of bacteria colonies can result in a 'poor' water quality rating in an assessment period (see figure 1). This is because of the way in which water quality is rated, as the following example illustrates: Over 12 months, 23 water samples collected from a beach presented enterococci counts of 2, 2, 4, 4, 4, 5, 8, 9, 11, 12, 12, 13, 14, 18, 22, 29, 32, 36, 56, 89, 93, 1 350 and 1 700 per 100 mℓ. In this example, the 95th percentile came to 1 473, a value between the two highest counts (i.e. 1 350 and 1 700). Therefore, water quality did not achieve 'excellent' or 'good' ratings. The 90th percentile came to 344, which means water quality did not meet the 'sufficient' rating either. In this example, water quality is thus rated 'poor', even though 21 of the 23 samples fell in the 'excellent' range. Of course, beach water quality might also be rated 'poor' because a large number of samples contain high numbers of enterococci bacteria colonies.

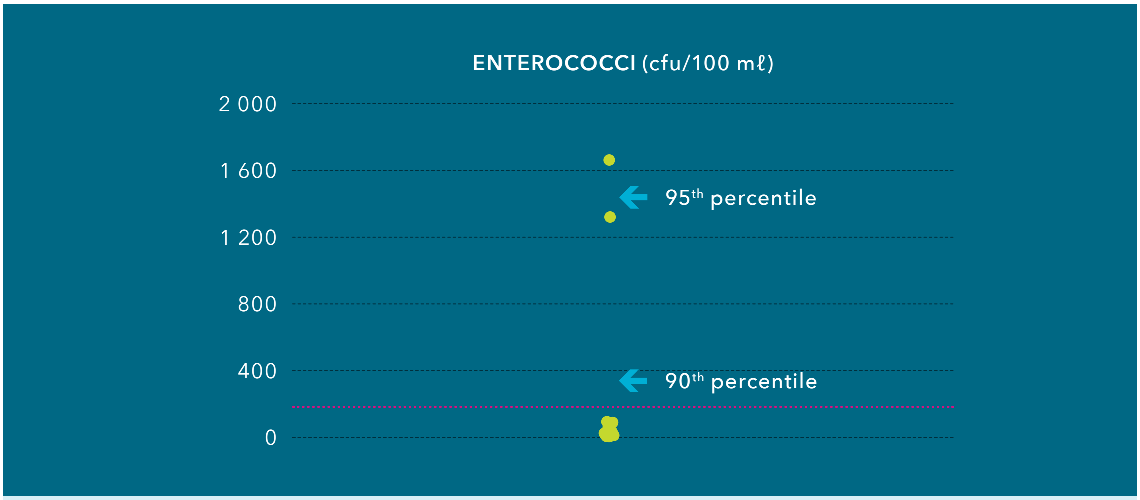

Figure 1: Graphical representation of how 'poor' water quality is determined

A 'real-life' example – specific to Cape Town – of how a few poor results may affect the overall coastal water quality category is shown in the table 2 on the next page. The results of the table are for Muizenberg (directly in front of the Muizenberg pavilion). Table 2 presents all the historical enterococci data for the site from August 2018 until to 5 April 2023. Total samples collected for this period was 110. Of the 110 samples collected, only 12 (or 11%) exceeded the one-off sample value of 180/100 mℓ. As per the risk adjusted approach applied by the South African Water Quality Guidelines for Coastal Marine Waters for recreational use, a few poor results have a very large and disproportionate impact on the calculation and determination of the final water quality category.

So while it is recorded as 'poor' water quality at this location for this set of data, only 11% of the samples over four years were elevated. The calculations are deliberately applied to be conservative in respect of generating coastal water quality categories and to limit risk to the public.

TABLE 2: HISTORICAL ENTEROCOCCI RESULTS FOR MUIZENBERG PAVILION

Wednesday, 01 August 2018	16			Sunday, 16 August 2020	6
Wednesday, 15 August 2018	10			Wednesday, 26 August 2020	350
Wednesday, 29 August 2018	6			Wednesday, 09 September 2020	0
Wednesday, 12 September 2018	8			Wednesday, 23 September 2020	5
Wednesday, 26 September 2018	19			Wednesday, 07 October 2020	300
Wednesday, 10 October 2018	64			Wednesday, 21 October 2020	4
Wednesday, 24 October 2018	0			Wednesday, 04 November 2020	0
Wednesday, 07 November 2018	15			Wednesday, 18 November 2020	38
Wednesday, 21 November 2018	16			Thursday, 26 November 2020	1
Wednesday, 05 December 2018	6			Wednesday, 02 December 2020	19
Wednesday, 19 December 2018	6			Thursday, 03 December 2020	80
Thursday, 03 January 2019	10			Wednesday, 09 December 2020	3
Wednesday, 16 January 2019	150			Sunday, 13 December 2020	14
Wednesday, 30 January 2019	8			Thursday, 17 December 2020	13
Wednesday, 13 February 2019	0			Wednesday, 30 December 2020	15
Wednesday, 27 February 2019	3			Thursday 21 January 2021	2
Wednesday, 22 May 2019	2			Thursday, 11 February 2021	4
Wednesday, 05 June 2019	46			Tuesday, 16 February 2021	450
Wednesday, 19 June 2019	150			Tuesday 23 February 2021	1
Wednesday, 03 July 2019	1 200			Tuesday, 02 March 2021	44
Wednesday, 17 July 2019	89			Tuesday, 09 March 2021	3
Wednesday, 31 July 2019	1 700			Wednesday, 10 March 2021	300
Wednesday, 14 August 2019	16			Tuesday, 16 March 2021	57
Wednesday, 28 August 2019	26			Wednesday, 07 April 2021	12
Wednesday, 09 October 2019	100			Wednesday, 21 April 2021	900
Wednesday, 23 October 2019	6			Wednesday, 05 May 2021	14
Wednesday, 06 November 2019	17			Wednesday, 02 June 2021	400

Wednesday, 20 November 2019	1		Wednesday, 28 July 2021	36
Thursday, 05 December 2019	74		Wednesday, 25 August 2021	13
Thursday, 05 December 2019	10		Wednesday, 08 September 2021	24
Thursday, 12 December 2019	1		Wednesday, 22 September 2021	16
Wednesday, 18 December 2019	81		Wednesday, 06 October 2021	45
Sunday, 29 December 2019	4		Wednesday, 17 November 2021	3
Thursday, 09 January 2020	1		Thursday, 02 December 2021	11
Wednesday, 15 January 2020	14		Thursday, 02 December 2021	11
Thursday, 16 January 2020	3		Thursday, 09 December 2021	1
Thursday, 23 January 2020	79		Thursday, 09 December 2021	1
Wednesday, 29 January 2020	19		Wednesday, 15 December 2021	2
Wednesday, 12 February 2020	500		Thursday, 23 December 2021	9
Thursday, 20 February 2020	1		Wednesday, 05 January 2022	3
Wednesday, 26 February 2020	150		Tuesday, 11 January 2022	13
Wednesday, 11 March 2020	20		Wednesday, 12 January 2022	3
Thursday, 19 March 2020	1		Saturday, 22 January 2022	3
Wednesday, 25 March 2020	11		Wednesday, 26 January 2022	30
Wednesday, 03 June 2020	50		Wednesday, 09 February 2022	3
Wednesday, 17 June 2020	41		Wednesday, 14 December 2022	195
Wednesday, 01 July 2020	7		Wednesday, 11 January 2023	50
Wednesday, 15 July 2020	2		Wednesday, 22 February 2023	1 733
Wednesday, 29 July 2020	9		Wednesday, 05 April 2023	70
Wednesday, 13 March 2019	6		Wednesday, 27 January 2021	86
Wednesday, 27 March 2019	4		Monday, 08 February 2021	450
Wednesday, 10 April 2019	9		Tuesday, 09 February 2021	5
Wednesday, 24 April 2019	51		Wednesday, 10 February 2021	0
Tuesday, 07 May 2019	30		Thursday, 11 February 2021	29

Q: WHY DOES THE CITY APPLY A RISK-ADJUSTED APPROACH TO COASTAL WATER QUALITY?

A: Coastal water quality testing is not an absolute nor precise science that will yield definitive results based on individual and/or isolated measurements. Individual measurements taken and assessed in isolation are in themselves largely meaningless and can be very misleading. Furthermore, the inherent nature of high bacterial variability in coastal waters means that two samples collected at the same time just a few metres apart may yield vastly differing results. The same applies from a temporal perspective: Water samples taken in the same location at different times, even on the same day, may also yield vastly differing results. Currently, there are no systems in place internationally that can reliably and accurately provide real-time data as required for coastal water recreational use and from which to generate the required categories. It is for this reason that the City applies a risk-adjusted approach, whereby measurements are taken and assessed over an extended period of time to determine a realistic representation of coastal water quality.

This approach is internationally accepted as the most appropriate means to determine realistic and informative risk levels as it relates to recreational coastal water quality. This risk-adjusted approach is critical to both informing and empowering citizens to make decisions in terms of recreating along Cape Town's coastline.

Q: WHY HAVE THERE BEEN GAPS IN THE CITY'S SAMPLE DATA?

A: Unfortunately, since 2021, an issue arose where the methods used to sample enterococci became unreliable due to a change in supplied agar. Difficulties in sourcing the correct materials took some time to rectify, which led to gaps in data.


CITY OF CAPE TOWN
LIFEGUARD

4. UNDERSTANDING COASTAL WATER QUALITY IN THE CONTEXT OF URBAN ENVIRONMENTS

Q: WHY IS WATER QUALITY A CHALLENGE AT SOME LOCATIONS IN CAPE TOWN?

A: Cape Town is a large coastal metropole with a population of approximately 4 million people. The people living in Cape Town collectively produce approximately 618 million litres of wastewater every day that the city receives via the formal sewage network. All of this wastewater gets channelled to water treatment works before being released back into rivers, canals and marine outfalls. Some is used for irrigation purposes (golf courses) but all of it goes back into our environment following various levels of treatment that reduce the pollution loading.

There are also of course failures where wastewater may enter the environment through failed infrastructure, load-shedding, vandalised or failing pump stations, sewer infrastructure blockages caused by foreign items disposed of into sewer systems, illegal connections from sewer to stormwater systems, lack of service infrastructure in informal settlements, etc. Importantly, and from a coastal water quality perspective, the city's sewer network is a gravity-fed system. This means that any wastewater produced moves down sewer infrastructure towards the lowest point before it is pumped to a wastewater treatment facility. As a coastal city this means that a significant proportion of wastewater is gravity fed to the coast as the lowest point relative to adjacent areas.

Effectively, wastewater flows 24/7 to pump stations, and if a pump station is not working, wastewater builds up and ultimately 'spills over' into the environment until the pump station can start pumping again. It is for this reason that when there are pump station failures – especially during load-shedding – wastewater spills are clearly evident and most impactful at the coast. For more detailed information in this regard, please refer to section 10: Sewer pump stations.

Further, it is important to note that catchments also discharge wastewater and other contaminants from neighbouring municipalities, which ultimately pass through the city via river systems. The sea is ultimately the receiving environment for the multitude of different pathways by which pollutants may enter the ocean. This has a significant impact on nearshore coastal water quality.

The city relies on its sewer network and wastewater treatment works, together with the assimilative capacity of the environment, to assimilate this wastewater effluent on our behalf. It is, however, increasingly recognised around the world that this approach is not sustainable. Understanding the full dimensions of the challenge is critical to develop appropriate responses to try to limit our collective impact on our environment and coastal waters.

Q: WHY MAY THERE BE DIFFERENCES IN WATER QUALITY BETWEEN THE ATLANTIC SEABOARD AND FALSE BAY?

A: The term ‘dilution’ refers to the process of reducing the concentration of a pollutant by mixing it with uncontaminated seawater to reach an acceptable level for ecosystems, and for recreational activities such as swimming. In the coastal environment, dilution and the effect of waste streams or pollution are determined by specific coastal processes and physical characteristics that are unique to any specific coastline. If we consider our Atlantic coastline versus our False Bay coastline, both have unique and distinctive physical characteristics and differing coastal processes. Therefore, the behaviour and dilution of similar waste streams will vary significantly when discharged along our Atlantic coastline compared to the False Bay coastline.

So, what are the main differences between our Atlantic and False Bay coastlines? It is the wave climate and our dominant wind directions; the water depth; the orientation of the coastlines and the presence of reefs, which can all influence the rate of assimilation and ultimately the quality of the water.

The Atlantic coastline is characterised by a high wave-energy coastline and which is directly exposed to southwesterly waves; while the False Bay coastline is partly sheltered. Thus, there is less wave energy in False Bay and this limits the dilution and transporting capacity of waste streams. Further, when the southeaster blows (normally in summer), both the surface and deep flows are generally clockwise in False Bay, with a strong and narrow outflow along the eastern shores of the bay (see figure 2). An exception to this is the northeastern corner of the bay (Gordon’s Bay area), which develops an anticlockwise gyre. On the other hand, when the northwester blows (normally in winter), this results in generally weaker flows, with an anticlockwise tendency at the surface but a cyclonic tendency in the deeper waters. Again, the Gordon’s Bay area tends to develop a closed circulation, which, in northwesterly wind conditions, is often cyclonic. These wind patterns influence the movement of sediment and other particles. In general, particles are transported northwards along the bay’s western shores, turning eastwards along the northern shoreline, while transport along the eastern shores is northwards. As a result, a convergence zone develops in the northeastern corner (in the vicinity of Gordon’s Bay), which also becomes a depositional zone or ‘trap’ for pollutants. Also, smaller embayments along the coast, such as sheltered areas in the northwestern corner of the bay (Fish Hoek and Muizenberg areas), which are quieter environments, will almost certainly act as traps for fine particles. Therefore, it is not surprising that most of the poorly rated recreational nodes are concentrated in these areas of the bay due to poor circulation in these areas.

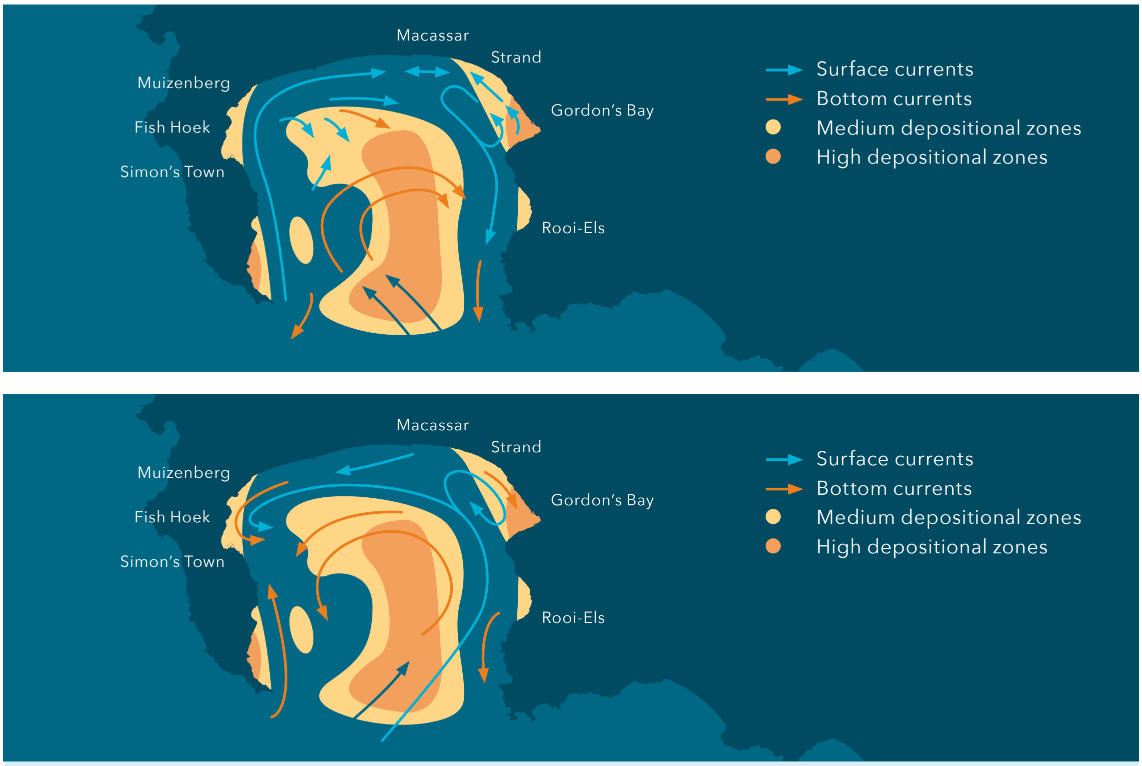

Figure 2: Typical current patterns and depositional zones in False Bay in southeasterly (top) and northwesterly wind conditions (bottom)

For the Atlantic coastline, the southerly and southeasterly winds blow offshore. In terms of seabed levels – also referred to as 'bathymetry' – it is significantly shallower in False Bay and therefore you have more shallow water. This results in smaller wave heights, which translates into less wave energy. With the reduced wave energy, as well as the shallow water and the presence of gyres, the assimilative capacity in False Bay is less. Thus, to put it simply: Our False Bay coastline has less capacity to deal with waste streams or pollution compared with our Atlantic coastline due to the different physical characteristics and coastal processes. This poor circulation is compounded both by the fact that False Bay is the receiving environment for some of the largest wastewater treatment plants in Cape Town and which also receives a significant amount of stormwater discharge into False Bay, especially during the winter months.

Q: WHY IS COASTAL WATER QUALITY TYPICALLY WORSE IN WINTER IN CAPE TOWN?

A: Stormwater discharged from stormwater systems has a significant impact on the nearshore environment, as it is known to transport and discharge a range of bioactive and mixed contaminants into receiving environments (Masoner et al., 2019). Studies show that elevated levels of contaminants and bacteria can be flushed through the stormwater system after rainfall events, and include contaminants from humans and animals (discharged into the stormwater system both illegally or unintentionally), and contaminants such as fuel, oil, pesticides, herbicides or fertilisers washed from hard and soft surfaces (Kleinheinz et al., 2009). Bacteria are also sometimes able to thrive and multiply in stormwater pipes under certain favourable conditions. It is for this reason that coastal water quality can be negatively impacted during Cape Town's winter rainfall period.

The contribution of the stormwater system to poor coastal water quality is a global phenomenon and not unique to Cape Town. Polluted water discharged from stormwater systems result in certain beaches and recreational waterbodies being closed after rainfall events. This intervention takes place in countries such as Canada, the USA and Australia, and is undertaken by the local authorities. More specifically, recreational nodes along the coast of California are automatically closed after a rainfall event that is greater than 2,5 mm over a period of 24 hours (Ackerman and Weisberg, 2003).

Another issue that comes into play in winter is ingress of rainwater into the sewer network. This occurs through illegal stormwater-to-sewer connections or through broken manholes or pipes. A graphic representation of this is provided in figure 3. There are many illegal stormwater-to-sewer cross-connections on private properties in areas across Cape Town, where water is channelled from residents' roofs, gutters, and paved or hard yard surface areas into sewer drains. If significant rainwater enters the sewer system, this then causes an added strain on the carrying capacity of the network as well as the pump stations. The network can be overrun by too much rainwater entering the system, which eventually leads to overflows. Residents should check that the gutters leading off a building lead into the stormwater system, and not into the sewer system. The City's Water Pollution Control Inspectorate conducts routine tests around Cape Town to detect these illegal connections.

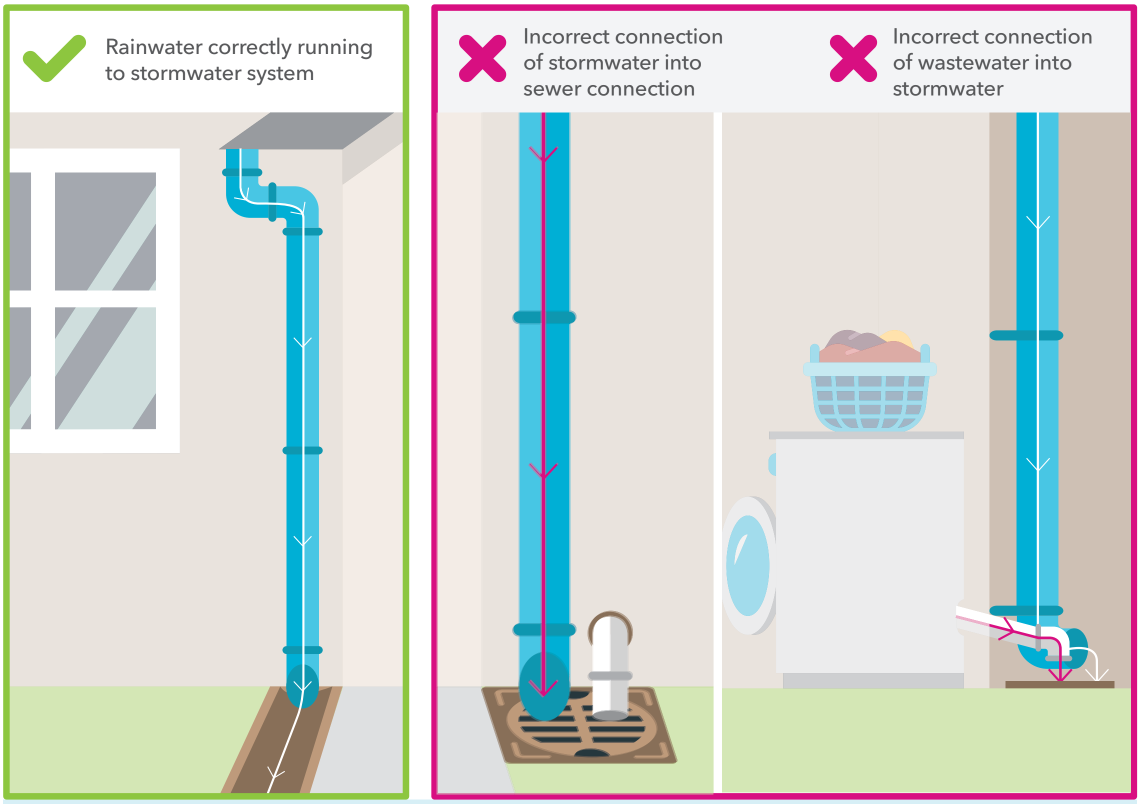

Figure 3: Illustration of correct and incorrect configuration of stormwater drains

Q: WHAT ARE THE TYPICAL SOURCES OF FAECAL CONTAMINATION IN URBAN ENVIRONMENTS?

A: Typical sources of faecal contamination include the following:

1. Wastewater treatment plant (WWTP) effluent: Although WWTPs treat sewage, effluent from these plants that enter the receiving environment may still contain traces of human waste, i.e. faecal bacteria, pharmaceuticals and nutrients.

2. River inflow: Rivers are used as the main discharge points for treated wastewater. Rivers also receive runoff from agricultural areas, urban centres, or areas with inadequate sanitation infrastructure, which may also result in faecal contamination in rivers.

3. Inadequate sanitation infrastructure: In regions with poor sanitation infrastructure or inadequate wastewater treatment facilities, untreated sewage may be discharged directly into water bodies.

4. Pump station overflow: During heavy rain or system malfunctions that may, for example, be caused by load-shedding, pump stations may overflow, releasing untreated sewage into stormwater and river systems.

5. Stormwater runoff: Rainwater can wash faecal matter from streets, lawns, and other surfaces into storm drains and waterways. Faecal matter may be present due to sewage spill events, i.e. blocked sewer lines, illegal sewer to stormwater connections, faecal matter from pets, lack of service infrastructure in informal settlements.

6. Blockages and overflows into stormwater systems: Blockages in sewer lines or sewer overflows caused by the illegal disposal of foreign items into the sewer network can lead to the discharge of untreated sewage into stormwater systems.

7. Failing septic systems: Malfunctioning or inadequately maintained septic systems can leak or overflow, releasing raw sewage into the surrounding soil and potentially contaminating groundwater or nearby surface waterbodies.

8. Additional sources leading to faecal contamination include faeces from domestic animals and wildlife, from livestock defecating near waterbodies, as well as improperly disposed of wastewater by vessels.

9. Illegal dumping: Intentional dumping of waste, including human waste, into waterbodies by individuals or businesses can lead to faecal contamination.

10. Bather shedding: This refers to the process by which swimmers release substances from their bodies into the water while swimming. These substances can include sweat, oils, urine, faecal matter, skin cells, and personal care products such as sunscreen or lotion. Bather shedding contributes to the overall contamination of recreational water bodies – especially in closed environments such as tidal pools – and can affect water quality and safety for other swimmers. For scientific articles and research on bather shedding, please click on the following links:

    - **Quantitative evaluation of bacteria released by bathers in a marine water**
    - **Bather Shedding as a Source of Human Fecal Markers to a Recreational Beach**
    - **Shedding of Staphylococcus aureus and methicillin resistant Staphylococcus aureus from adult and pediatric bathers in marine waters**

Q: WHAT ARE SOME OF THE OTHER SOURCES OF POLLUTANTS TO OUR COASTAL WATERS IN AN URBAN CONTEXT?

A: The following are examples of the various sources of pollutants:

1. Urban runoff: Stormwater runoff from urban areas can carry pollutants such as oil, heavy metals and debris into waterways and ultimately into the sea.

2. Industrial discharge: Industrial facilities may release chemicals, heavy metals, and other pollutants into waterbodies through wastewater discharge as well as urban runoff via stormwater systems.

3. Bin washing: Wheelie bins contain remnant pollutants and contaminants. Washing of wheelie bins and the discharge of the fouled water into the stormwater system can contribute to poor coastal water quality. This is especially evident in densely populated residential areas in close proximity to the coast.

4. Agricultural runoff in catchments: Pesticides, fertilisers, and animal waste from farms can be washed into waterbodies during rain or irrigation, which pass through urban environments and ultimately discharge into the sea.

5. A study by Kole et al. (2017) in the Netherlands has revealed the significant contribution that vehicle tyre 'wear and tear' has in terms of releasing microplastics into the environment. The study estimated that the per capita emission of microplastics from tyre wear and tear ranges from 0,23 to 4,7 kg/year, with a global average of 0,81 kg/year. The relative contribution of microplastics from tyre wear and tear to the total global amount of plastics in our oceans is estimated to be 510%. The study also revealed that due to the chemical makeup of microplastics, it has the ability to enter the food chain, which has a potential to impact human health. This still requires further research. The study may be accessed from the following link:

   Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment - PMC (nih.gov)

6. Topical treatment of pets with flea medication, where such pets may enter waterbodies: A study in the UK found that 99% of samples collected from river systems contained synthetic chemicals of fipronil and imidacloprid. In terms of UK standards, levels of these synthetic chemicals commonly exceeded safe limits as determined by experts. For further information on this study, please access the following link:

   Down-the-drain pathways for fipronil and imidacloprid applied as spot-on parasiticides to dogs: Estimating aquatic pollution - ScienceDirect

7. Everyday and common use of herbicides and pesticides in gardens and parks: Ultimately, these chemicals will find their way into the marine and coastal environment through various pathways such as stormwater and river systems. For further information on the presence of herbicides, pesticides and other synthetic chemicals in the environment, please access the following links:

    - **Rebuttal: Presence and risk assessment of herbicides in the marine environment of Camps Bay (Cape Town, South Africa). Sci. Total Environ**
    - **Urban Stormwater: An Overlooked Pathway of Extensive Mixed Contaminants to Surface and Groundwaters in the United States | Science Inventory | US EPA**
    - **Contaminants of emerging concern in urban stormwater: Spatiotemporal patterns and removal by iron-enhanced sand filters**
    - **Trace organic contaminants in urban runoff: Associations with urban land-use - PubMed (nih.gov)**

5. DISTINGUISHING BETWEEN SEWAGE SPILL EVENTS AND NATURAL PHENOMENA

Q: WHAT IS THE BROWN WATER COMMONLY SEEN IN THE INSHORE AREA OF FALSE BAY?

A: Diatoms, photosynthetic micro-organisms, are common in various waterbodies, including in the surf zone of sandy beaches. In South Africa, two surf zone diatom species, *Anaulus australis* and *Asterionellopsis glacialis*, have been identified. *A. australis* is found exclusively in the southern hemisphere's surf zones. Although *A. australis* blooms can give the water a brown discolouration (see figure 4), the bloom is not toxic and pose no swimming hazards.

Figure 4: *Anaulus australis* bloom in Cape Town. Credit to Coleen Moloney.

These blooms serve as important food sources for various marine life forms in sandy beach ecosystems. For more information, please refer to page 52 of the 2020 Know Your Coast **Report**. As algal blooms not only discolour the water, they can also produce an unpleasant smell. It is for these reasons that algal blooms may be mistaken for sewage. As a general rule of thumb, if foam is evident on the surface of the water, it is likely to be an algal bloom breaking down and not from the presence of sewage. For further information on how to distinguish between algal blooms and sewage and wastewater, please read the following links:

- **Telling the difference between an algal bloom and sewage**
- **Algal bloom vs pollution - how can you tell the difference?**
- **Brown foam on the beach - what is it?**

Q: WHY DOES CAPE TOWN'S COASTLINE SOMETIMES HAVE THE SULPHURIC 'ROTTEN EGG' TYPE SMELL?

A: Cape Town's coastline may have a sulphuric type 'rotten egg' type smell for a number of reasons:

- **Presence of kelp:** Cape Town has significant quantities of kelp washing ashore. This is especially evident after high seas and strong winds. The City endeavours, as far as possible, to leave as much kelp as possible on the beaches. This is due mainly to the **role that kelp plays in contributing to the ecological integrity** of Cape Town's beaches. When kelp washes up en masse, it can start decomposing. The process of kelp decomposing can lead to the production of the 'rotten egg' type smell. The presence of this odour may be especially prominent when there is a significant wash-up of kelp in the summer months when the temperatures are warmer. Beach kelp may also get buried in beach sand, with some decomposition taking place beneath the sand. The breakdown of kelp beneath the sand may result in groundwater seepage at low tides that is black in colour. This is caused by the pigments of kelp mixing with groundwater that can seep out closer to the shore at low tide. The pungent smell, together with the discolouration of this water, should not be confused with sewage. Kelp may also break down in the surf, especially during big winter storms. The presence of broken-down organic material may also result in the production of sea foam as well as mucilage or 'sea snot' that is brown and discoloured. This should not be confused with wastewater (see figure 5 on the next page).

Figure 5: Presence of discoloured foam arising from kelp breaking down due to wave action

Algal blooms: Decaying algal blooms may result in both discolouration of coastal waters, production of marine foam, mucilage as well as the production of a pungent smell. This should not be confused with sewage. For further information on algal blooms, please refer to section 30 "Algal blooms: What causes them, and what are their impacts?". The links below also provide information on sea foam, what it looks like, and what causes it.

- **What is sea foam? Sea foam forms when dissolved organic matter is the ocean is churned up**.
- **That foam on the beach is (probably) fine**.

Q: WHAT DOES WASTEWATER LOOK LIKE?

A: Wastewater is not typically brown or filled with solid matter as some might expect. Wastewater is generally a milky grey colour, which often leaves a black residue when it dries. There is a lot more than human excrement that flows through the sewer system – there is water from showers, washing machines, dishwaters, etc. that can also give the wastewater a chemical odour. Brown liquid discharging from stormwater systems is typically not from a wastewater spill.

Q: DOES THE PRESENCE OF A MILKY PLUME IN THE NEARSHORE, SOMETIMES EXPERIENCED ON THE ATLANTIC SEABOARD, REFLECT THE PRESENCE OF SEWAGE?

A: The presence of a milky plume in the nearshore environment (see figure 6) at Camps Bay is proven not to be sewage/wastewater but is likely attributed to calcium carbonate leaching out of beach sand sediment. This is especially evident under warm, calm conditions during the summer months.

Figure 6: Milky plume evident at Camps Bay. (Photographer: Jean Tresfon).

For further information on this phenomena, please access the following links:

- Whiting events in SW Florida coastal waters: a case study using MODIS medium-resolution data
- Satellite-Derived Estimates of Suspended CaCO3 Mud Concentrations from the West Florida Shelf Induced by Hurricane Ian

6. BATHING

Q: WHAT WILL HAPPEN IF I SWIM IN CAPE TOWN'S COASTAL WATERS?

A: Thousands of people swim and recreate in Cape Town's coastal waters on a daily basis. Along some stretches of Cape Town's coastline there are, however, known pollution sources (stormwater outlets and rivers) that can and do pollute coastal waters. Swimming in contaminated water, especially water with elevated levels of faecal contamination, can pose health risks. The potential consequences of swimming in contaminated water include the following:

1. Gastrointestinal illnesses: Ingesting water contaminated with faecal matter can lead to gastrointestinal infections, causing symptoms such as diarrhoea, vomiting, stomach cramps and nausea.

2. Skin infections: Exposure to contaminated water can increase the risk of skin infections, for example rashes, dermatitis, or bacterial infections such as cellulitis.

3. Respiratory problems: Inhaling water droplets or aerosols contaminated with pathogens can lead to respiratory infections or exacerbate existing respiratory conditions.

4. Ear, nose and throat infections: Swimming in contaminated water can also increase the risk of ear infections (otitis externa), sinusitis, or throat infections (pharyngitis).

5. Eye infections: Contaminated water can cause eye irritation, conjunctivitis (pink eye), or other eye infections.

Overall, swimming in contaminated water can lead to various health issues, ranging from mild discomfort to more severe illnesses, depending on the level and type of contamination present. To reduce the risk of illness, it is important to heed water quality advisories and avoid swimming in areas where contamination levels are high.

Q: WHAT ARE SOME OF THE STEPS I CAN TAKE TO LIMIT ANY POTENTIAL HEALTH RISKS?

A: The following steps are recommended:

- Avoid swimming in the sea or paddling in rock pools near stormwater outlets. This has been shown to increase the risk of illness.
- Do not swim within 150 m either side of an open river mouth.
- Avoid swimming for 12 to 24 hours after moderate to heavy rainfall. Rainfall increases the possibility of poor water quality, as it washes faecal matter from land and overflowing sewers. Avoiding swimming after rainfall is common practice in other countries where stormwater and river discharge are known to release contaminated water.
- Keep an eye open for public warning signs that may either be permanent or temporary signage.
- Do not swim if you have an open wound.
- View coastal water quality information on the City's Coastal Water Quality web page. Information provided on this page includes the latest raw data results as well as long-term trends in coastal water quality.

7. IMPROVING COASTAL WATER QUALITY

Q: WHAT CAN I DO TO LIMIT SEWER SPILLS ARISING FROM THE CITY'S SEWER NETWORK?

A: During 2020, the City's Water and Sanitation Department cleared approximately 122 000 sewer blockages across Cape Town, the primary cause (75%) being misuse of the system, including the illegal disposal of foreign materials into the sewer system. In one busy week alone, from Monday 3 to Sunday 9 June, maintenance teams responded to 2 799 sewer blockages – almost 400 blockages a day. More than R350 million was spent on efforts to address this chronic – yet largely avoidable – problem. Here are a number of actions that will assist the City in reducing the pressure on the sewer system:

1. Flush only human waste, toilet paper, and cleaning detergent down the toilet. Everything else such as rags, cooking oil/fats, newspapers, feminine hygiene products, condoms, nappies, wet wipes and building materials need to be disposed of via the appropriate solid waste services that are provided by the City. Flushing anything apart from human waste and toilet paper is illegal in terms of the **Wastewater and Industrial Effluent By-law, 2013**.
2. Install and properly maintain a grease trap if you run a restaurant or are involved in food preparation.
3. Put a strainer in the sink to catch food and do not wash food scrapings down the drain. Throw these in the rubbish bin. Do not install a food grinder in your sink.
4. Manholes must not be used for dumping/waste disposal. These should remain closed as they are only used for inspection and maintenance purposes.
5. Report missing manhole covers to the City. Manhole covers prevent objects such as sand, stones and discarded items from falling into our sewers. They are also important for safety and prevent bad smells and cockroaches from leaving the system. Missing manhole covers and any other faults may be reported to the City **here**.
6. Check that tree roots are not growing into your sewer system.
7. Ensure that your drains are fitted with suitable covers to prevent sand, leaves and other foreign material from entering the sewer system.
8. Sweep sand away from drains and dispose of it in small amounts in the normal household bin, or at your local **drop-off site**.
9. Ensure that rain gutters, downpipes and surface runoff on your property flow into stormwater drains in the street rather than sewers. Illegal discharge of stormwater (i.e. from rain gutters) into sewers contributes to overflows by overloading the capacity of the pipes, particularly during heavy rainfall.
10. Call a qualified, registered plumber to unblock sewers on your private property. Call our Technical Operation Centre if the blockage is in the street or on public land. For further information, refer to the Bin it, Don't Block It campaign.

8. STORMWATER SYSTEMS

Q: WHAT ARE THE DOS AND DON'TS OF STORMWATER SYSTEMS?

A: The city has an extensive stormwater network that is designed to prevent the flooding of roads and the built environment during rainfall events. The rainwater enters the stormwater system through inlets on the sides of the roads, and is then channelled underground and transported via stormwater mains to the sea. This runoff is not treated, or diluted, but goes straight into the sea.

The only substance that should end up in the stormwater network is runoff during and after rainfall events. This means, if it has not been raining, nothing should flow out of the stormwater system. But this is, unfortunately, not the case in Cape Town. Some residents and businesses use the stormwater system as a convenient dumping site to get rid of pollution – be it domestic animal waste, fat, oil, industrial coolants, or other pollutants. All of this waste goes straight into the ocean and has a huge impact on the quality of the water in the nearshore. This explains why we often find that the water quality is poor in coastal areas close to stormwater outlets and after rainfall events that flush the stormwater system. The extent and severity of the abuse of Cape Town's stormwater system – either knowingly, or because of ignorance – are evident from the following two examples.

The first was from a pilot study conducted by the City to test the feasibility of an environmentally friendly method of exposing stormwater outflow to UV light to sterilise the stormwater before it enters the nearshore coastal environment. Unfortunately, the UV bulbs were covered in fats and oils within hours and in the end it rendered the project ineffective and a failure. We suspect that the fats and oils that smothered the bulbs originated from the restaurant industry illegally discharging these substances into the stormwater system.

The second was when the City found industrial coolant entering a stormwater drain in Adderley Street in the middle of the Cape Town CBD. We traced the source of the discharge to the top of a multi-storey building where it was being used in an industrial cooling system. When the City spoke to the technician responsible for applying the coolant in servicing the cooling system, the technician acknowledged that it was 'industry standard' to discharge excess coolant into the stormwater system, despite it being illegal to do so. Although the incident may have taken place in Adderley Street in the centre of town, this liquid would have ultimately found its way to the sea via the stormwater system. Figure 7 provides an example of the indiscriminate discharge of illegal substances into the stormwater system.

These two examples and real events reveal the systemic challenges that we face as a city in respect of managing, and improving, coastal water quality in Cape Town. We need businesses and industry to respect the stormwater system and to get rid of waste in a responsible and sustainable manner. We also need residents to respect the stormwater system and to report anyone who dumps illegally into the system. Pollution is everybody's problem. Any long-term solution should be founded on a collective response and a shared responsibility between all of us who live and work in Cape Town.

Figure 7: A key challenge for the City is tracing substances illegally discharged into the city's stormwater network, which ultimately discharges into the sea

9. WASTEWATER SYSTEM

Q: HOW DOES THE WASTEWATER SYSTEM WORK?

A: The wastewater system in the city of Cape Town is a complex network designed to collect, treat, and dispose of wastewater generated by residential, commercial and industrial activities. Here is an overview of how the system works:

1. Collection: Wastewater is collected from homes, businesses and other sources through a network of gravity-fed sewer pipes. These pipes convey the wastewater either directly to the Wastewater Treatment Works (WwTW) or where gravity flow is not possible to centralised collection points called pump stations.

2. Pump stations: Pump stations are strategically located throughout the city to pump the wastewater from low-lying areas to the respective WwTW, overcoming natural gravity flow limitations. These pump stations move the wastewater through pressurised pipes to ensure continuous flow towards treatment facilities.

3. Wastewater treatment works (WWTW): The City of Cape Town operates 21 wastewater treatment works where the collected wastewater undergoes treatment to remove specific pollutants and pathogens. Treatment processes typically include screening and degritting, primary sedimentation, biological treatment (such as activated sludge or biological filtration), secondary clarification and disinfection. Advanced treatment processes, e.g. membrane bioreactors and UV disinfection are provided at certain WwTW.

4. Treatment and discharge: After treatment, the treated effluent is discharged into receiving water bodies such as a river, or directly into the sea. The treated effluent must meet regulatory standards to ensure minimal impact on the environment and public health.

5. Outfalls: The City operates three marine outfalls where wastewater from the outfall catchment is discharged directly into the ocean via purpose designed pipeline and diffuser combinations. These outfalls are designed to disperse preliminary treated (screened) wastewater into the marine environment where natural processes help further dilute and assimilate the effluent.

Overall, the City of Cape Town's wastewater system handles a significant volume of wastewater on a daily basis (on average approximately 611 megalitres per day). Just over 94% of this wastewater The majority thereof is treated at wastewater treatment works before being discharged into the receiving water bodies, while the balance is discharged via the three marine outfalls. The system's infrastructure, including pump stations, treatment plants and outfall pipes, plays a vital role in protecting public health and the environment by safely managing wastewater disposal.

Q: WHAT ARE THE PREDOMINANT CAUSES OF SEWER SPILLS IN THE CITY?

A: The City can respond to up to 400 sewer system failures each day. During 2020, the City's Water and Sanitation Department cleared approximately 122 000 sewer blockages across Cape Town. The primary cause (75%) was misuse of the system, including the illegal disposal of foreign materials into the sewer system. More than R350 million was spent on efforts to address this chronic – yet largely avoidable – problem.

Q: HOW DO FOREIGN ITEMS IN THE SEWER SYSTEM CAUSE SEWER OVERFLOWS?

A: Flushing or washing meat fat, cooking oil, sanitaryware, earbuds, wet wipes, cotton balls or rounds, nappies, face masks, food scraps, etc. down the drain can and do contribute to poor water quality. There are metal grids at various points in the sewer system and these items can get trapped against the grid and prevent normal flow. This can cause a blockage and result in an overflow from a nearby manhole. If these items get past the grids and into a pump station they can also cause havoc by getting stuck in the pump. This causes the pump to trip and potentially an overflow from the pump station if it is not caught in time.

These items are very commonly found blocking pipes and pump stations. What is surprising is the amount and types of dumped goods that are found in sewer lines. Items such as car bonnets, television sets, tyres, cutlery, car seats and many other large items have been pulled out of sewer lines. These cause blockages and surges of sewage from nearby manholes into the receiving residential or natural environment.

10. SEWER PUMP STATIONS

Q: HOW DO SEWER PUMP STATIONS WORK?

A: In a gravity sewage system, sewage pump stations play a crucial role in managing wastewater flow. Below is an overview of how it works in Cape Town:

1. Collection of wastewater: Gravity sewage systems rely on the natural downward flow of wastewater from homes, businesses and other sources towards a central collection point. This wastewater, which includes sewage and other liquid waste, enters the sewer network through gravity-fed pipes.

2. Transfer to pump station: As wastewater flows downhill, it eventually reaches a low point where it needs to be lifted to continue its journey towards the treatment plant or disposal site. At these low points, sewage pump stations are installed to lift the wastewater to a higher elevation, overcoming the natural gravitational flow.

3. Pumping process: Inside the sewage pump station, one or more pumps are housed in a wet well or chamber. When the wastewater level in the wet well reaches a certain height, sensors or floats trigger the pumps to activate. The pumps then draw in the wastewater from the wet well and forcefully discharge it through a pressurised pipe system.

4. Forceful discharge: The pumps in the sewage pump station generate enough pressure to propel the wastewater through the pressurised pipes, even uphill or over long distances. This ensures that the wastewater continues to flow towards its destination, whether it is a treatment plant, storage facility, or discharge point.

5. Monitoring and control: Sewage pump stations are equipped with monitoring and control systems to regulate pump operation, monitor wastewater levels, and detect any issues such as pump failures or blockages. These systems may include alarms, telemetry, and remote monitoring capabilities to alert operators to any problems and facilitate timely maintenance or repairs.

6. Treatment or disposal: After being pumped from the sewage pump station, the wastewater continues through the sewer network until it reaches a wastewater treatment plant for processing or a designated treatment plant for processing or a designated marine outfall.

Overall, sewage pump stations play a critical role in maintaining the functionality and efficiency of gravity sewage systems, ensuring the safe and reliable conveyance of wastewater from source to treatment or disposal.

Q: WHY DO THERE APPEAR TO BE A LOT OF SEWER SPILLS FROM PUMP STATIONS DURING LOAD-SHEDDING?

A: Pump stations have a storage facility called a sump, which holds the wastewater until it reaches a certain level and the pump kicks in to transport it further along the system. If the sump was getting close to full as load-shedding starts, wastewater from the residential area will continue to flow in and fill up the sump. Without electricity the sensor system may not work and the pump will not kick in at the right time. This may lead to an overflow into the adjacent stormwater system.

There are also anecdotal trends of more overflows in summer months. While this may be because of greater presence on the beach and greater chance of overflows being reported, there is in fact merit to this claim. Some suburbs in Cape Town are holiday destinations in summer, with people from all over the world and country flocking to holiday homes and beaches in the area. This can cause strain on the sewerage system with the sump filling up more quickly in the two-hour load-shedding period, resulting in an overflow before the power comes back on.

While there are certainly infrastructure failures around Cape Town, it is also true that load-shedding has a terribly detrimental effect on electronic systems. They are not designed to cope with continuous shut downs and restarts. This damages the electrical circuits and often results in blown or tripped pumps.

Q: WHAT IS THE CITY DOING TO MITIGATE AGAINST PUMP STATION OVERFLOWS?

A: The City endeavours to preempt load-shedding events and overpumps pump stations so that they are empty before load-shedding starts. The City has also installed generators and UPS systems into pump stations so that they are more resilient to load-shedding. Further to this, the City is in the process of developing pump station failure response protocols. These protocols are designed to facilitate an efficient and coordinated response to sewer spill incidents across various line departments. The response covers the entire 'lifecycle' of the incident, from identifying the problem, stopping the discharge, mobilising staff, public communication, mitigating environmental impacts, reporting, etc.

11. BLUE FLAG

Q: HOW IS BLUE FLAG WATER QUALITY SAMPLED?

A: Blue Flag sampling and analysis are undertaken by an independent laboratory. An initial preseason sample is conducted in November, where after beaches are required to be tested twice a month. However, the City undertakes to sample once a week, with some exceptions over the week of Christmas and New Year. Samples are collected in the designated bathing areas, as well as at stormwater/river outlets, if applicable. Blue Flag allows for follow-up sampling in the event of a failed result. This happens when there is an unexplainable result, or if there was a known incident, and will mean that another sample will be taken as soon as possible.

If there is a known spill, the flag is lowered until such a time as the cleanup operation is completed or the water quality results are satisfactory. The flag is lowered whether or not the wastewater reached the sea, which is why we may have a number of lowered flag instances during the season, while the water quality results remain excellent. The majority of the time, spills from manholes are reported and attended to quickly.

Q: HOW IS IT POSSIBLE THAT A BLUE FLAG BEACH CAN GET A POOR RESULT BUT DOES NOT LOSE ITS STATUS?

A: Blue Flag (BF) season is from December to January for most of our beaches, with the larger beaches ending in March. Results leading to a 'poor' categorisation are likely to have been recorded outside of the BF season. Blue Flag, coordinated by WESSA in South Africa, look at results over a four-year period, rather than one year as the City usually reports on, but follows the same 95th percentile calculation for 'excellent' water quality.

Because the internal samples and BF samples are not collected on the same days, it is also possible for differing results between the two sample collections. This highlights the potential for great variability between samples collected at different times and at slightly different locations at a beach.

There are also a number of other factors involved in Blue Flag status, as there are 33 criteria that are activity monitored. Blue Flag is an environmental education programme and coastal management tool that comprises standards ranging from the provision of universal access to environmental management.

12. MARINE OUTFALLS

GENERAL INFORMATION, AND HISTORY OF CAPE TOWN'S MARINE OUTFALLS

Q: HOW MANY MARINE OUTFALLS DOES THE CITY OF CAPE TOWN OPERATE?

A: The City operates three marine outfalls, which are located offshore at Hout Bay, Green Point and Camps Bay.

Q: WHEN WERE THESE MARINE OUTFALLS BUILT?

A: The Camps Bay marine outfall was commissioned in 1977, and both the Green Point and Hout Bay marine outfalls were commissioned in 1993.

Q: HOW WAS SEWAGE DISPOSED OF AT THESE THREE LOCATIONS PRIOR TO THE MARINE OUTFALLS BEING BUILT?

A: Previously, sewage at all three sites was disposed into the sea via short pipes over the beaches. This was the practice since the very first permanently established human settlements at all three locations.

Q: WHAT IS THE DESIGN CAPACITY OF EACH OF THE MARINE OUTFALLS?

A: The outfall at Camps Bay has a design capacity of approximately 5 Mℓ/day (and operates at around 50% of that), the one at Green Point 40 Mℓ/day (and operates at about 60–65%), and the one at Hout Bay 9 Mℓ/day (and operates at around 60%).

Q: WHAT DOES 'DESIGN CAPACITY' MEAN?

A: Design capacity is the maximum volume of wastewater that can be released at that specific site before significant environmental impacts or public health impacts materialise. The design capacity is specific to the environment of each outfall, depth of release and distance of the diffusers from the shoreline. Another way of phrasing this is: "Providing the maximum volume of wastewater does not exceed that stipulated by the design capacity, we should not see significant, deleterious environmental impacts or public health risks". Seven years of research and data from 2015–2022 show this to be holding true at the three outfalls – see section 21 below to access the said research and data.

Q: HOW MUCH PRELIMINARY TREATED SEWAGE IN TOTAL IS DISCHARGED DAILY IN CAPE TOWN FROM THE THREE MARINE OUTFALLS, AND HOW DOES THIS COMPARE INTERNATIONALLY?

A: The City discharges around 30 Mℓ/day from its three marine outfalls. By comparison, Sydney (Australia) discharges up to 950 Mℓ/day that is treated to primary level, which is one stage further than preliminary treatment.

Q: HOW MUCH DO THE THREE MARINE OUTFALLS DISCHARGE RELATIVE TO THE CITY'S LAND-BASED WASTEWATER TREATMENT WORKS (WWTW)?

A: The City's marine outfalls account for approximately 5% of the total amount of wastewater produced in Cape Town. The remaining 95% of Cape Town's wastewater comes from land-based WWTW. While they may be land based, however, the WWTW discharge into river systems that ultimately reach the sea.

Q: IS WASTEWATER PRETREATED AT THE MARINE OUTFALLS?

A: Yes. Cape Town's marine outfalls have preliminary treatment in the form of screenings removal. The preliminary treatment includes the removal of wastewater constituents such as rags, sticks, floatables, grit and grease that may cause maintenance or operational problems with the treatment operations, processes and ancillary systems.

The current operation at the outfalls also includes two stages of screening, namely coarse and fine (3 mm) screens, as part of the preliminary treatment of the raw wastewater.

Q: IS THE CITY CONSIDERING FURTHER PRETREATMENT OF WASTEWATER BEFORE IT IS DISCHARGED INTO THE MARINE ENVIRONMENT?

A: Yes. The City commissioned a study to determine the feasibility of various higher-level pretreatment interventions. The City is currently in the process of considering the outcomes of this study.

Q: ARE THERE ANY OTHER MARINE OUTFALLS IN CAPE TOWN'S COASTAL WATERS THAT ARE NOT OPERATED BY THE CITY OF CAPE TOWN?

A: Yes. A marine outfall located on the eastern shore of Robben Island is administered by the Robben Island Museum. Its effluent, which is currently macerated, is discharged 465 m offshore from Robben Island into Table Bay. Plans are afoot to build a WWTW on Robben Island with a throughput capacity of 300 m^3 per day.

MARINE PROTECTED AREAS AND MARINE OUTFALLS

Q: WHEN WERE THE MARINE OUTFALLS BUILT IN RELATION TO THE PROCLAMATION OF THE TABLE MOUNTAIN NATIONAL PARK MARINE PROTECTED AREA (TMNP MPA), AND DO CAPE TOWN'S MARINE OUTFALLS DISCHARGE INTO THE TMNP MPA?

A: The TMNP MPA was proclaimed in 2004, a full 27 years after the Camps Bay marine outfall was commissioned. The outfall at Camps Bay discharges into a control zone in the TMNP MPA, and not into a sanctuary or no-take zone. The Hout Bay outfall was commissioned in 1993 – 11 years before the TMNP MPA was declared. It, too, discharges into the MPA. While also commissioned in 1993, the Green Point outfall now discharges into the Robben Island MPA, which was established in 2019. It must be noted that at all three locations, wastewater has been disposed of in the same way ever since the construction of the marine outfalls at all three locations. Prior to their construction, wastewater was discharged over the shoreline.

Q: HOW CAN A MARINE OUTFALL BE PERMITTED TO DISCHARGE INTO THE TMNP MPA?

A: During the investigation and motivations to declare the TMNP MPA, the Camps Bay and Hout Bay marine outfalls and their operation were not identified as an impediment or risk to the MPA in terms of its marine and environmental impact. No reference was made to the need for, or possible consideration of, decommissioning either outfalls during the declaration of the TMNP MPA. Therefore, the TMNP MPA was declared with the full knowledge of a pre-existing marine outfall at Camps Bay and Hout Bay.

REGULATION OF MARINE OUTFALLS

Q: ARE MARINE OUTFALLS REGULATED BY LAW?

A: Yes. Each marine outfall must have a Water Use Licence in terms of the National Water Act, Act 36 of 1998 as well as a Coastal Waters Discharge Permit in terms of the National Integrated Coastal Management Act, Act 24 of 2008.

Q: WHAT IS THE PURPOSE OF THE WATER USE LICENCE (WUL) AND COASTAL WATERS DISCHARGE PERMIT (CWDP)?

A: National Government requires the WUL and CWDP to ensure that marine outfalls operate according to and within various parameters and prescripts set by the departments of Water Affairs and Forestry, Fisheries and the Environment. The WUL and CWDP also impose strict monitoring requirements on the three marine outfalls, which are the responsibility of the operator (in this case, the City of Cape Town) to uphold.

Q: WHAT IS THE CURRENT PERMITTING STATUS OF THE CITY'S THREE MARINE OUTFALLS?

A: The Hout Bay outfall has a CWDP. Both Camps Bay and Green Point outfalls have been issued with CWDPs, which are being finalised pending the appeals process. All three also have WULs.

SPECIALIST MARINE SCIENCE STUDIES

Q: WHAT MARINE SCIENCE STUDIES HAS THE CITY COMMISSIONED TO BETTER UNDERSTAND THE IMPACT OF MARINE OUTFALLS IN CAPE TOWN?

A: The City commissioned the following specialist marine science studies over the past six years:

- The technical report on marine outfall monitoring and assessment **(CSIR, 2017)**
- Detailed dispersion modelling for each marine outfall **(PRDW, 2020/21)**
- Six seasons (winter/summer) of seawater quality monitoring **(CLS, 2020–2022)**
- Preliminary biodiversity assessment at Camps Bay marine outfall **(CLS, 2022)**
- Initial benthic macrofauna survey at Camps Bay marine outfall **(CLS, 2022)**
- Assessment of pharmaceutical compounds in Cape Town's coastal waters in both winter and summer **(CSIR, 2021)**

Q: WHAT OTHER MARINE OUTFALL REPORTS HAS THE CITY COMMISSIONED?

A: An expert panel was asked to prepare environmental summary reports for **Camps Bay**, **Green Point** and **Hout Bay** marine outfalls, using the data and findings from the aforementioned marine science studies. The reports were released in 2022. The panel comprised Dr Robin Carter (over 40 years' marine science expertise), Lisa Holden (over 10 years' marine science expertise), Dr Barry Clark (over 30 years' marine science expertise) and Dr Brent Newman (more than 25 years' marine chemistry expertise).

Q: WERE THESE ENVIRONMENTAL SUMMARY REPORTS REVIEWED BY AN INDEPENDENT EXPERT?

A: Yes, Dr Lynn Jackson (over 40 years' marine science expertise) reviewed them.

Q: ARE THE REPORTS AND DATA PRODUCED BY THESE MARINE SCIENCE EXPERTS ACCESSIBLE TO THE PUBLIC?

A: Yes, the marine scientists' results, analysis and findings inform the City's position regarding the outfalls and are available on the City's Coastal Water Quality web page. Alternatively, go to **www.capetown.gov.za**, enter the search terms 'coastal water quality' and scroll down to the section on marine outfalls.

OVERALL FINDING AND KEY TAKE-AWAYS FROM THE MARINE SCIENCE STUDIES

Q: WHAT IS THE OVERALL FINDING OF THE SPECIALIST MARINE SCIENCE STUDIES?

A: The findings of all seven major studies listed above, which were undertaken by different marine science experts over the past six years – all investigating different measurable aspects such as bacteria, toxicity, mussel growth, animal tissue, biodiversity, chemicals of emerging concern (CECs), dissolved oxygen and detailed numerical modelling – suggest that the pollution is concentrated in the permitted mixing zone located close to the diffuser (a specialised component used for the controlled discharge of treated wastewater). There is not yet any evidence of significant or deleterious environmental impacts. The overall key conclusion is that the marine outfalls are meeting their design objectives in reducing potential deleterious ecological and/or human health effects of discharged effluent by taking advantage of increased effluent dilution offered by deep water.

Q: WHAT ARE THE OTHER KEY TAKE-AWAYS FROM THE STUDIES AND ENVIRONMENTAL SUMMARY REPORTS?

A: Additional key findings include the following:

- All three outfalls are operating in accordance with their original design, which is to dispose of preliminary treated wastewater (or screened wastewater) by using deep-water dispersion so that the ocean assimilates waste without exceeding its environmental capacity.
- Data collected from multiple studies and supported by detailed numerical dispersion modelling indicate that the effluent discharged through the Green Point, Camps Bay and Hout Bay outfalls does not have any significant or deleterious impacts in the Cape Town outfalls study area.
- Detailed numerical dispersion modelling and extensive water sampling show that the South African water quality guidelines for the recreational use of coastal marine waters are not exceeded anywhere along the shoreline as a result of the effluent discharged from the marine outfalls.
- Detailed numerical dispersion modelling and analysis of over 4 000 water samples reveal the following:

▪ **Green Point:**
  - The minimum number of dilutions achieved at the edge of the 256-metre radius mixing zone is 528 in winter/spring and 628 in summer/autumn.

▪ **Camps Bay:**
  - The minimum number of dilutions achieved at the edge of the 274-metre radius mixing zone is 3 480 in winter/spring and 2 700 in summer/autumn.
  - The low-point discharge rates and velocities cause the effluent to be trapped near the seabed, which is where the lowest dilutions and the highest bacterial counts are consequently found.

▪ **Hout Bay:**
  - The minimum number of dilutions achieved at the edge of the 272-metre radius mixing zone is 1 500 in winter/spring and 1 970 summer/autumn.
  - Plume (a body of water affected by the presence of pollutants) has the lowest dilutions and highest bacterial concentrations at mid-depth.
  - The big-wave surf spot, Dungeons, may at times be exposed to bacterial levels that exceed the national guidelines for short periods.

- For further information and context surrounding dilution results from the marine outfall analysis, please refer to the detailed dispersion modelling reports.

OTHER NOTEWORTHY STUDY RESULTS

Q: WHAT ELSE DID THE MARINE SCIENCE STUDIES FIND?

A: Other important study results include the following:

- Of the 196 marine toxicity tests conducted, none found toxicity to marine biota.
- Twelve bags of mussels were moored around each outfall every winter and every summer for three years. There was no statistically significant difference in growth rates or metal accumulation in the mussel tissue close to the marine outfalls compared to the control sites located away from known pollution sources.
- Preliminary and initial biodiversity assessment data show little to no impact on marine biodiversity (abundance and diversity) at Camps Bay.
- A preliminary macrofauna survey suggests a potential localised impact directly around the diffuser, although this needs to be confirmed. The impact is limited to a narrow geographical area and has not resulted in a monospecies environment or the presence of unexpected species in the benthos. Therefore, it is not considered environmentally significant.
- The marine outfalls discharge chemicals of emerging concern (CECs), as do all the City's wastewater treatment works, which produce some 95% of Cape Town's wastewater. Globally, there is no reasonably practicable and financially feasible technology available to remove CECs from wastewater at city scale. This is a global challenge and is not only a marine outfall issue. Nearshore concentrations of CECs are highest in rivers, stormwater and estuaries. Currently, the only way to stop this contamination would be for residents to stop all chemical use, including pharmaceuticals commonly found in daily medications.
- The outfalls' contribution to eutrophication and algal blooms is considered minuscule.
- There is no evidence yet of the long-term build-up of organic or inorganic contaminants in the sediment.
- There is no evidence of dissolved oxygen stress in the water column.
- Public perception of marine outfalls tends to be very negative, which has a significant impact on the public's view of the quality of Cape Town's coastal environment.

MARINE OUTFALLS, ALGAL BLOOMS AND SEAL BEHAVIOUR

Q: DO MARINE OUTFALLS CAUSE ALGAL BLOOMS?

A: On average, the three marine outfalls at Green Point, Camps Bay and Hout Bay discharge 2,62 x 1 010 millimoles (mmol) of ammonia-nitrogen into the sea per year (estimated from data in CSIR, 2017 and the PRDW 2020/21). This, however, is not the major source of inorganic nutrient supply to the euphotic zone (the uppermost layer of water).

There is significant natural upwelling in the region. The three marine outfalls are located in the Cape Point upwelling cell, the southernmost of the major upwelling nodes on the west coast. (The environmental summary report for Camps Bay contains a scientific explanation.) Annually, approximately 19 natural upwelling events of varying intensities and durations occur in the southern Benguela current region, which are said to inject around 2,0 x 1 014 mmol of nitrogen into the euphotic zone.

Therefore, the ammonia and nitrogen discharged from the three outfalls accounts for only a minuscule portion of regional eutrophication. Moreover, in the vicinity of the outfalls, metocean conditions (meteorological and oceanographic conditions) and seabed topography largely limit algal bloom development and consequences. (Consult page 21 of the environmental summary report for Camps Bay for more.)

Q: ARE THE SEWAGE OUTFALLS CAUSING INCREASED LEVELS OF DOMOIC ACID IN OUR WATERS?

A: No evidence has yet been documented that the level of domoic acid (which is produced by a naturally occurring species of alga) has increased in our waters in any way. The species of alga that produces domoic acid has always formed part of our algal species diversity and is not a new introduction. This type of alga is commonly found across the world.

Q: IS DOMOIC ACID CAUSING AGGRESSIVE BEHAVIOUR IN SEALS?

A: National Government (the Department of Forestry, Fisheries and the Environment), the state veterinarian and research organisations are yet to determine definitively whether domoic acid is accumulating in seals to any level of concern. No state or research organisation has linked domoic acid to seal aggression; it is a working hypothesis only.

REMOVAL OF CHEMICALS OF EMERGING CONCERN FROM WASTEWATER

Q: IS IT POSSIBLE TO REMOVE CHEMICALS OF EMERGING CONCERN (CECS) FROM WASTEWATER?

A: Yes, CECs can be removed by means of advanced water treatment processes typically used for the production of drinking water. However, even this kind of treatment process produces a toxic brine, which still has to be disposed of somewhere. None of our waste simply disappears.

Q: WHY CAN THE CITY NOT APPLY THIS TECHNOLOGY TO ALL WASTEWATER PRODUCED IN CAPE TOWN?

A: The limiting factor is affordability. The estimated capital cost for an advanced treatment process is R25 million/Mℓ of treated capacity per day.

PRESENCE OF CHEMICALS OF EMERGING CONCERN IN MARINE BIOTA

Q: DOES THE PRESENCE OF CHEMICALS OF EMERGING CONCERN (CECS) IN MARINE BIOTA (SUCH AS FISH, PENGUINS, SEAWEED, ETC.) NECESSARILY MEAN THAT THE CHEMICALS ORIGINATE EXCLUSIVELY FROM THE EFFLUENT DISCHARGED FROM MARINE OUTFALLS?

A: No. While marine outfalls contribute to the presence of CECs in the marine environment, they are by no means the only contributor. There are a range of other contributors, including effluent discharged from land-based WWTW into rivers (which ultimately reach the sea and which amounts to approximately 95% of wastewater produced in Cape Town), industrial and urban runoff into stormwater systems which eventually discharge into the sea), agricultural runoff into river systems (which finally meet the sea), etc. For detailed research on the contribution of urban stormwater systems to the presence of CECs in the receiving environment, please refer to the following study as an example: **Urban Stormwater: An Overlooked Pathway of Extensive Mixed Contaminants to Surface and Groundwaters in the United States**.

Precisely because of the numerous ways in which they can enter the marine and coastal environment, CECs are now ubiquitous in both populated and remote marine and coastal areas, which is a global phenomenon. For example, a **scientific study found CECs at Diaz Beach** at the tip of Cape Point – one of the most isolated areas of Cape Town.

Another study, and indicative of this phenomena being a global challenge, identified the **presence of toxic anthropogenic pollutants in the deepest ocean on Earth**.

MARINE OUTFALLS AND BLUE FLAG STATUS

Q: WHAT IS THE BLUE FLAG STATUS OF CLIFTON AND CAMPS BAY, AND WHO MONITORS THE WATER QUALITY FOR BLUE FLAG BEACHES?

A: Both Camps Bay and Clifton have had Blue Flag status for over ten years. The City does not take the water quality samples for determining and awarding Blue Flag status at these beaches. Instead, coastal water quality samples are taken and analysed by an independent laboratory, and the results are submitted to the Wildlife and Environment Society of South Africa (WESSA) for evaluation.

Q: HAS THE PRESENCE OF MARINE OUTFALLS AFFECTED CAMPS BAY AND CLIFTON'S ABILITY TO RETAIN THEIR BLUE FLAG STATUS?

A: No. As mentioned, both Camps Bay and Clifton have now retained their Blue Flag status for over ten years. While these beaches at times lost their status, this was caused by land-based sewage spills, which were quickly resolved. The monitoring of coastal water quality at these beaches is undertaken by an independent laboratory and analysed in accordance with the **South African Water Quality Guidelines for the Recreational Use of Coastal Marine Waters**. The consistent achievement of Blue Flag status confirms that the presence of marine outfalls has not affected coastal water quality to the extent that these beaches no longer meet Blue Flag requirements.

13. PHARMACEUTICALS, YOU, AND THE ENVIRONMENT

Author: Dr Brent Newman

The discovery of pharmaceutical compounds to treat diseases and other health afflictions suffered by people and animals is one of mankind's great achievements. Today, people in many countries enjoy a longer, healthier life compared to past generations, while the productivity on livestock farms has improved, due in part to the use of pharmaceutical compounds. However, these benefits have had unintended consequences. Pharmaceutical compounds are one of the most common contaminants found in rivers, lakes and the sea. They can enter the environment in several ways. One of the most important is in wastewater. Pharmaceutical compounds are not fully absorbed or broken down in the human and animal body. As much as 90% of some compounds may not be absorbed. One reason is that many pharmaceutical compounds are designed to resist disintegration in our bodies, so they have time to act.

The unused remainder is excreted in our urine and faeces. Pharmaceutical compounds are also found in treatments you might apply to your skin, such as acne treatments. The compounds are washed from your body when you bathe. In towns and cities where houses, businesses and industries are serviced by a sewer system, bathroom waste goes to a wastewater treatment plant. The problem is that conventional wastewater treatment plants are not able to effectively filter out and remove all pharmaceutical (and other complex chemical) compounds from the wastewater. The compounds are thus released from wastewater treatment plants into the rivers or directly into the sea. Other sources include the disposal of unused or expired pharmaceuticals down the sink or toilet, septic tank systems, leaking sewers, pet waste, hospital wastewater, wastewater from pharmaceutical manufacturing operations, and agricultural runoff.

The contamination of the environment by pharmaceutical compounds is nothing new since they have been used for a long time. However, it is only in about the last 25 years, and particularly in the last ten years, that scientists and regulators have focused major attention on the presence and effects of pharmaceutical compounds in the environment. Studies have shown that the contamination of rivers, lakes and the sea by pharmaceutical compounds is a global challenge – they have been found on all continents, including Antarctica.

In a study commissioned by the City of Cape Town, the concentrations of 58 pharmaceutical compounds were measured in seawater samples collected in winter and summer at 28 coastal sites between Bloubergstrand on the west coast and Kogel Bay in the east. Water samples were also collected in some rivers and in the flow from stormwater pipes onto the shoreline. Pharmaceutical compounds were found in all seawater samples. In winter, 37 compounds were found in the samples, compared to 45 in summer.

The highest number of compounds found at a coastal site in winter was 27 at Lifebox23 Beach, and 33 at Macassar Beach in summer. Salicylic acid, which is both a precursor and a breakdown product of the chemical found in aspirin but is also found in acne and psoriasis treatments, was the most widespread compound in each season. Acetaminophen, also known as paracetamol, which is used to treat mild to moderate pain and is an ingredient in headache tablets was also widespread. Antibiotics, anti-inflammatories, and psychiatric drugs were also found in the seawater. Pharmaceutical compounds were also found in water flowing from stormwater pipes onto the shoreline. Other studies in Cape Town have shown that certain pharmaceutical compounds have accumulated in seaweeds and the bodies of marine invertebrates and fish.

Pharmaceuticals do degrade in the environment over time. However, the regular release of the compounds in some areas means aquatic animals and plants are exposed to the compounds before they degrade. An important unknown is how most pharmaceutical compounds affect aquatic plants and animals. The effects of some are known. Synthetic hormones in birth control pills cause feminisation in the males of certain fish, so that they become 'intersex' and show female sexual characteristics. This affects their reproduction to a degree that in some rivers there are abnormally more females than males in some fish species. Some anti-anxiety and antidepressant medications alter the behaviour of certain fish and cuttlefish. In some cases, the changed behaviour could make them more susceptible to predation.

Antibiotics are designed to affect microbes. Their presence in the environment can alter the composition of bacterial communities, which can have important consequences since bacteria perform many roles in aquatic ecosystems. The prolonged exposure of certain bacteria to low levels of antibiotics is also known to cause them to develop a resistance, so they are no longer affected. If they are disease-causing bacteria, they can spread to new areas and cause problems. The ecological effects of most pharmaceutical compounds are, however, unknown. A challenge in understanding these effects is that pharmaceutical compounds usually occur as a mixture in the environment and might interact in ways that enhance the effect of each compound on its own. There is no clear evidence that pharmaceutical compounds, at the concentrations they are usually found in the sea, pose a threat to swimmers and surfers.

Addressing pharmaceutical compound contamination in aquatic environments requires a multifaceted approach. People must accept that their use and improper disposal of drugs and medicines are part of the reason pharmaceutical compounds are found in the environment. While this does not mean you should not use drugs and medicines if you are unwell, you have an important part to play in reducing the problem. You can do this by following this advice:

- Do not overuse drugs or medicines – you might not need them to treat all afflictions.
- If you do not use all the drugs or medicines prescribed to you by a doctor or purchased in a store, or you have expired drugs and medicines in your home, the most important thing you can do is to NOT flush these down the toilet or sink. They will end up in a wastewater treatment plant and ultimately in a river, lake, or the sea.
- Find out if the pharmacy where you buy drugs and medicines takes back and disposes of unused or expired drugs and medicines. If there are none, ask your local political representative to lobby the government, health practitioner councils, pharmaceutical companies, and pharmacies to implement such a scheme.
- Small volumes of hazardous household waste such as cleaning waste may be dropped off at the City's waste drop-off centres in Athlone and Bellville. You can find more information **online**.
- Dispose of unused and expired drugs and medicines along with your ordinary household waste as a last resort. However, needles and non-expired pharmaceuticals need to be taken to a government health facility for responsible disposal.
- Waste removal service companies disposing hazardous waste (including medical and sanitary waste) need to obtain a special waste permit.
- Ask your doctor or vet to prescribe drugs and medicines that pose the lowest environmental hazard – different products that act in the same way may pose different environmental hazards.
- The medical and veterinary fraternities can assist by not overprescribing pharmaceutical compounds.
- Livestock farmers should try and reduce the use of pharmaceuticals and limit runoff from holding pens into rivers.
- Over time, the City of Cape Town must invest in wastewater treatment technology that is able to filter or degrade complex chemicals in wastewater. Providing proper sanitation facilities to all communities will also aid in reducing inputs of pharmaceutical compounds directly into the environment.

14. A BRIEF HISTORY OF URBAN STORMWATER DRAINAGE SYSTEMS – WITH IMPLICATIONS FOR HOMEOWNERS

Author: Professor Neil Armitage

Ever since there have been cities, there has been a need to remove excess rainwater, which is called 'stormwater' once it has reached the ground. An associated problem is the removal of wastewater, which usually emanates from clean water brought into the settlement to supply the drinking, washing, commercial and industrial needs of the population and is subsequently contaminated to the point where it is no longer fit for use.

The earliest evidence of urban drainage systems comes from Crete and the civilisations of the Indus Valley (modern Afghanistan, Pakistan and northwest India), where surplus water was drained in stone channels dating from as long as 5 000 years ago (De Feo et al., 2014; Burian and Edwards, 2002). The Romans (roughly 2 000 years ago) had particularly well-designed drainage systems, which can still be clearly seen at historical sites such as Hadrian's Wall (northern England) and Pompei (near Naples, Italy). In the case of the latter, rainwater was harvested off roofs for later use, while surplus water ran down the cobbled streets and out of the settlement. Stepping stones were placed at intersections to allow pedestrians to walk across the flooded streets, while openings between the stones allowed passage for wheeled vehicles, such as carts bringing goods in and out of the city.

The fall of the Roman Empire saw the end of major cities in Europe, and in the long period of political instability that followed, most urban areas were small towns serviced by earthlined ditches (Butler et al., 2018). This is how urban drainage remained until the Industrial Age resulted in the rapid growth of large, dense cities where the question of what to do with liquid waste suddenly became very pressing. Population density impacts urban drainage in several very significant ways: Large parts of the ground surface are made impermeable through the construction of buildings, roads, parking areas and the like, resulting in a huge increase in the stormwater volumes and flow rates; groundwater tables drop as recharge rates drop while more people pump underground aquifers as a supplementary source of water; the quantity of wastewater is massively increased; and, finally, the space to cope with liquid waste streams is reduced.

The urban drainage problem came to a head in what was then the world's largest city, London, in the middle of the 19th century when its population exceeded one million people crammed into a relatively small area. Human waste was discharged to cesspools located in any available open space and stormwater ran down the street to the Thames and its tributaries. To make matters worse, the streets were full of horse manure, as this was the era before motor vehicles! Unsurprisingly, frequent outbreaks of water-borne diseases, such as cholera, killed thousands of people. Something had to be done. So a plan devised by the civil engineer Joseph Bazalgette was completed in 1875. This saw all liquid 'wastes', including stormwater, collected into one system of underground tunnels, technically called 'combined sewerage', and discharged into the Thames River downstream of the city. It is still in use today (Butler et al., 2018).

Thirdly, it proved almost impossible to keep the two streams separate, with rain-/stormwater getting into the foul sewers (causing overloading at the wastewater treatment works) and sewage getting into the storm sewers.

The problem of polluted stormwater grew internationally until the passage of the Clean Water Act in 1972 (Health and Environment, 2022). This soon prompted similar legislation elsewhere in the world – including South Africa. However, it took until around 1990 before stormwater engineers and associated professionals had fully figured out better ways of managing stormwater. The new approach (over 30 years old now!) has different names depending on what part of the world you live in, but in South Africa – as in the UK – it is called sustainable drainage systems (SuDS).

SuDS aim to provide a holistic solution to stormwater management by mimicking the natural processes as far as is reasonably possible. It has four main objectives: Controlling stormwater flows, improving water quality, providing amenities (recreation space) and preserving biodiversity. There are at least 12 different options open to engineers. Although some involve 'blue-green' areas such as ponds, others are effectively invisible, such as permeable pavements that are roads and parking areas designed to soak up the rainwater rather than spill it. Some of the most effective options involve interventions as simple as ensuring that all rainwater is allowed to temporarily puddle on the property – and infiltrate into the ground – or forced to travel over vegetated areas such as gardens or grass verges (removing the worst of the pollutants and some of the liquid) before entering the formal drainage system.

Grass-lined ditches – technically called 'swales' – are preferred to concrete pipes. In many cases, SuDS are cheaper to construct and maintain than separated sewerage – particularly if one considers the cost of the downstream damage. The SuDS approach has made a huge difference wherever it is applied. For example, children can now safely swim in the canals of the Netherlands and Denmark, which would have been unthinkable a few decades ago! South Africa has also gradually been adopting SuDS. The City made it mandatory for new developments with their Management of Urban Stormwater Impacts Policy published in 2009 (CCT, 2009), while The South African Guidelines for Sustainable Drainage Systems was published in 2013 (Armitage et al., 2013). However, take-up has been slow as town planners, engineers and landscape architects have struggled to come to grips with the new approach – particularly in established areas with old-fashioned road and stormwater systems that are expensive to retrofit.

15. HARMFUL ALGAL BLOOMS OF THE COASTAL WATERS OF CAPE TOWN AND ITS SURROUNDINGS

Author: Dr Grant Pitcher

The coastal waters of Cape Town and its surroundings are located within the Benguela upwelling system. The flow of the Benguela towards the equator is driven by SE winds that force offshore flow of surface waters, resulting in the upwelling of cold, nutrient-rich waters into the coastal zone. The enrichment of surface waters inshore supports high plankton productivity beneficial to the functioning of the ecosystem, while also supporting the productive fisheries of the region. However, a small number of the algal species contributing to the plankton cause problems when they accumulate in sufficient numbers or when they produce toxins. These are known as harmful algal blooms (HABs), formerly called 'red tides' because they often colour the water red when achieving dense concentrations. Owing to coastal enrichment, the waters surrounding Cape Town experience a high incidence of HABs that is further enhanced by the retentive properties of Table Bay and False Bay, which thereby contribute to dense accumulations of plankton. Of the plankton species forming HABs many are motile, specifically a group known as the dinoflagellates, and their development is favoured by bay stratification during late summer and autumn.

One of the earliest HAB reports in the Benguela was in 1888, when many people became ill and some died after eating shellfish collected near Cape Town. The waters of Table Bay were described at the time as being luminescent after dark. Also, many baboons were found dead, having apparently been poisoned after eating white mussels. We now know that the likely species causing this event was the dinoflagellate *Alexandrium catenella* producing saxitoxins responsible for the syndrome of paralytic shellfish poisoning (PSP). Confirmed cases of PSP in the region were, however, only described in 1948 when groups of people became ill and a man died after eating mussels collected near Bloubergstrand. *Alexandrium catenella* remains the greatest risk to shellfish consumers on the west coast owing to the severity of the toxins, which result in paralysis of the neuromuscular system. The resulting symptoms include tingling and numbness of the mouth, lips and fingers, accompanied by general muscular weakness and incoordination. Acute doses inhibit respiration, and death results from respiratory paralysis.

In 1991, a further shellfish poisoning syndrome was identified on the west and south coasts of South Africa known as diarrhetic shellfish poisoning (DSP). Attributed to various species of *Dinophysis*, these dinoflagellates cause diarrhoea through the production of the toxin okadaic acid. It is likely that DSP has gone unreported on previous occasions because of the relatively mild nature of the symptoms. Despite the mild symptoms, DSP is the most common shellfish poisoning syndrome owing to the widespread occurrence of *Dinophysis* species on the South African coast, their presence throughout the upwelling season and the ability of low cell concentrations to render shellfish toxic.

More recently, toxins of a third shellfish poisoning syndrome known as amnesic shellfish poisoning (ASP) have been identified in the Benguela and are produced by various diatom species of the genus *Pseudo-nitzschia*. Despite the prevalence of these diatoms and their toxin domoic acid (DA) within the region, ASP has yet to be confirmed in the Benguela region. On the Californian coast this neurotoxin has severely impacted marine mammal health, including the death of whales, dolphins, porpoises, seals, and sea lions. Over the past few years, suspected domoic acid toxicosis has been linked to aberrant seal behaviour in the Benguela and ultimately to a high number of seal deaths. However, further investigation is required before this connection can be confirmed.

Some HAB species known as ichthyotoxic species are toxic to various forms of marine life but do not typically pose a risk to public health. Mortalities of marine life in False Bay, including an estimated 40 tons of abalone, were associated with such a toxin-producing dinoflagellate in the late 80s. These blooms caused an olive-green discolouration of the sea and were also associated with the production of an aerosol toxin affecting humans. The causative dinoflagellate was later described as a new species, *Karenia cristata*. Blooms of this dinoflagellate were again prevalent in the mid-90s when they occurred during the peak of the summer holiday season, causing beachgoers and seaside residents severe coughing, burning of the nasal passages, breathing difficulties, stinging eyes, and irritation to the skin.

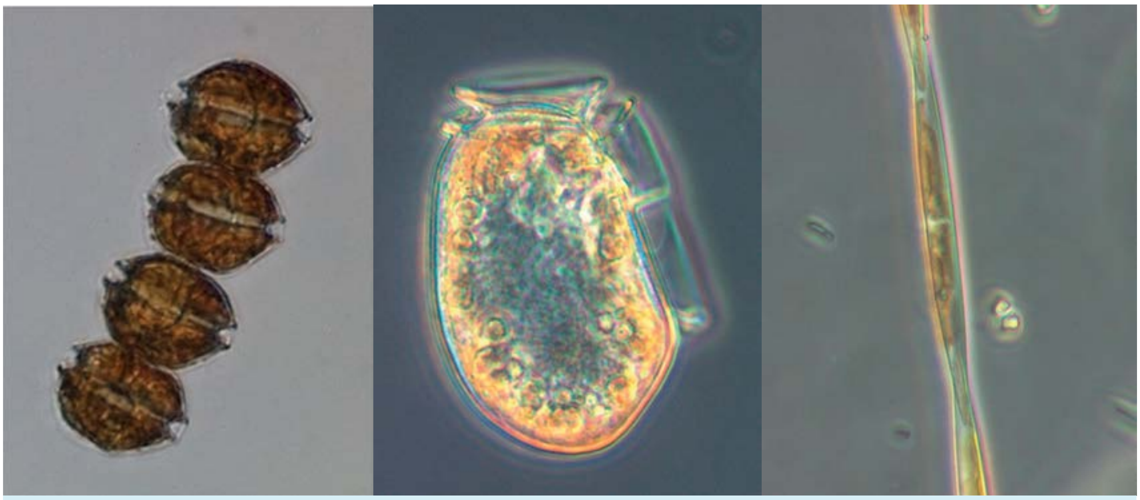

Figure 8: Toxin-producing microalgae in the coastal waters surrounding Cape Town posing a risk to consumers of shellfish. *Alexandrium catenella* (left) responsible for paralytic shellfish poisoning, *Dinophysis fortii* (centre) responsible for diarrhetic shellfish poisoning, and some of the *Pseudo-nitzschia* species (right) responsible for amnesic shellfish poisoning.

Most of the red tides occurring in the coastal waters around Cape Town are non-toxic. Their visual impacts are nevertheless often considered aesthetically undesirable. These blooms are particularly common in False Bay, with the bay serving as a site of bloom incubation and accumulation. Under conditions of upwelling, blooms are introduced into the bay by cyclonic circulation. During late summer, bloom development is advanced in a clockwise direction under increasingly stratified conditions. Blooms may become entrapped in Gordon's Bay where they are retained in a semi-permanent anticyclonic eddy, rendering this area more vulnerable to HABs and their negative impacts. Among the harmful effects of these high-biomass, non-toxic blooms are die-offs resulting from anoxia or hypoxia following the decay of blooms.

The first account of a mortality of marine life in False Bay linked to the presence of a red tide occurred in the early 60s. The decay of a particularly dense bloom of *Gonyaulax polygramma* caused an estimated 100 tons of dead and dying fish and invertebrates to be washed up on the beaches between Gordon's Bay and Strand, due to the depletion of oxygen. The region around Gordon's Bay has been subject to recurring events of oxygen depletion and consequent mortalities of marine organisms.

A further discolouration of coastal waters, specifically along the northern shore of False Bay, commonly draws the attention of the concerned public. These fundamentally harmless blooms, responsible for a brown discolouration, are confined to the surf zone and caused by the diatom *Anaulus australis*. The first reports of Anaulus were made in the 1970s. These diatoms form brown patches in the surf on a semi-permanent basis with few cells occurring behind the breaker line. Suitable conditions for their growth are thought to include long sandy beaches of moderate to high energy, rip current activity and an associated dune system providing nutrients by groundwater flow. Indeed, surf zone blooms in False Bay are thought to attain particularly high cell concentrations in response to local nutrient inputs. These blooms are particularly pertinent in the False Bay area where high concentrations of nutrients are supplied through river discharges, effluent discharges from wastewater treatment works as well as submarine groundwater discharge.

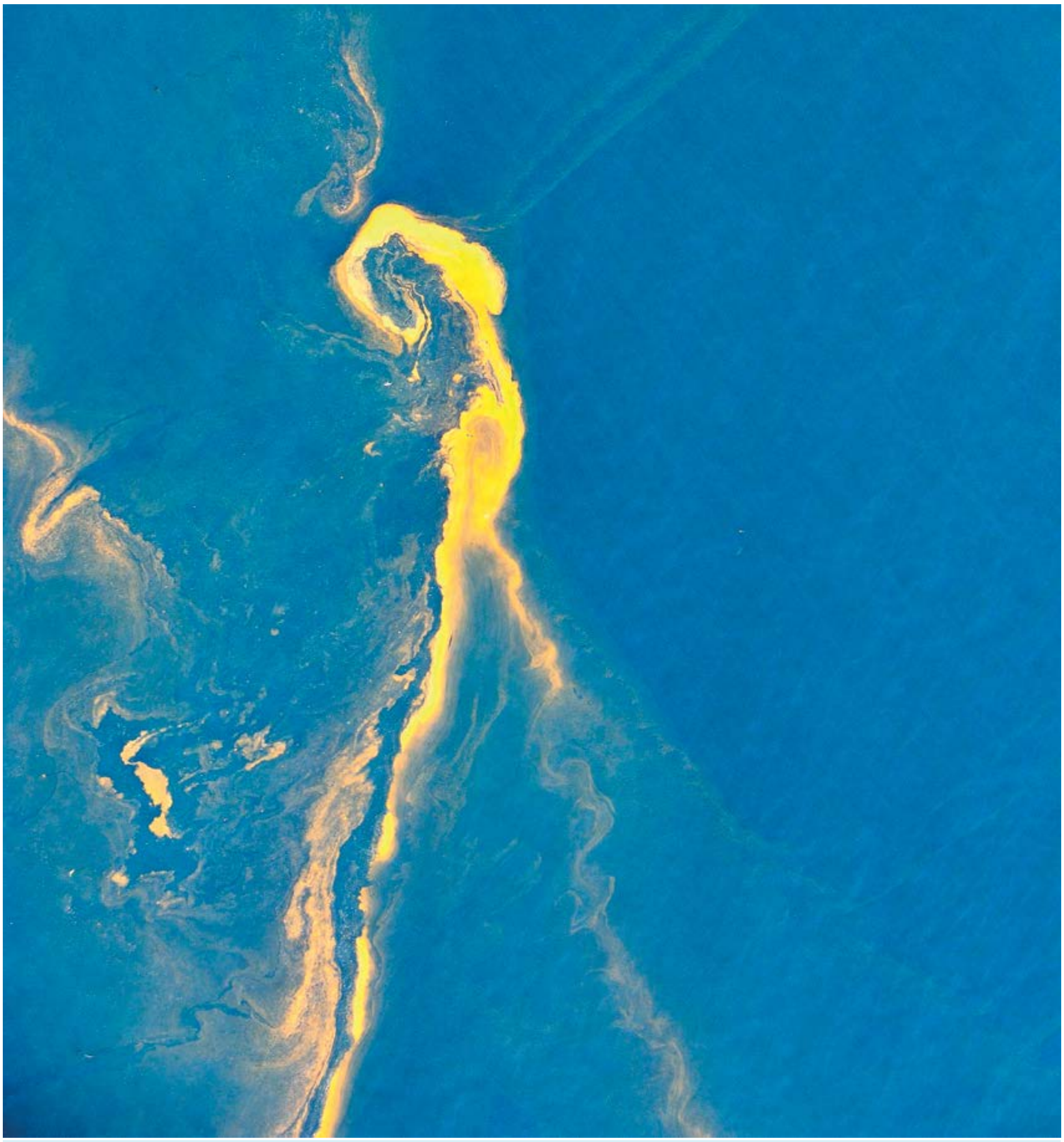

Figure 9: Summer blooms of dinoflagellates are responsible for discolouration of the ocean owing to their dense surface accumulations. These so-called red tides are particularly common in False Bay. Here blooms of the dinoflagellate *Noctiluca scintillans*, depicted above, were first reported in the early 1900s. *Noctiluca* has subsequently been identified as the dinoflagellate most often responsible for red tides in the bay but is seldom associated with any harmful impacts.

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This report can be found online at:
www.capetown.gov.za

Information on Cape Town's coastline, beaches and coastal amenities is available on the City's website.

If you wish to report a pollution incident, please visit: www.capetown.gov.za/ServiceRequests

If you see pollution or witness it being discharged into the stormwater system:

Emergencies:	Call 107 from a landline, 112 toll free or 021 480 7700 from a cellphone
Water and Sanitation:	Call 0860 103 089, select option 2 (24 hours)
SMS:	31373 (max 160 characters)
Email:	waterTOC@capetown.gov.za

Please help us keep our oceans clean and safe.

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Making progress possible. Together.