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# Public Consultation

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## List of Prohibited Concentrations

Produced for:

Environmental Engineering Division and Coastal Zone Management Unit,  
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Prepared by:



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In association with:



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## FOREWORD

It is with great pleasure that I present this public consultation document to the Barbadian public on behalf of the staff at the Coastal Zone Management Unit and the Environmental Engineering Division. It is anticipated that the Coastal Zone Management Act and Marine Pollution Control Act will greatly enhance the Government's ability to manage and protect our coastal resources for this and future generations. The coast and the many activities that take place within the Coastal Zone are fundamental to our society and economy and it is imperative that we look after it so that it may continue to be a source of pride to our Nation.

The tables included in this document give the preliminary compliance standards for each pollutant as well as the reasons for including them and where the standard originated. The Government cannot achieve its aims of protecting the coast without the help of the Barbadian public and the companies operating in Barbados. It is for this reason that the Consultation is taking place, to ensure that a workable system is put in place and to ensure that everyone understands the role they play in protecting our heritage.

I encourage you to read the document and provide us with feedback on our proposals so that we can all work together to protect and manage our resources for the benefit of all.



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Chief Environmental Engineer.

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### Glossary of Terms.

µg/l –	micrograms/litre $\equiv$ 1000 mg/l $\equiv$ parts per billion.
µg P/l or µg N/l –	The mass of the phosphorous or nitrogen in a litre rather than the mass of the atoms they are attached to, e.g. oxygen in nitrates.
% Saturation –	The measured concentration compared with the normal atmospheric equilibrium concentration at that temperature.
Bioaccumulation –	The retention and accumulation of a chemical within the tissues of a biological organism.
Geometric mean –	The list of values are multiplied together and then the taken to the power $1/n$ , where $n$ is the number of values.
Half-life –	The time period required for a process to remove half of the original quantity.
Organic/inorganic –	Organic compounds contain Carbon. Inorganic compounds do not contain carbon.
psu –	Practical Salinity Units, numerically equivalent to parts per thousand or grams/kilogram.
NTU –	Nephelometric Turbidity Units.
Toxic –	Poisonous to biological organisms.
Volatile –	Prone to evaporate rapidly.

**Table 1. List of Pollutants and Ambient Standards.**

Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
<b>General Parameters and Nutrients</b>				
Chlorophyll a	An indicator of the presence of algae, which can be an indicator of high nutrient levels.	Elevated levels detected occasionally, up to 3.23 at the Careenage.	Anzecc, 2000 for tropical marine systems.	0.5
Dissolved Oxygen <sup>1</sup>	Essential for aquatic life. Requirements vary depending on species, life stage, and life processes. Many compounds become more toxic as Dissolved Oxygen decreases; so can have an indirect effect.	Oxygen levels are often supersaturated, but can dip quite low where there is an outfall with high oxygen demand.	Anzecc, 2000 for tropical marine systems.	90 (% saturation) -actual concentration varies with temperature.
Faecal streptococci / enterococci	Public health indicator of sewage pollution in seawater. This is generally the preferred indicator of health risk.	Priority pollutant that has previously been detected at high levels.	US EPA, 2002. UNEP, 1999 - LBS Protocol.	Geometric mean of min. 5 samples should not exceed 35 colonies/100ml in any 30-day period.
Faecal coliform	Public health indicator of sewage pollution in freshwater, but historically used in seawater as well.	Priority pollutant that has previously been detected at high levels.	UNEP, 1999 - LBS Protocol.	Geometric mean of min. 5 samples not exceed 200 colonies/ 100ml in any 30-day period. No more than 10% of samples exceed 400 colonies/100ml.
Phosphate (Filterable Reactive)	Primary nutrient causes high algal growth, which then impacts on coral by blocking light and smothering.	Priority pollutant. The recommended level is often exceeded.	Delcan, 1994	2.48 ( $\mu\text{g P/l}$ )
Oxides of Nitrogen (nitrate/nitrite)	Primary nutrient causes high algal growth, which then impacts on coral by blocking light and smothering.	Priority pollutant. The recommended level is often exceeded.	Delcan, 1994	9.8 ( $\mu\text{g N/l}$ )
Ammonia	Form of nitrogen most easily used by plants. Causes high algal growth, which then impacts on coral.	Priority pollutant. Not regularly measured, but	Delcan, 1994	9.8 ( $\mu\text{g N/l}$ )

<sup>1</sup> Dissolved Oxygen – is measured as a concentration then the saturation level is calculated based on the Normal Atmospheric Equilibrium Concentration (NAEC). At 35psu and 24°C the NAEC for oxygen is 5.5ml/l. Around Barbados we typically measure 6.5-7mg/l.

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
		the recommended level is exceeded.		
Total nitrogen (inorganic and organic)	Better indicator of nutrient loading as measures organic load as well.	Not measured.	Anzecc, 2000 for tropical marine systems.	100
Total phosphorous (inorganic and organic)	Better indicator of nutrient loading as measures organic load as well.	Not measured.	Anzecc, 2000 for tropical marine systems inshore.	15
pH	General indicator of acidity/alkalinity. Change in pH can be either toxic directly or indirectly by changing the toxicity of other pollutants.	Rarely measured.	CCME, 1999	7.0-8.7
Salinity	General parameter describing the total salt content of seawater. An indicator of the presence of freshwater or hyper saline discharges.	Ambient levels generally within the range although not always measured.	Delcan, 1994.	30-38 (psu)
Temperature	Indicator of thermal pollution from, for example, cooling water discharges. Changes in temperature can affect the toxicity of chemicals or kill coral directly through bleaching.	Isolated cases, but typically between 26-29°C.	Delcan, 1994.	<31°C
Total Suspended Solids (TSS)	Suspended solids increase turbidity, reduce light penetration, and decrease photosynthetic activity – the basis of coral growth. Also important in the transport of other pollutants that are strongly associated with the solids, such as metals.	Can be problematic during construction or near freshwater discharges such as drains and gullies. Occasionally exceeds standard.	Delcan, 1994 standard is 4mg/l, but given observations, the standard is set at 5mg/l.	5 (mg/l)
Sedimentation Rate	Indicator of the amount of solids that settles on the seabed. Settling solids can smother a reef. Bank reefs are more susceptible than fringing reefs.	Can be problematic during construction or near freshwater discharges such as drains and gullies. Not frequently measured, but can exceed standard.	Delcan, 1994.	Fringing reefs: 25 mg/cm <sup>2</sup> /day Bank Reefs: 5 mg/cm <sup>2</sup> /day
Turbidity	Aesthetic impact; reduced water clarity; impact on	Typically <1NTU	Delcan, 1994.	1.5 (NTU)

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
	photosynthetic capacity of corals. Another measure of the amount of sediment in the water column.			
<b>Non-metallic Inorganics</b>				
Chlorine (Total Residual Chlorine)	Chlorine is commonly used as a disinfectant in potable water and in sewage treatment, toxic to many marine species.	Not measured.	Delcan, 1994.	2
Cyanide (un-ionised HCN)	Used in metal plating / metal finishing and photo-processing. Toxic. HCN (hydrocyanic acid) is the most toxic form of cyanide as it can cross biological membranes.	Not detected in past samples.	Anzecc, 2000. 95% protection level <sup>a</sup> .	4
<b>Metals</b>				
Cadmium	Used in metal plating, in batteries, and in the manufacture of semiconductors. Toxic. Bio-concentration can be significant for bivalves. If shellfish from the area are consumed an even lower trigger value of 0.2 $\mu\text{g/l}$ is recommended. Causes kidney damage in humans.	Not detected in past samples.	Anzecc, 2000. 99% protection level <sup>b</sup> .	0.7
Chromium III (trivalent)	Used in metal plating, leather industry and as a corrosion inhibitor in cooling systems. Toxic. Chromium III less toxic than Chromium VI.	Low values have been detected.	Anzecc, 2000. 95% protection level <sup>a</sup> .	27.4
Chromium VI (hexavalent)	Used in metal plating, leather industry and as a corrosion inhibitor in cooling systems. Toxic.	Low values have been detected.	Anzecc, 2000. 95% protection level <sup>a</sup> .	4.4
Copper	Commonly used metal, specifically by the rum industry. An essential trace element, but toxic at higher concentrations. Readily accumulated by plants and animals. Copper toxicity to marine species generally increases as salinity decreases. Long-term exposure causes liver and kidney damage in humans.	Detected occasionally.	Anzecc, 2000. 95% protection level <sup>a</sup> .	1.3
Lead	Historically added to paint and gasoline; used in old water pipes. Toxic.	Detected occasionally, primarily in Careenage and Port.	Anzecc, 2000. 95% protection level <sup>a</sup> .	4.4
Mercury (inorganic)	Used in switches, thermometers, and dentistry. Can be converted by microorganisms in sediment to methyl	Not detected in past samples.	Anzecc, 2000. 99% protection level <sup>b</sup> .	0.1

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
	mercury. Methyl mercury is soluble, more toxic than inorganic mercury and bio-accumulates.			
Nickel	Used in metal plating, present in batteries. Nickel toxicity increases with decreasing salinity. The 95% protection level not deemed to provide sufficient protection to juvenile mysids and molluscs.	Low values have been detected.	Anzecc, 2000. 99% protection level <sup>b</sup> .	7
Silver	Used in the electronics and photography industries. The acute toxicity of silver to marine fish is considerably lower than to freshwater fish. Toxicity to most species increases with decreasing salinity.	Historically present in at least one local industrial effluent. Low values have been detected.	Anzecc, 2000. 95% protection level <sup>a</sup> .	1.4
Vanadium	Occurs in 4 valency states. Vanadium +5 (Vanadate) is the most common in water and the most toxic.	Low values have been detected.	Anzecc, 2000. 95% protection level <sup>a</sup> .	100
Zinc	In greater than trace concentrations, harmful to aquatic organisms. Zinc uptake and toxicity generally decrease as salinity increases.	Low values have been detected, primarily in Carenage.	Anzecc, 2000. 95% protection level <sup>a</sup> .	15
<b>Organotins</b>				
Tributyltin	Highly toxic to marine bivalves. Present in marine antifouling paints and wood preservative.	Used in Barbados, but not detected.	Anzecc, 2000. 95% protection level <sup>a</sup> .	0.006
<b>Organic Alcohols</b>				
Ethanol	Present in alcohol distillery waste. Volatile and completely mixable with water. Large inputs can significantly reduce Dissolved Oxygen levels. Limited marine toxicity data. Anzecc present a low reliability value taken from the freshwater value, which should be considered only as an interim working value. It is recommended for inclusion due to the known presence of ethanol in marine waters off of the west coast of Barbados.	Not measured.	Anzecc, 2000. 95% protection level <sup>a</sup> in freshwater.	1400
<b>Chlorinated Alkanes and Alkenes</b>				
1,1,2- trichloroethane	Volatile and relatively soluble in water. Commonly used industrial solvent. Not expected to bioaccumulate significantly.	Not measured.	Anzecc, 2000. 95% protection level <sup>a</sup> .	1900
1,1,2,2-tetrachloroethylene	Commonly used in the dry cleaning industry in	Not measured.	Anzecc, 2000. Low	70

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
(perchloroethylene)	Barbados. Not expected to bioaccumulate or to bind to sediment. Volatile with a half-life of 1-6 days in water. Due to its known use in Barbados the Anzecc marine low reliability value is recommended as an interim working value. Anzecc considers that there is insufficient data to generate a marine medium reliability trigger value.		reliability value.	
<b>Aromatic Hydrocarbons</b>				
Benzene	Benzene, toluene, ethyl benzene and xylene (BTEX) are the simplest aromatic hydrocarbons. Products of oil refining and important common aromatic solvents. Commonly associated with contaminated petroleum sites (e.g. Needham's Point). BTEX compounds are highly volatile, have low water solubility and have low bioaccumulation potential. However, water managers should be aware of possible additive effects (mixture toxicity). Anzecc 99% protection level is recommended to provide protection against chronic toxicity to crabs.	Rarely measured. Below detectable limits.	Anzecc, 2000. 99% protection level <sup>b</sup> .	500
Toluene	Insufficient data. Low reliability value recommended as an interim value.	Rarely measured. Below detectable limits.	Anzecc, 2000. Low reliability 95% protection value.	180
Ethyl benzene	Insufficient data. Low reliability value recommended as an interim value.	Rarely measured. Below detectable limits.	Anzecc, 2000. Low reliability 95% protection value.	80
Xylenes	Insufficient data. Low reliability value recommended as an interim value for m-xylene.	Rarely measured. Below detectable limits.	Anzecc, 2000. Low reliability 95% protection value.	75
Naphthalene	Naphthalene is the simplest polycyclic aromatic hydrocarbon (PAH), used as an insect-proofing agent for stored materials and clothes. Will absorb strongly to sediment. UV light increases the toxicity. Only PAH that Anzecc considers there are sufficient data to generate a moderately reliable guideline value. Due to chronic toxicity to the crab <i>C. magister</i> , the Anzecc 99%	Rarely measured. Below detectable limits.	Anzecc, 2000. Moderate reliability 99% protection level <sup>b</sup> .	50

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
	protection level is recommended.			
<b>Polychlorinated Biphenyls</b>				
PCBs	Used as a dielectric fluid in transformers and capacitors. No longer used by the Barbados Light & Power Company Ltd. High persistence and potential to bioaccumulate. Moderate reliability trigger values have been derived for Arochlors 1242 & 1254 in freshwater. These numbers have been converted to marine low reliability figures and should be considered as interim values.	Not detected.	Anzecc, 2000. Moderate reliability 99% protection level <sup>b</sup> in freshwater.	Arochlor 1242: 0.3 Arochlor 1254: 0.01
<b>Phenols</b>				
Phenol	Commonly used raw material in the manufacture of a wide range of products. A common by-product of oil refining. Readily soluble in water and low bioaccumulation potential. Imparts taste and odour in fish and shellfish at low concentrations. Variable toxicity.	Not detected.	Anzecc, 2000. Moderate reliability 95% protection level <sup>a</sup> .	400
Pentachlorophenol (PCP)	A biocide, disinfectant, pesticide and wood preservative. Found in chlorinated effluents from sewage treatment plants. Impair taste, more toxic at lower pH. The Anzecc 99% protection level is recommended in the absence of local bioaccumulation data.	Not detected.	Anzecc, 2000. Moderate reliability 99% protection level <sup>b</sup> .	11
<b>Pesticides, Insecticides, Herbicides and Fungicides</b>				
All organochlorine (OC) pesticides	The use of OC pesticides was phased out in Barbados more than a decade ago. However, the compounds are persistent with high bioaccumulation potential. The detection limits for most OC's are greater than the standards, so it is recommended that OC's should not be detectable in marine waters.	Some have been detected at low levels, but not in exceedance of guidelines.	Anzecc, 2000.	Not detectable, based on a detection limit of 0.005.
All organophosphate (OP) pesticides	Commonly used in Barbados. Toxic to most species. Detection limits in the order of 0.02 $\mu\text{g/l}$ in water. Recommended standards are lower. Therefore, it is	Some have been detected at low levels, but not in exceedance of	Anzecc, 2000.	Not detectable, based on a detection limit of 0.05.

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	Ambient Water Quality Standard ( $\mu\text{g/l}$ ) unless otherwise stated.
	recommended that OP's should not be detectable in marine waters.	guidelines.		
Other Insecticides, Herbicides and Fungicides	Insufficient data currently exists to allow Anzecc to generate moderate reliability trigger levels for other pesticides at this time. To be precautionary, it is recommended that a No Detection limit be used as a default in the absence of other data.	Some have been detected at low levels, but not in exceedance of guidelines.	Anzecc, 2000.	Not detectable, based on a detection limit of 0.01.

<sup>a</sup> The 95% protection level means that at this concentration it is expected that 95% of species will be protected.

<sup>b</sup> The 99% protection level means that at this concentration it is expected that 99% of species will be protected.

**Table 2. Domestic Waste End of Pipe Standards.**

Parameter	Rationale	Current Status in Barbados	Basis of Standard	End of Pipe Standard
Biochemical Oxygen Demand	When there is a large quantity of biological matter in the water bacteria will break it down but use up oxygen at the same time. This is a measure of that oxygen demand and will lead to a drop in dissolved oxygen levels.	This can be high for specific types of discharge such as sewage effluent and rum distillery waste.	UNEP, 1999 - LBS Protocol.	Class 1 – 30mg/l Class 2 – 150mg/l
Total Suspended Solids (TSS)	Suspended solids increase turbidity, reduce light penetration, and decrease photosynthetic activity – the basis of coral growth. Also important in the transport of other pollutants that are strongly associated with the solids, such as metals.	Can be problematic during construction or near freshwater discharges such as drains and gullies. Occasionally exceeds standard.	UNEP, 1999 - LBS Protocol.	Class 1 – 30mg/l Class 2 – 150mg/l
Total nitrogen (inorganic and organic)	Better indicator of nutrient loading as measures organic load as well.  The end-of-pipe standards have been set to meet the ambient standard in Class 1 waters within a 50:1 mixing zone.	Not measured.	Class 1 based on 50:1 dilution with nutrient removal. Class 2 based on no or advanced preliminary treatment.	Class 1 – 5mg/l Class 2 – 45mg/l
Total phosphorous (inorganic and organic)	Better indicator of nutrient loading as measures organic load as well.  The end-of-pipe standards have been set to meet the ambient standard in Class 1 waters within a 50:1 mixing zone.	Not measured.	Class 1 based on 50:1 dilution with nutrient removal. (CEHI, 1998) Class 2 based on no or advanced preliminary treatment.	Class 1 – 1mg/l Class 2 – 10mg/l
pH	General indicator of acidity/alkalinity. Change in pH can be either toxic directly or indirectly by changing the toxicity of other pollutants.	Rarely measured.	EEC, 1976 and World Bank, 1999.	6-9 in Class 1 and 2 waters.
Faecal streptococci	Public health indicator of sewage pollution in seawater. This is generally the preferred indicator of health risk.	Priority pollutant that has previously been detected at high levels.	US EPA, 2002. UNEP, 1999 - LBS Protocol.	Class 1 - Geometric mean of min. 5 samples should not exceed 35 colonies/100ml in any 30-

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Parameter	Rationale	Current Status in Barbados	Basis of Standard	End of Pipe Standard
				day period.
Faecal coliform	Public health indicator of sewage pollution in freshwater, but historically used in seawater as well.	Priority pollutant that has previously been detected at high levels.	UNEP, 1999 - LBS Protocol.	Class 1 - Geometric mean of min. 5 samples not exceed 200 colonies/100ml in any 30-day period. No more than 10% of samples exceed 400 colonies/100ml.
Total Residual Chlorine	Chlorine is commonly used as a disinfectant in potable water and in sewage treatment, toxic to many marine species.	Not measured.	CEHI, 1998.	Class 1 - 0.1mg/l
Fats, Oils and Grease	Found in urban runoff and domestic waste. Smothers shoreline ecosystems. Can be toxic.	Not measured as a general group. Generally below detectable limits.	UNEP, 1999 - LBS Protocol.	Class 1 – 15mg/l Class 2 – 50mg/l
Floatables	Plastics and other materials that are not easily removed by natural processes. They can smother or be ingested by organisms.	An important problem.	UNEP, 1999 - LBS Protocol.	Not visible in Class 1 and 2 waters.

**Table 3. Petroleum Hydrocarbons End of Pipe Standards for Class 1 Waters<sup>2</sup>.**

Parameter	Rationale	Current Status in Barbados	Basis of Standard	End of Pipe Standard
Total Petroleum Hydrocarbons (TPH)	Important chemicals used in the production of oils and fuels. Found in industrial discharges and urban runoff. Smothers shoreline ecosystems. Lighter fractions are most toxic.	Not measured as a general group. Generally below detectable limits. Longer chain hydrocarbons found at detectable limits in Careenage and at tanker moorings, but below standards.	Max - State of Wyoming, 2000. Av. Daily value is interim value recommended by consultants to allow some flexibility.	Max. daily discharge (mg/l): 10 Av. Daily concentration over 30 consecutive days (mg/l): 5
Total Oils & Greases	Found in industrial discharges and urban runoff. Smothers shoreline ecosystems. Can be toxic.	Not measured as a general group. Generally below detectable limits.	Max - World Bank, 1999. Av. Daily value is interim value recommended by consultants to allow some flexibility. Based on US EPA, 1995.	Max. daily discharge (mg/l): 10 Av. Daily concentration over 30 consecutive days (mg/l): 5
Total Organic Carbon	The level of organic carbon can influence the availability of other pollutants. Directly non-toxic.	Not measured.	Max - US EPA, 1995. Av. Daily value is interim value recommended by consultants to allow some flexibility.	Max. daily discharge (mg/l): 110 Av. Daily concentration over 30 consecutive days (mg/l): 55

<sup>2</sup> Petroleum Hydrocarbons – consistent standards are difficult to find. The daily average over 30 days is included to allow some flexibility for dischargers, but may be more difficult for regulators to monitor. The values are at this stage based on the 50% difference seen for oils and grease, but are certainly up for discussion. It may be preferable to use a standard for BTEX rather than TPH etc.

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