environmental management authority

TRINIDAD AND TOBAGO:

STATE OF THE ENVIRONMENT 1998 REPORT

CHAIRMAN'S MESSAGE

The 1998 State of the Environment Report is the second of our annual reports that focuses on a selected area or aspect of the environment, which the Environmental Management Authority (EMA) has prioritised for attention. The 1997 Report dealt with Biodiversity while the focus this year is on freshwater because of the importance of this resource to our quality of life and indeed our very survival. Freshwater management is also critical to the sustenance of our wildlife and ecosystems. We should be careful to note though, that in one of the marvels of nature, our forested watersheds provide us with free water management services by purifying water and impeding flooding in low lying areas. We ignore these facts at our peril. Continuing deforestation is the major cause of the annual flooding which has now become common place in Trinidad during the wet season. This phenomenon is coupled with the paradox of inadequate supplies of potable water for some members of the populace.

Freshwater is also a critical resource for industry. Industrial applications range from the use of water for equipment cooling to its use as a receptacle for liquid wastes. It is this latter use that frequently conflicts with its other use in sustaining life. The pervasive nature of freshwater pollution from domestic sewage, agricultural and industrial effluent, is a significant threat to the environment in Trinidad and Tobago.

This report on freshwater represents part of the process of educating the public about the state of our freshwater sources and the imperatives for management. The EMA's Water Pollution Management Programme will be implemented via the Water Pollution Rules, which the EMA have recommended to Government. These Rules will among other things:

1. Prohibit the discharge of water pollutants from industrial, commercial, agricultural premises, or sewage works, without a Permit from the EMA.

2. Allow the EMA to impose the water pollution standards and reporting requirements, which each applicant for a Permit will be required to meet.

3. Allow the EMA to enter premises with a warrant to verify compliance with the conditions of a Permit.

4. Establish a National Register of Permits that will be open to the public for inspection.

Dr. John Agard
CHAIRMAN

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYMS/ ABBREVIATIONS	MEANING
NH_3	Ammonia
BOD_5	5-day Biochemical Oxygen Demand
BTEX	Benzene, toluene, ethylbenzene and xylene
CAWTP	Caroni Arena Water Treatment Plant
Cu	Copper
m^3/d	Cubic metres per day
m^3/yr	Cubic metres per year
^0C	Degrees Celsius
DO	Dissolved oxygen
EMA	Environmental Management Authority
EIA	Environmental Impact Assessment
ha	Hectares
IMA	Institute of Marine Affairs
pH	Hydrogen ion concentration
km	Kilometres
km/hr	Kilometres per hour
#	Number
mm	Millimetres
MCM	Million cubic metres
P	Phosphorous
km^2	Square kilometres
UST	Underground Storage Tank
WASA	Water and Sewerage Authority
Zn	Zinc

GLOSSARY OF TERMS

Hydrologic Cycle	Biogeochemical cycle that collects, purifies and distributes the earth's fixed supply of water, from the environment to living organisms and then back to the environment.
Ecosystem	A unit to denote a region of the environment inclusive of the habitats contained therein, the biota (living entities) and their relationships with each other and the abiotic environment.
Aquifer	An underground rock body (or underground geological formation) that has a high-to-moderate permeability and can yield an economically significant amount of water.
Wetland	Land that is inundated on a frequent or permanent basis with salt or freshwater, excluding streams, lakes and the open ocean.
Catchment	The area drained by a river or body of water. Also called catchment basin.
Watershed	The entire drainage area that contributes water to a river, wetland, aquifer or other body of water.
Point source	Any discernible, confined and discrete conveyance source from which pollutants are or may be discharged.
Non-point Source	Pollution that is diffuse entering a waterway from a wide geographic area rather than a single point.
Contamination	The introduction of a foreign chemical or element to an area in trace or significant quantities which results in adverse effects.
Deforestation	The process of large-scale denudation of an area's forests without adequate revegetation.
Effluent	The liquid drainage output that is discharged to an inland, nearshore or offshore receiving water body.
Environmental Impact Assessment	A process of systematic study used to predict the environmental consequence of a proposed development activity.

Biochemical Oxygen Demand (BOD)	The quantity of dissolved oxygen consumed by micro-organisms in decomposing organic material in a given volume of polluted water, at a certain temperature over a specified time period.
Feedlot	Confined outdoor or indoor space used to raise large numbers of domestic livestock.
Landfill	1. Sanitary landfill is a land disposal site for non-hazardous solid wastes at which the waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operating day. 2. Secure chemical landfill is a disposal site for hazardous waste. They are selected and designed to minimise the chance of releases of hazardous substances into the environment.
Leachate	The chemical(s) or element(s) that are transported from upper soil layers (or the soil surface) to lower soil layers through the processes of percolation or dissolution. A liquid that results from water collecting contaminants as it trickles through wastes, agricultural pesticides, or fertilisers. Leaching may occur in farming areas, feedlots, and landfills, and may result in hazardous substances entering surface water, ground water, or soil.
Monitoring	Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things.
Organic	Derived from living organisms; or containing carbon.
Pollutant	Substance causing deviation from natural conditions in the environment which may cause harm to human health or the environment
Pollution	The creation or existence of any deviation from natural conditions within the environment, which may cause harm to human health, or the environment.
Pollution Prevention	The establishment and maintenance of measures to eliminate the root causes of pollution.

Receiving Water	A standing or dynamic, inshore or coastal body of water that is the destination of effluents.
Release	Includes any disposing, spilling, leaking, emitting or other incidence of discharge into the environment of any hazardous substance/pollutant.
Run-off	That part of precipitation or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into the receiving waters.
Sewage	The waste and wastewater produced by residential and commercial establishments and discharged into sewers.
Silt	Fine particles of sand or rock that can be picked up by the air or water and deposited and discharged into sewers.
Total Suspended Solids	The portion of total solids retained by a 0.45 micron filter under defined conditions.
Underground Storage Tank	Any one or combination of tanks (including underground pipes connected thereto) that is used to contain an accumulation of substances, and the volume of which is 10% or more beneath the surface of the ground.
Waste	1. Unwanted materials left over from an agricultural, commercial, industrial manufacturing, mining or other extraction process. 2. Refuse from places of human or animal habitation.
Wastewater	Water that may contain dissolved or suspended matter, discharged after being used in, or produced by, a process, and which is of no further immediate use or value to that process.
Water Pollution	The man-made or man-induced alteration of the physical, chemical, biological, and radiological integrity of water.

EXECUTIVE SUMMARY

This fourth assessment of the state of the environment of Trinidad and Tobago focuses on WATER but does not treat with the resource in its totality. It deals only with the freshwater component of the resource and the environments that are supported by it or those that are responsible for its production - essentially the inland aspects. While it is recognised that marine waters are part of the hydrologic (water) cycle, and that whatever is done on land affects the marine area, sea water and associated environments are not addressed in this report.

Because of its use and attributes, fresh water provides an eminent example for demonstrating how human activity impacts on the environment at the local level as well as nationally, and, consequently, on the health and livelihood of people. There is no doubt that everyone understands the importance of water in their daily lives: it is needed for drinking, washing, cooking, agriculture and animal rearing. The resource is also a revenue generator at community and national levels through the varied tourism and recreation activities it supports. For most of us, too, it is an integral part of our religious practices. What is not fully appreciated however, is that water is a continuum linking air, land and sea through the hydrologic cycle; a valuable resource and a true mirror of the decisions and actions we take. Whatever we do therefore, has its fallout in water directly or indirectly, to our pleasure or peril.

The data accessed and analysed and the information available for this report have revealed that Trinidad is not a freshwater-scarce country although there are large variances of raw water availability caused by physiography. With a population of 1.3 million persons and annual maximum rainfall of 3800mm in some parts of the country, the water scarcity experienced by some sections of the population is due in part to the cost and efficiency of tapping water from a number of small sources, to increased run-off and to leakages from the distribution system.

Increasing run-off is a direct consequence of the types of human activity taking place in the watershed e.g. loss of vegetation particularly on hillslopes. These activities are both authorised and unauthorised and include quarrying, timber harvesting, residential and infrastructure development, slash and burn agriculture, squatting and annual uncontrolled fires.

While the water demand for human consumption and development has first-call on the water supply, the intrinsic water demand of the freshwater environments such as wetlands cannot be overlooked. Essential life-supporting functions are carried out in these areas and their water demand is not catered for at present. Whatever is left after other demands are met has to suffice for these areas. Future calculations of water demand will set aside a percentage to meet these needs.

The quality of water to be sourced and distributed is also of great concern. The various assessments, partial and comprehensive, all demonstrate worrying signs of substandard water quality. Comprehensive data sets that would have derived from consistent monitoring and recording of the status of water is non-existent. The one area that has attracted most attention for repeated study and research over the years, is the Caroni River Basin, which supplies potable water to over 40% of the population. Notwithstanding the intermittent studies, the conclusions on the same watercourses by different studies all demonstrate deteriorating water quality induced by human activity. The effects of natural factors on water quality, such as iron in groundwater, are very limited and do not usually pose high risks to the water supply.

The major threats and potential threats to water quality are sewage, high strength organic wastes from agricultural farms and agro-processing plants, grey water containing phosphates and nitrates from homes and toxic wastes from landfills and industrial effluents. Groundwater, which is linked to surface water in the water continuum is exposed to the same threats by these pollutants. In addition, on account of their location, aquifers in the vicinity of underground fuel storage tanks may become contaminated by carcinogenic hydrocarbons such as benzene, toluene and xylene. Those aquifers, which are located close to the sea and are overpumped, are subjected to saltwater intrusion as already experienced in the El Socorro gravels.

Freshwater wetlands are affected primarily by suspended soil particles, drying out and salinisation. Species diversity and abundance are reduced.

Persistent water quality problems are the result of a combination of factors ranging from: inadequate research and monitoring, ineffective legislation and regulations, failure to accept the true value of fresh water and to continue to devalue it; lack of enforcement brought about by inadequate regulations and fines for violations; and, dissipation of responsibility for water management among agencies.

The assessment concludes by providing four major recommendations:

1. Management of the quantity and quality of fresh water must be through an integrated approach involving all stakeholders.

2. A system for grey water management must be introduced urgently and implemented.

3. All sewage treatment plants serving residential areas (whether functioning or not) must be adopted, rehabilitated and maintained by the central wastewater authority. Cost recovery strategies must be introduced to ensure viability and guarantee health.

4. The initial large financial resources required for public education, consistent research and monitoring, legislative improvement and adequate and trained personnel must be provided in the short term. This will complement the on-going initiatives of a number of agencies regarding standards for water quality, rationalisation, modernisation and consolidation of legislation and the use of biological indicators for water quality assessment.

1.0 INTRODUCTION

1.1 THE REPORT

This report has adopted the theme of freshwater because of the critical importance of this resource to our survival. Without it there can be no security of food, health, and livelihood for our people. Many of us are already experiencing the consequences of water scarcity and are desperately searching for solutions.

The subsequent chapters of this report have utilised a variety of sources to collate and analyse information on freshwater in Trinidad and Tobago-how much have, where, what is its condition and what are the demands on it. Where appropriate, the situation in Trinidad is compared with that of Tobago. The need for water by life forms other than humans and by ecosystems is also treated in this report.

1.2 WATER IS LIFE AND CONNECTS US ALL

In a real sense, water is life, since life on earth depends on it. Water links land, air, plants and animals and sustains the variety of life in ecosystems. Of the 3 per cent freshwater on the earth's surface, one third is held in groundwater and less than 1 per cent in lakes and rivers. It is continuously recirculated in the water or hydrologic cycle (**Fig. 1-1**). In this cycle, water falls as rain, some enters the soil and permeable rock to form groundwater, or flows into rivers, streams, wetlands and then into the sea. Through evaporation water again rises to form rain. This continuum, this interconnectedness of water, means that the different bodies and physical states of water may influence each other directly or indirectly. This influence is demonstrated by the transmission of diseases where, about 80 per cent of all diseases and a very large number of deaths in developing countries are caused by contaminated water.

This report focuses only on the freshwater that appears in the rivers, impoundments, groundwater and swamps of Trinidad and Tobago. In Trinidad and Tobago, freshwater is integral to our cultural, religious and economic well-being. In addition to drinking, cooking, washing and disposal of wastes, a large quantity of freshwater is used in agriculture (crop irrigation) and in many industrial processes. Rivers are our major source of freshwater. They harbour fish and other useful plants and animals on which the lives of many people (particularly rural) depend. Many of our rivers are also popular tourism and recreation sites.

1.3 WATER IS OUR MIRROR

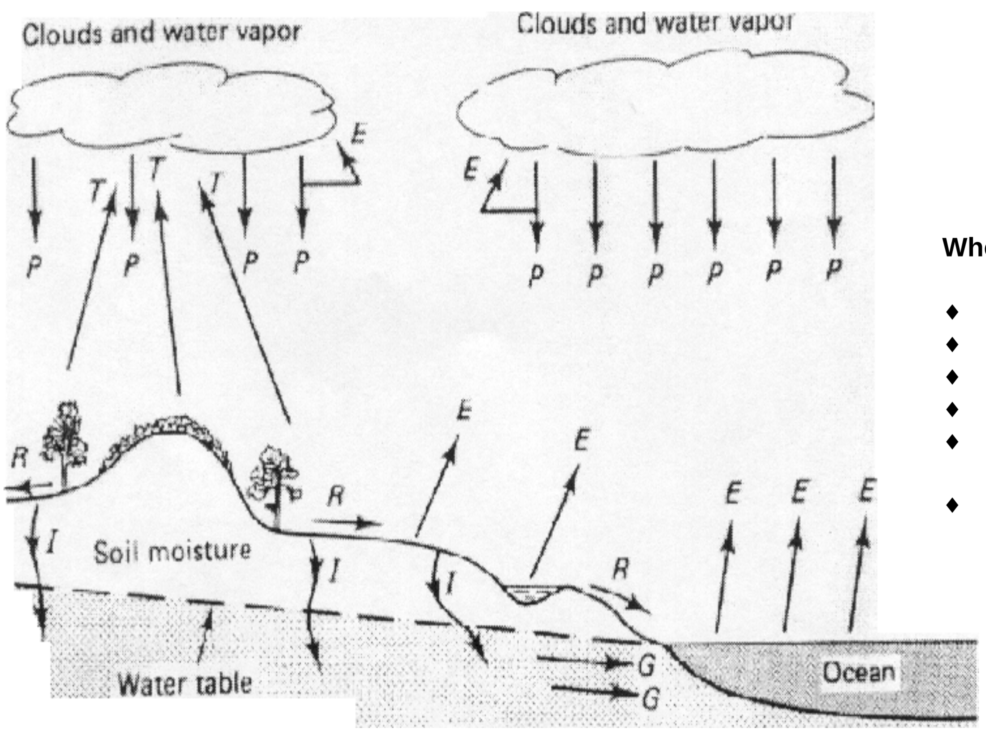
Water is our mirror. It is a true reflection of our individual and collective actions. What we put into this precious finite resource is exactly what we get back from it. Degraded, freshwater requires large resources and effort to treat it before we can use it for its various essential purposes. So the need to protect and manage our freshwater resources should be obvious. This report will demonstrate whether it is. The following quote from the Executive Director of the United Nations Environment Programme, Mr. Klaus Topfer aptly describes how water reflects our every action.

"The quality of water reveals everything, right or wrong, that we do within the entire ecosystem. Every decision we make-whether the issue is housing, transportation, energy, agriculture, or economic development-is potentially linked to the use of our water resources.

Every mistake we make in development-storm drain overflow, mine drainage, nutrient loading, over-irrigation, sewage overflow, excessive withdrawal of groundwater, or topsoil erosion from clear-cut forests-shows up in our water in the form of toxic pollution, dead fish and dried-up streams."

FIGURE 1-1

The Hydrologic Cycle



Where:

- **T = Transpiration**
- **E = Evaporation**
- **P = Precipitation**
- **R = Surface Runoff**
- **G = Groundwater Flow**
- **I = Infiltration**

Source: Water Quality Assessment

2.0 FRESH WATER

2.1 THE RESOURCE

In Trinidad and Tobago rivers and groundwater aquifers supply the water requirements of an expanding human population, industry, irrigated agriculture and the support of biological species and wetland ecosystems. The Caroni River in Trinidad is one of the major contributors to the potable water supply of Trinidad. It is 40km long and drains an area of approximately 1000 km^2 which is approximately one fifth the area of Trinidad and Tobago.

Despite our dependence on this life supporting element, many of us do not regard water as a valuable natural resource in which high costs are incurred to improve its quality and provide for its distribution. The true value of fresh water is therefore not fully appreciated. This has led to its considerable wastage and abuse!

2.2 WHAT INFLUENCES IT

Trinidad and Tobago's climate is typical of the wet tropics with two pronounced seasons, a wet season from June to November and a dry season from December to May. The climate (and consequently the rainfall) is determined mainly by:

- Latitude – the country lies at the southern end of the Caribbean island chain between 10 degrees and 11 degrees 30 minutes North latitude
- Size of land mass - has a relatively small land mass of 5,123 square kilometres
- The ocean – the Atlantic Ocean, Caribbean Sea and oceanic water from the north eastern coast of South America influence climate; and
- Topography – there are three mountain ranges in Trinidad – the Northern, Central and Southern ranges; with intervening lowland areas – the Northern and Southern Basins. In Tobago there is the Main Ridge, an area of high land running from northeast to southwest; and a small coastal plain in the southwest.

These are illustrated in **Map 2-1**

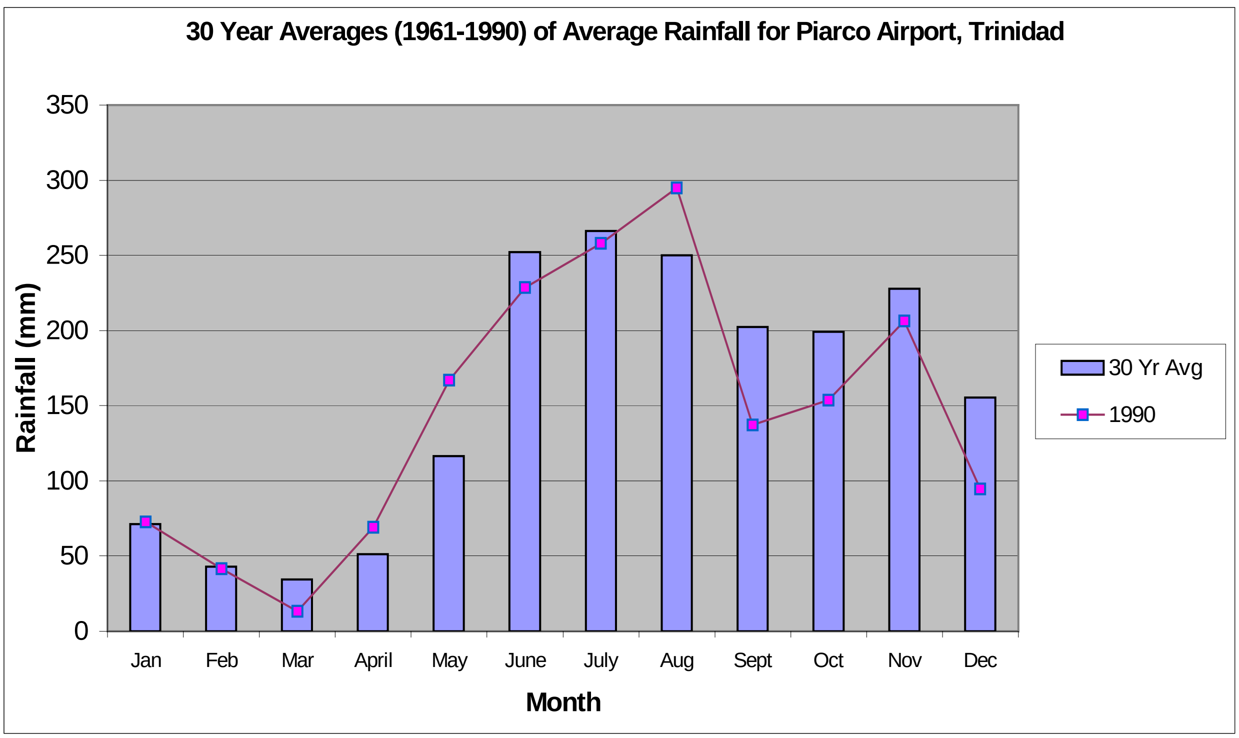
2.3 HOW MUCH RAINFALL AND WHERE

Like the other climate features, rainfall – the source of our fresh water – is seasonal. The pattern of wet and dry seasons is determined by the annual north to south migration of the inter-tropical convergence zone (ITCZ), an organised system associated with heavy showers. In the wet season there is usually a short dry spell called the *petit careme* for two weeks during September/October. Approximately 70 to 80% of all precipitation occurs in the rainy season, the heavy showers and high rainfall intensities of the ITCZ contributing the major portion of this.

Mean annual rainfall is estimated at 2200mm and through evaporation and transpiration (loss of water through pores in plants) a large percentage re-enters the atmosphere. The transpiration rate is influenced by a number of factors including mean daily temperatures of about 26°C, wind velocities of up to 25km/hr and daily sunshine up to a maximum of 9hrs.

Rainfall is unevenly distributed in both islands. Mean annual rainfall varies from location to location between 1400mm and 3800mm in Trinidad and 1400mm and 2800mm in Tobago. Monthly averages are between a minimum of about 25mm in March and 250mm in June to August as illustrated in **Figure 2-1.**

FIGURE 2-1



Source: Meteorological Service, Piarco International Airport, Trinidad and Tobago

The western coast of Trinidad and the south-western plains in Tobago are in a rain shadow, and exhibit relatively low mean annual rainfall when compared with the northeastern areas of Trinidad or the north-facing slopes of the Main Ridge in Tobago where most rainfall is concentrated. Rainfall in the dry season tends to be in the form of isolated localised storms. The seasonal rainfall pattern is similar for Trinidad and Tobago. **Map 2-2** illustrates the major rainfall variances.

The frequent high intensity rainfall during the wet season is one of a number of factors that contribute to flooding. There are reports of flooding in at least one catchment every year during the wet season. Flooding causes loss of property, agricultural crops and much human misery. Characteristic rainfalls for this season are short isolated showers with the majority of rain falling within two hours. Other factors contributing to flooding are:-

- physical - steep upper catchments and flat lower catchments; and
- man-induced - excessive removal of vegetation resulting in high run-off, high sediment loads with river bed siltation, channelisation of watercourses and man-made obstructions to flow.

Following the intense tropical depressions that occur every few years, severe flooding is reported. Areas generally prone to floods are the plains, basins and troughs that lie in the lower catchments**.**

2.4 WHERE DOES THIS WATER GO?

2.4.1 to surface channels – rivers and streams

Map 2-3 shows the major drainage divides in both Trinidad and Tobago that separate the water, which collects in the rivers and swamps. The Northern Range, the easternmost extension of the Andean Mountain system of South America, has a main divide, which separates a longer incline on the southern side from the land on the northern side, which falls steeply towards the Caribbean Sea. Some of the rivers and streams which emanate from it, flow north to the Caribbean Sea, others flow south through the Northern Basin to the Gulf of Paria and the Atlantic Ocean and some drain into major wetland areas such as the Caroni, Oropouche and Nariva Swamps.

Drainage of the Southern Range is by shorter rivers flowing to the east and south coasts. In Tobago several steeply inclined rivers flow directly northwestwards from the highland to the leeward coast, while the windward drainage pattern is dominated by longer, less steeply-inclined rivers.

At higher elevations the headwaters of a few rivers cascade and create ‘spectacular’ falls. The more prominent of these occur at Maracas, Paria, Chaguaramas and Salybia in the north of Trinidad; and at Argyle and Kings Bay in Tobago.

2.4.2 to separated hydrologic units

For the purpose of harnessing and managing the fresh water resources, Trinidad and Tobago has been subdivided into 14 hydrometric areas, nine in Trinidad and five in Tobago

(**Table 2-1)**. Each hydrometric area is a major hydrologic unit which groups a number of watersheds/subwatersheds drained by rivers and streams. There are 54 of these watersheds in Trinidad and 15 in Tobago as illustrated **in Maps 2-4** and **2-5** respectively.

Table 2-1

HYDROMETRIC AREAS OF TRINIDAD AND TOBAGO

TRINIDAD			TOBAGO		
REF No.	AREA NAME	AREA (km^2)	REF No.	AREA NAME	AREA (km^2)
1	North Coast	368	11	North Coast	49
2	North Oropouche	606	12	East Coast	49
3	Nariva	461	13	Windward	114
4	Ortoire	479	14	Courland	39
5	Southern Range	526	15	Lowlands	46
6	Cedros peninsula	420			
7	South Oropouche	438			
8	Central South West Coast	518			
9	Western Peninsula Caroni	1010			
	TOTAL:	**4826**		**TOTAL:**	**297**

Source: Water Resources Agency, T&T
(Reference Numbers after Map 2-4)

(a) In Trinidad

The largest watersheds contain the major river systems and drain the Northern and Southern basins to the west into the Gulf of Paria and to the east into the Atlantic Ocean. The headwaters of these systems are fed/ sustained by surface water runoff from the adjacent uplands. The main rivers discharging to the west are the Caroni (the largest of the river systems which drains the western two-thirds of the Northern Basin) and the South Oropouche. Discharging east to the Atlantic Ocean are the North Oropouche (draining the eastern third of the Northern Basin), the Navet and Ortoire rivers.

Although draining substantially smaller areas, the Yarra, Marianne, Paria, Matelot, Shark and Grand Riviere Rivers flow to the north from the highest rainfall areas in the Northern Range. All are perennial and potentially important sources of good quality water. Of the several rivers draining from the

Southern Range to the south, only three are perennial, the Erin, Moruga and Pilote Rivers.

(b) In Tobago

Rivers in Tobago are generally smaller than those in Trinidad. Five minor river systems have their head waters in the Main Ridge and are perennial in their upper courses. These are the Bloody Bay, Castara, Englishman's Bay, Parlatuvier and Courland Rivers. Draining south to the Atlantic Ocean are major Rivers - the Richmond, Goldsborough and Hillsborough.

2.4.3 *to support other life forms and ecosystems such as wetlands*

In Trinidad extensive areas of freshwater appear seasonally in wetlands particularly at Nariva, North Oropouche, Caroni, South Oropouche, Rousillac and Los Blanquizales. These generally retreat during the dry season and some sections occasionally dry out completely. Where topography permits, there may be permanent standing water at river mouths such as is found at the mouths of the Marianne and Yarra Rivers in Trinidad and the Courland River in Tobago.

This freshwater directly supports life other than human life. The flora and fauna present in aquatic systems are a result of the combined effects of hydrological, physical and chemical factors e.g. water density and nutrients are responsible for the amount and type of plankton. The variety of biological species and ecological systems that are sustained is important for the local as well as the national economies. For example, crabs and crayfish inhabiting watercourses contribute to the protein intake of local communities; other freshwater species such as the pui pui and teta are traded/exported as aquarium fish; the flood plains of Caroni and Nariva support spectacular concentrations of water birds and other wildlife which attract tourists, birdwatchers and nature photographers. These plains are themselves attractive landscape units. Animals graze on some of the freshwater plant species while others are used in the art and craft industry. Most of the large-scale agricultural activities in Trinidad are carried on in alluvial flood plains such as Aranguez.

2.4.4 *to dams and other surface areas*

There are four relatively large impoundment reservoirs with a combined capacity of 75 million cubic metres (MCM) in which surface waters are collected and stored to supply the various water demands. These are the Hollis, Navet and Caroni/Arena reservoirs in Trinidad; and the Hillsborough reservoir in Tobago. (also shown on **Map 2-3**). With the exception of the Caroni-Arena which regulates streamflow to a water treatment plant downstream, these are direct supply reservoirs.

The Navet system consists of a high dam on the Navet River and a low dam about 2.5km downstream of the existing reservoir. The reservoir for the Caroni-Arena system is on the Arena River and stores runoff from the Arena watershed as well as provides off-stream storage capacity for water from the Tumpuna River.

Private interests have constructed and operate other small impoundment reservoirs for water supply, particularly in south Trinidad.

and may have adverse effects

Diversion, damming/impoundment of fresh water while aiming to improve supplies causes changes in ecological communities by altering their physical environment through changes in flow rates, amount of available nutrients, sedimentation rate , etc. In some cases, access to spawning or breeding areas for some species may be cut off. Evidence of some of these changes has been observed in the wetland areas of Caroni and Nariva as a result of such diversions and damming to supply water for irrigated agriculture. While new ecological balances are created from such changes in the hydrological regime, they do not generally reflect the original range of life.

In addition to changes in the range of biological species and ecosystems, the construction of dams and reservoirs have indirect adverse effects. For example, they open new access routes that lead to encroachment into upstream areas of watersheds for expanded development and over-exploitation of forests and wildlife. The reservoirs themselves are susceptible to enhanced growth of phytoplankton (suspended plants) which may cause tainting of the water.

2.4.5 *or stored in underground aquifers*

Depending on the geological characteristics of certain areas, rainfall may infiltrate the soil and collect in groundwater aquifers. An aquifer is a geological formation, group of formations or part of a formation that is capable of yielding water to a well or spring. The aquifers of Trinidad are present in a variety of sands and gravels in the north, central and south of the island. Groundwater is a very important component of the freshwater resources of the country and because of its links with surface water and the hydrologic cycle as a whole, is exposed to similar threats, abuse and potential pollution.

a) In Trinidad

The major aquifers of Trinidad are the Northwest Peninsula Gravels, the Northern Gravels, the Central Sands and the Southern Sands. The aquifers of the Northwest and Northern Gravels are described as unconfined; those of the Central and Southern Sands are confined. The Central Sands aquifers are separated by a 300 metre-thick clay formation.

There are some minor aquifers in the east of Trinidad such as the Mayaro Sandstone and the Guayaguayare Sandstone **(Map 2-6).** The Northwest Peninsula and Northern Gravels and the Central Sands are the major producing aquifers of Trinidad. Their main source of recharge is by direct infiltration of rainfall. The importance of effective watershed management for this purpose cannot be overstated since the rate of runoff determines the water available for infiltration. Streambed infiltration and subsurface flow also contribute to recharge.

(i) Northwest Peninsula Gravels and Limestones

These consist of **alluvial and piedmont** deposits in valleys in the western part of the Northern Range extending from Chaguaramas in the west, to Port of Spain in the east. In addition there are some water-bearing **limestone** areas in the Northern Range such as at St. Ann's, Dorrington Gardens and Paramin.

The Chaguaramas, Cuesa, Diego Martin, St. Ann's, Cascade and Maraval rivers flow through these north-south oriented valleys. The main aquifers are the Tucker Valley Gravels (buried valley of the Cuesa River), the Diego Martin Valley Gravels and the Maraval Valley-Port of Spain Gravels which include Cascade and St. Ann's.

(ii) Northern Gravels

The Northern Gravels consist of wedge-shaped alluvial deposits and gravel-fans along the southern foot of the Northern Range. These extend from east of Port of Spain to approximately three kilometres east of Arima and southward onto the Caroni Plain. The rivers which emerge from the southern flank of the Northern Range and their related aquifers are, from west to east, the San Juan (El Socorro Gravels), the St. Joseph/Maracas (Valsayn Gravels), the Tacarigua (Tacarigua Gravels), the Arouca (Arouca Gravels) and the Arima (Arima Gravels). These rivers recharge the gravel-fan aquifers as they flow over them on their way to the Caroni River. **There is lateral connection between the El Socorro, the Valsayn and the Tacarigua Gravel aquifers.**

(iii) Central Sands

The Central Sands are located on the southern limb of the Caroni syncline. The aquifers consist of blanket sands differentiated as Sum Sum sand, Mahaica sand and Durham sand. They outcrop at irregular intervals in a band extending diagonally from Claxton Bay in a north-easterly direction, trend toward the Cumuto area and dip in a north-westerly direction toward the Gulf of Paria. **The sands are divided into a series of isolated pockets, which are generally not hydraulically interconnected.**

(iv) Southern Sands

The Southern Sands are multiple-sand aquifers divided into two formations, the Erin formation and the Morne L'Enfer formation in a heavily faulted area. **The two formations are divided into a series of hydraulically discontinuous basins.** It is known that before the groundwater was exploited, springs existed in the area.

(v) Other Aquifers

The Mayaro Sandstone in the south-east of Trinidad dips in a southeasterly direction and is susceptible to salt water intrusion. It is consequently not regarded as a major aquifer for drinking water supply. There are other aquifers in the central and south of Trinidad where no substantial volumes of water are abstracted at present and which are also not regarded as potential major water resources.

(b) In Tobago

Tobago is largely composed of igneous and metamorphic rocks **(Map 2-7)** that are hard and impervious and **offer little potential for groundwater development**. Groundwater is abstracted in the south-western part of the island where there are sedimentary deposits of coral limestone underlain by impermeable sedimentary clays.

Alluvial deposits adjacent to the Bloody Bay and Courland rivers appear to have low potential for groundwater yield. **No aquifer is known to exist within any of the river catchment areas in Tobago.**

CHAPTER 2

SUMMARY BOX

- The Caroni River System which drains an area of approximately 1000 km^2, is the major contributor to the potable water supply in Trinidad
- Water is generally not regarded as a valuable resource which depends upon effective management and this influences how it is used
- Availability of water is determined mainly by location, climate, topography and storage and distribution capacity
- Average monthly rainfall may vary from 25mm to 250 mm depending on the season
- Surface water – rivers and impounding reservoirs – are the major sources of water supply; but groundwater is the more significant supply source in South Trinidad
- Fresh water in transition areas like flood plains and swamps performs a critical role in supporting agriculture and a variety of life forms and ecoystems

3.0 FRESHWATER QUALITY

3.1 A National Water Quality Assessment

On the basis of information collated over the last two decades, observations and recent analyses and assessments, the quality of water in the rivers of Trinidad and to a lesser extent Tobago, has deteriorated. The most recent national water quality survey of rivers in Trinidad and Tobago in which 79 sites were sampled, was carried out during 1996 and 1997 (Phillip, 1998). Water quality criteria were used to classify the sites into three categories - pristine, perturbed and polluted. The criteria included chemical and biological parameters as indicated in **Table 3-1**.

TABLE 3-1

Criteria used for 1997 Water Quality Assessment

Parameter	**Concentration mg/L**	
	Low	High
Metals		
Cu	<0.02	>0.025
Zn	<0.1	>0.2
BOD_5	<4	>6
Oil and Grease	<10	>80
Nutrients	<0.12	>0.5
NH_3	<1	>3
P		
Dissolved Oxygen	**<2**	**5-10**

Source: Compiled from data provided in Dawn Phillip's (1998) Thesis

A pristine site is essentially one with the lowest concentrations of degradable organic matter and nutrients and a concomitantly high dissolved oxygen content. A polluted site is one which showed a low dissolved oxygen content and high concentrations of the other parameters while a perturbed site demonstrated intermediate levels of these parameters.

This assessment shows that all sites classified as polluted were found in Trinidad, occurring mainly in the western and southwestern parts of the island which correspond with the most industrialised and urbanised areas of the country. Additionally, many of the sites surveyed in Trinidad were perturbed. None of the sites on the rivers along the north facing slopes of Trinidad were polluted and no polluted sites were found in Tobago. These results are illustrated in **Map 3-1.**

3.2 Quality of Distributed Water

The most recent report (PUC, 1999) on the quality of water within the water distribution system has indicated a continuing decline over the period 1996 to 1998. The main reasons for this decline have been attributed to:-

- Insufficient chlorination leading to reduced bacterial quality;
- Mechanical problems such as malfunctioning of the lime silo and alum dosing pump resulting in lower physico-chemical quality;
- Inadequate water quality testing at the Central Laboratory; and
- Temporary closure of water treatment plants to address episodic loadings of pollutants from sewage, quarrying and other sources.

3.3 The quality of Waters in the Caroni River Basin.

Relative to WHO guidelines for chemicals in surface water sources used for producing drinking water, many of the detailed studies and reports done on surface water quality over the last three decades have been for the Caroni River Basin **(Map 3-2).** This is related to the fact that catchments in this area provide 272,760m^3/d of potable water to over 40% of the population. The results of some of these studies/reports are highlighted hereunder.

1976 Report for the Caroni Arena Water Supply project concluded that on the basis of available information collected at that time, the Caroni Arena Water Treatment Plant (CAWTP) was capable of producing safe and palatable water, however levels of bacteria and ammonia-nitrogen in the raw water needed special attention.

1984 A study done on organic micro-pollutants in the Caroni River Basin upstream of the Caroni Arena Water Treatment Plant, indicated that the organic chemicals present in the water samples might have originated from an industrial estate.

1987 A survey of organic pollution in the lower reaches of the Caroni River, identified a rum distillery as the major pollution source.

1997 i) A study done by the Environmental Management Authority (EMA) during the wet season, revealed that the raw water quality in the Caroni River at the CAWTP deteriorated since 1974. The main reasons for this decline were identified as increases in uncontrolled discharges of industrial effluents including wash waters from quarries; increased deforestation coupled with slight to moderate erosive soils; poor land use practices; and increase in discharges of untreated and partially treated sewage effluents.

ii) A study by the Water and Sewerage Authority (WASA) and the Institute of Marine Affairs (IMA) on surface water quality in all the rivers of the Caroni River

Basin have indicated that many of the rivers, especially in their middle and lower reaches, are severely polluted by a combination of domestic, industrial and agricultural wastes. Sampled in both the dry season and wet season, many of the rivers had bacterial counts far in excess of international guidelines for the respective uses. The most polluted rivers in this Basin were the Santa Cruz/San Juan, Maracas/St. Joseph, Tacarigua, Oropuna, Mausica, Arima, Aripo, Manacal/Caparo, Guanapo, El Mamo, Cunupia and Guayamare.

Some of the more important conclusions on river water quality of the Caroni River Basin (1997) study compared with earlier studies and are:-

- In general, the pH of the rivers fall well within the acceptable limits of 6.5 – 9.5 set by the WHO (1996) for drinking water; high pH levels in the St. Joseph River are attributed to effluents from the nearby dairy processing plant; in the vicinity of its confluence with the St. Joseph River, where the mean dissolved oxygen levels fell below the WHO guidelines of 0.5 mg/l. It should be noted, however, that dissolved oxygen levels often fall below this limit in the lower reaches of the San Juan River.

- The degree of pollution of rivers increases from upstream to downstream; in the less polluted rivers, solids usually consist of eroded material while in the more polluted rivers, solids may include sewage, soil material, livestock wastes and domestic refuse;
- Based on the levels of BOD and total coliforms the quality of water in the rivers were considered to be of a low quality requiring full treatment and disinfection.

3.4 The quality of our Groundwaters

The composition of rock and soil type, through which water travels, can affect its quality. Water, in coming into contact with soil and rock, may dissolve some of the chemical constituents. These dissolved chemicals in water influence its suitability for various uses. For surface water in Trinidad and Tobago, this phenomenon has not played a significant role but there is evidence of this effect on groundwater.

The natural groundwater quality of the major aquifers in Trinidad is generally within the limits set by the WHO for potable water and therefore requires little treatment. In some well fields near limestone lenses in the Northern aquifers, the water can be hard. Groundwaters in the Central Sands and the Southern Sands aquifers generally have high iron contents above the WHO limit of 0.3 mg/l. Aquifers close to the coast (e.g. El Socorro wells) experience seawater intrusion due to over-abstraction, but generally, chloride (salt) content is below recommended standard. Minor aquifers exist in southwestern Tobago but these have not been exploited over the years and their quality cannot be verified.

While there have been no confirmed instances of significant groundwater pollution, one preliminary assessment of subsurface water samples taken near the underground storage tanks (USTs) of three service stations in Trinidad showed very high concentrations of hydrocarbons at two of them. These hydrocarbons included benzene, toluene, ethylbenzene and xylene (BTEX) which are either carcinogenic, depending on concentration and length of exposure. Contamination of these waters was attributed to leaking fuel from corroded USTs plumbing lines leaching into the soil. One of these sites was actually located above a productive aquifer. The absence of confirmed reports of significant groundwater pollution is somewhat curious in light of the existing and potential polluting agents in surface waters that are detailed in the next chapter. This may be due to the method of groundwater quality monitoring used in Trinidad and Tobago which is not equipped to detect micro-pollutants such as polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons, pesticides and BTEX. The location of the productive aquifers in Trinidad in relation to land fills, garbage dumps and underground fuel storage tanks is illustrated in **Map 3-3.**

3.5 Other Aquatic Environments such as Wetlands

Limited water quality assessments have been carried out in aquatic environments other than rivers. These have been made for the larger wetland areas of Caroni, Nariva and South Oropouche. Alterations to the natural drainage patterns continue to be the major factor contributing to the quality of water in these areas, such changes resulting in increased salinity of the water and drying out. The use of pesticides and fertilisers in these areas has also contributed to changes in species composition and abundance in these areas, large portions of which have been converted to rice growing. A recent study commissioned to determine the cause of a mangrove die-back on the Pt. Lisas Industrial Estate revealed that the combined effects of ammonia, temperature and salinity associated with industrial effluents was the root cause.

3.6 Constraints of Limited Data and Information

Notwithstanding the limited data and information on which assessments are based due to inconsistent monitoring and surveys, there is no doubt that the quality of fresh water resources and environments has been deteriorating over the last two decades. Although individually some of the determining parameters appear to be insignificant, when viewed collectively and in the absence of deliberate corrective action, their cumulative effects are pervasive and may be long-lasting.

CHAPTER 3

SUMMARY BOX

- Using the results of the most recent national water (surface) quality assessment, river water quality in most of Trinidad shows a high level of pollution
- Because of its major contribution to potable water supply, the Caroni River Basin has been the subject of many studies and its water quality has declined over the last two decades
- The quality of water in the distribution system has also shown decline during the last two years
- Levels of BOD and coliforms in the Caroni River Basin indicate that the quality of water is low, making full treatment and disinfection necessary
- Groundwater analyses may not be sufficiently sensitive to detect a number of potentially dangerous chemical contaminants within aquifers
- While current methods of groundwater analyses do not demonstrate significant pollution, productive aquifers are located within the zones of influence of a number of potential pollution sources
- Improved methods of monitoring pollutants and more consistent scientific surveys are necessary to provide additional information on water quality

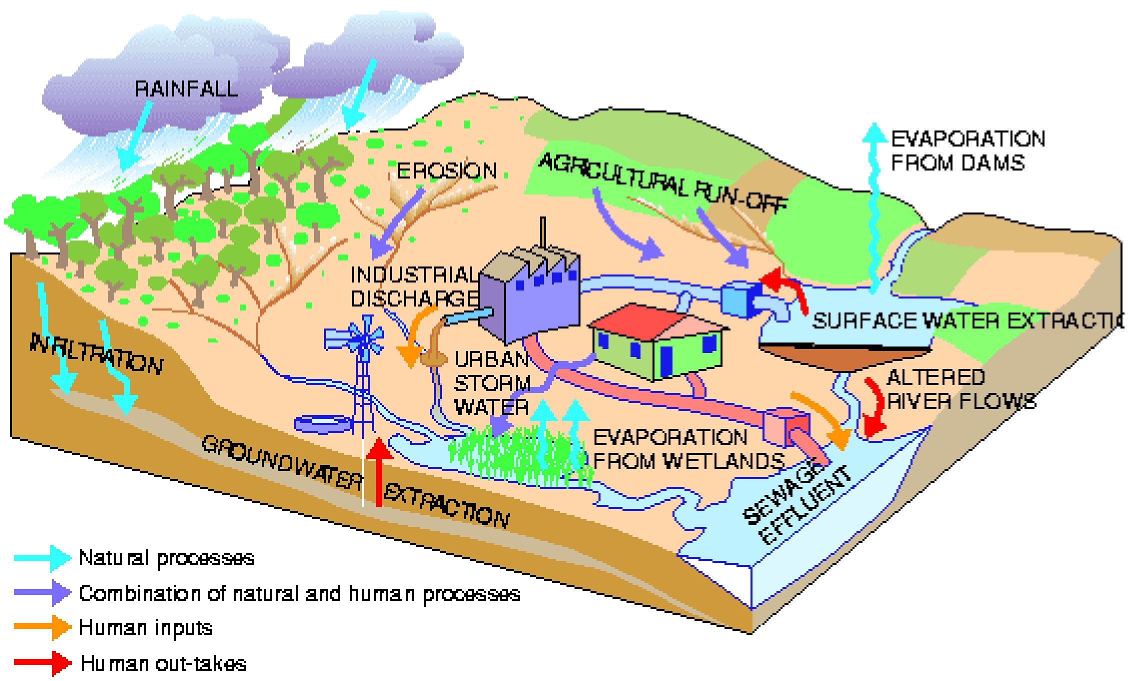
4.0 THREATS TO WATER QUALITY

4.1 THEY ARE MANY AND VARIED; NATURAL AND MAN-MADE

The previous chapter showed that the quality of water in most of our rivers needs to be improved. The factors and activities which affect or pose threats to this water quality are many and varied. They originate from both point (single) sources and diffuse (many individual points over a large area) sources. Although most of these factors result from human activity, natural features e.g. rock composition and events such as tropical storms, torrential rains, etc. sometimes aggravated by human action, also impair the quality of fresh water resources and aquatic environments. Physical, chemical and biological factors interact and have both direct and indirect impacts on these resources. These interactions are simply illustrated in **Figure 4-1**.

FIGURE 4-1

General relationships between a catchment area, surface water and groundwater



Source: USEPA Office of Water

4.2 SURFACE WATERS

4.2.1 Erosion

Watershed degradation is a major cause of impairment of fresh water and the aquatic environment. The main activities in Trinidad and Tobago which contribute to this are:

- the removal of forests and vegetation for housing, timber, squatting, urban expansion and agriculture;
- quarrying operations and road construction on steep slopes;
- the use of inappropriate soil conservation measures; and
- the recurrence of fires particularly, on steep hillslopes which result in the loss of vegetative cover.

The catchments of the Northern and Central Ranges in Trinidad have been significantly affected by these activities which have caused high sediment loading in the rivers which drain them. Some of these sediments remain suspended in the watercourses or are transported to the flood plains and wetland areas where they may reduce the light penetration, smother species when they settle and generally affect species composition, abundance and normal interrelationships in ecosystems, even if on a temporary basis. The Diego Martin, Maraval, Maracas/St. Joseph, Tacarigua, Aripo, El Mamo, Guanapo, North Oropouche and Arima rivers and the Caroni Swamp have been receiving increased sediment loads as a result of these activities.

Map 4-1 shows the erosion status of watersheds in the 1960's. The information indicates that at that time 15% of the watersheds in Tobago had lost their entire topsoil and 42% lost more than half of their topsoil. The picture for Trinidad showed that only 1% of watersheds had lost all of their topsoil while less than 10% lost more than half. All of the Trinidad watersheds were on the south-facing slopes of the Northern Range. Judging from the rapid urban expansion and industrialisation during the last three decades, concomitant with the increased population, this situation would have worsened by several degrees. In addition, the records for reforestation of areas destroyed by fire over the last ten years (44,850 ha) show that only about 0.5% or 230ha have been replanted by the State. The figure for private reforestation is not available for inclusion in this report, but it can safely be assumed to be considerably less than that by the State.

A more recent attempt at ranking river basins in the northwest of Trinidad and Tobago by degree of degradation revealed that the Maraval, St. Ann's and Diego Martin basins in Trinidad and the Courland and Hillsborough in Tobago are the most degraded.

4.2.2 Structural/Engineering Interventions

Modification of hydrological regimes through structural and engineering works such as paving of waterways, channelisation and diversion of water within drainage basins and over-pumping of aquifers result in long-term degradation of fresh water environments. The main effects are drying out and salt water intrusion which alter species diversity and abundance as evident in the Caroni, Nariva and South Oropouche Swamps, and in coastal water recharge areas such as the El Socorro gravels.

4.2.3 Chemicals

Chemical pollution emanates from a number of sources including agriculture, industry and households. Fish kills in rivers have, on occasion, been traced to the use and abuse of pesticides and fertilisers in agriculture. Analyses of water and tissue samples taken from the Maraval, St. Ann's, Santa Cruz/San Juan, Caroni and Arima rivers in Trinidad have demonstrated this. Domestic household chemicals released from the kitchens, baths and laundries of individual homes can also degrade water quality. The cumulative impacts of all of these have been evident in the quality of the waters.

Trinidad and Tobago has a variety of industries, which include sugar and oil refining, rum distillation, petro chemicals, agro-processing, paint manufacture and metal finishing. Effluents from these are discharged into nearby drains and rivers. Rivers along the east-west corridor and the western coast of Trinidad are the recipients of the largest quantities of these effluents. Industrial activity in Tobago is small compared to Trinidad and located primarily in the south west of the island.

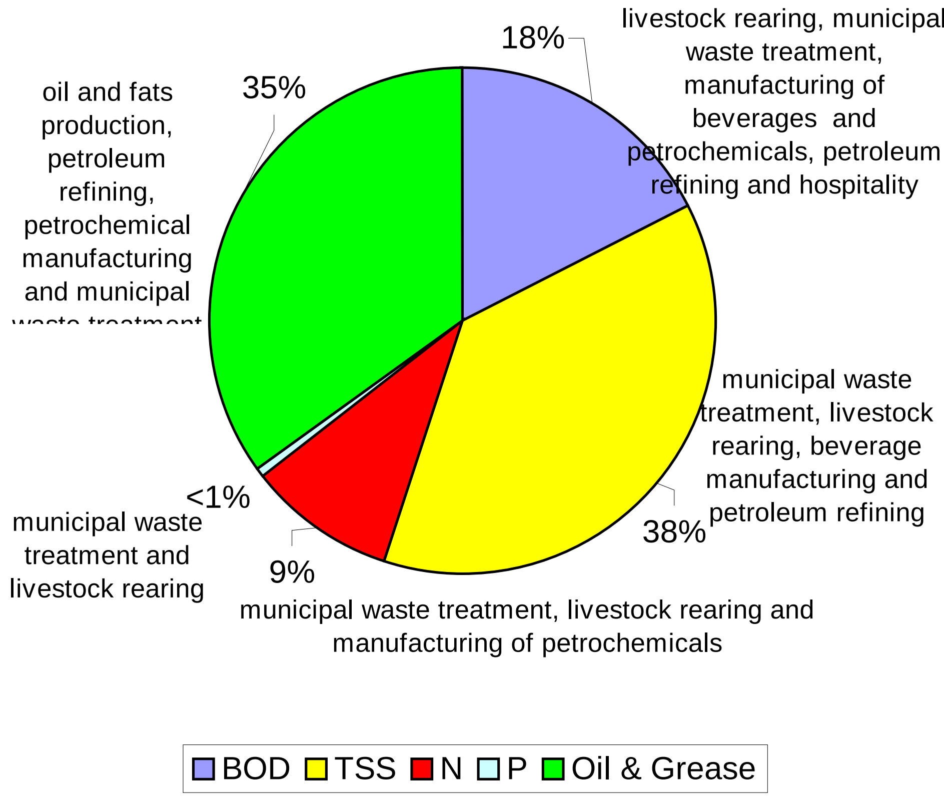
The Guaracara and Cipero rivers in south Trinidad are impacted by effluents from oil and sugar-cane refining respectively. Water quality in rivers in oil - producing areas is impaired by runoff from land-based activities during the rainy season. The Guapo, Erin, Vance, Silver Stream and John rivers are so affected. Some watercourses receive washings, excess oils, etc from factories and service stations. Because of the large number and wide distribution of service stations across Trinidad and Tobago, many watercourses are exposed to deterioration of their quality from this source. **Map 4-2** (Trinidad) and **Map 4-3** (Tobago) show the location of industrial pollutant sources in relation to surface water.

4.2.4 Sewage and Farm Wastes

Organic wastes from livestock farms and non-functional sewage treatment plants as well as overflowing septic tanks and pit latrines tend to be of 'high strength' creating malodours and eutrophication when released into surface waters. This condition is exacerbated when flow rates in watercourses are reduced as happens during the dry season. Farm wastes have been observed on different occasions over time to affect the quality in the Poole, Erin, Arima and Cunupia rivers in Trinidad and the Hillsborough in Tobago. With respect to sewage effluents, many of the rivers flowing through the highly urbanised areas in Trinidad and Tobago are susceptible (**Map 4-3** and **Map 4-4**). While up-to-date information on the functioning status of Sewage Treatment Plants was not available during the preparation of this report, in 1992 several of these were non-functional and there are confusing reports of this in various housing developments.

On the basis of limited data from the Pollutant Inventory Study (EMA, 1998) estimates of pollutant loads for Trinidad and Tobago have revealed that municipal and livestock wastes have contributed significantly to loadings of Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Nitrogen (N) and Phosphorous (P). **Figure 4.2** summarises the contribution of the individual pollutant loads and their significant pollution sources to the total effluent load.

Fig.4.2 Contribution of individual pollutant loads and their significant pollution sources to the total effluent load



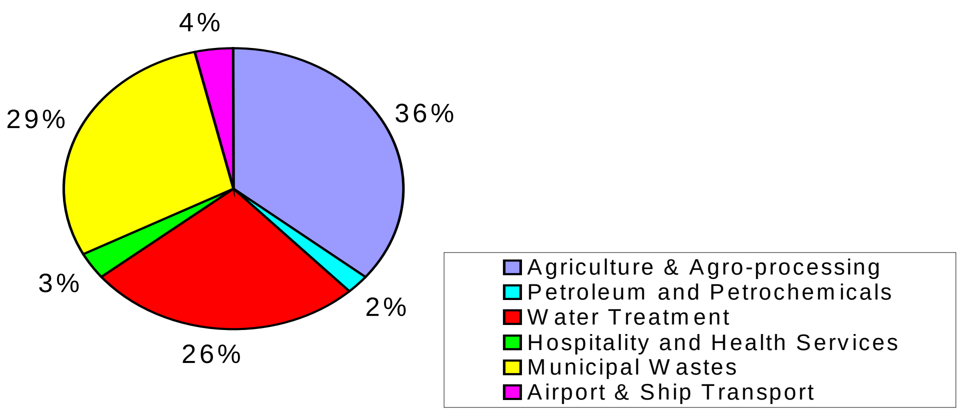
Source: Information Extracted from Pollutant Inventory Study, EMA 1998

4.2.5 Domestic Refuse and Solid Wastes

There is an unfortunate community culture in Trinidad and Tobago in which solid waste is disposed in drains and natural watercourses. This waste comprises the whole range of animal entrails, chicken feathers, faeces, used containers and bulky household items. Besides being very unsightly and creating odours, the chemical residues from these may also dissolve in the water and detract from its quality.

Using a similar approach, the Pollution Inventory Study estimated that approximately 1 million tonnes of solid wastes (which include sludges from potable and waste water treatment) are generated annually in Trinidad and Tobago. **Figure 4.3** summarises the significant contributors to these solid wastes.

Fig.4.3 Summary of significant sources of solid waste



Source: Information Extracted from Pollutant Inventory Study, EMA 1998

4.3 Our most critical fresh water source – The Caroni River Basin.

As seen earlier the Caroni River Basin has been the most studied of the water catchments of Trinidad, no doubt because of its size and importance to the potable water supply of the country.

Analyses and assessments of the rivers have shown that many of the rivers, which flow into this basin, have their water quality degraded by a variety of pollutants. These include high strength organic wastes, chemical pollutants, high levels of bacteria and large loads of suspended solids. Rivers such as the Mausica, Arima, Guanapo, El Mamo, Aripo, Cumuto and Tumpuna are so affected **(Table 4-1).**

TABLE 4-1

Existing and Potential Sources of Pollution in the Caroni River Basin

River Systems	Domestic Refuse[1]	Domestic Sewage[2]	Industrial Effluents[3]	Farm Wastes[4]	Agricultural Chemicals[5]
1. Caroni	+	+	+	+	+
2. Santa Cruz	+	+	+	+	+
3. Maracas/St. Joseph	+	+	+	+	+
4. Tacarigua	+	+	+	+	+
5. Arouca	+	+	+	+	+
6. Oropuna	+	+	+	+	+
7. Mausica	+	+	+	+	+
8. Arima	+	+	+	+	+
9. Guanapo	+	+	+	+	+
10. El Mamo	+	+	+	+	+
11. Aripo	+	+	+	+	+
12. Cumuto	+	+	-	+	+
13. Tumpuna	+	-	-	+	+
14. Guayamare	+	+	+	+	+
15. Cunupia	+	+	+	+	+

\+ - existing and potential pollution as identified in the literature from field measurements and observations
\- no confirmed reports
1 - includes garbage, trade refuse and leachates from solid waste disposal sites
2 - includes seepage from cesspools and pit privates
3 - includes sand and gravel wash-waters
4 - includes wastewater from animal processing plants/abbattoirs
5 - includes runoff from the use of fertilisers and pesticides

Source: Surface Water Quality in the Caroni River Basin, IMA, 1996
(Study done for Water and Sewerage Authority)

4.4 GROUNDWATER

Since groundwater and surface water are inextricably linked in the water continuum, groundwater may be impaired by some or all of the pollutants in surface water, as long as these are discharged or leach directly into recharge areas or close to where they can infiltrate an aquifer. Leachate from open dumps and sanitary landfills is one of the main threats to groundwater quality such as at Beetham and Guanapo (the Northern Gravels), Forres Park and Studley Park (the local watertable).

4.5 WETLANDS

Water quality of the aquatic environment in the major wetlands of Trinidad are affected mainly by drying out and salinization resulting from structural interventions to the hydrologic regimes of these areas. This has been evident in the larger wetland areas where drainage and flood-protection works, as well as water diversions for large-scale agriculture, have reduced their fresh water supplies and storage capacity and encouraged extensive saline intrusion. Sediments, agricultural and industrial chemicals, organic pollutants and salt water have impaired the functioning of these systems by altering flow rates conductivity, light penetration and availability of oxygen. Thus the interactions of soils, water and biota which enable wetlands to perform vital functions such as water storage purification and recharge would be disrupted.

CHAPTER 4

SUMMARY BOX

- Surface water, groundwater and aquatic environments are under threat from a variety of natural and man-made factors acting singly and in concert
- The destruction of forests by fire, logging, urban development, quarrying and infrastructure development, especially in catchments of the Northern and Central ranges, is a major threat to the quantity of available water
- Municipal, industrial and livestock wastes contribute significantly to water pollution and impairment of quality
- Leachate from sanitary landfills and open dumps is a major threat to groundwater, but other sources such as fuel from underground storage tanks also contribute to contamination of aquifers
- Structural interventions to the hydrologic regimes of aquatic environments such as wetlands, facilitate drying out and salinisation

5.0. WATER AVAILABILITY, PRODUCTION AND DEMAND

5.1 HOW MUCH WATER IS AVAILABLE

Despite the man-induced influences which present limitations to the collection of adequate quantities of water such as deforestation, loss of top soil and increased runoff and the geographic and topographic variances in rainfall, Trinidad and Tobago is well endowed with fresh water resources. A high volume of runoff is due in part to unauthorised or indiscriminate human activity in critical watersheds, the most significant being deforestation by squatters for construction of homes and intensive agriculture and by logging. Squatting is so prevalent in Trinidad that a 1994 study conservatively estimated the number of squatters occupying State-owned forest reserves covering an area of 4429 ha to be 1900.

5.1.1 From the Surface

There is wide variation in the surface water availability (runoff) figures recorded for individual years for Trinidad and Tobago. On average, however, the annual surface water availability for Trinidad is estimated at 2500MCM, only 513 MCM of which is available in the dry season (December to May). Storage during the rainy season is therefore critical to the dry season water supply. Estimates for Tobago are 140 MCM and 28 MCM respectively. Although surface water availability varies among hydrologic units, by some international criteria this country cannot be described as water-scarce. Expressed on a per capita basis, water availability in Trinidad and Tobago is about 2500 m^3/year.

Some of this water is stored for the dry season and for distribution to those areas such as Port of Spain where the catchment capacity falls short of demand. The combined surface water storage capacity for the public water supply (domestic and industrial) is at present limited to 75 MCM, which represents about 3% of the total yearly demand for both Trinidad and Tobago. Storage is in the four major impoundment reservoirs – the Hollis, Navet, Caroni-Arena in Trinidad and the Hillsborough in Tobago. Individual storage capacities are provided in **Table 5-1.**

The country's high average annual rainfall of 2200mm suggests that the average annual surface water availability is also high (run-off varies by hydrologic unit between 20% and 50%), and is estimated at more than ten times the present public water supply demand.

Table 5-1

Reservoir Storage in Trinidad and Tobago

NAME (Year Commissioned)	RIVER SYSTEM	CAPACITY (Million Cubic Metres – MCM)
TRINIDAD		
Hollis (1936)	North Oropouche	4.7
Arena (1981)	Caroni	46.6
Navet (Upper) (1966)	Navet	18.6
Navet (Lower) (1976)	Navet	4.3
TOBAGO		
Hillsborough	Hillsborough East	0.7
TOTAL		**74.9**

Source: Water Resources Agency

5.1.2 From the ground (aquifers)

Compared to surface water, groundwater availability is small but is a very significant component of potable water especially for areas in the south of Trinidad. Safe yield is estimated at 107 MCM per year which is approximately one and one-half times the combined reservoir storage capacity, but is only 3% of surface water availability. It is believed that groundwater resources are being used close to their sustainable limit.

5.2 WHO/WHAT NEED WATER

Demand for water is described in terms of consumptive (use in homes, institutions, factories and agriculture), non-consumptive (the in-stream requirements of rivers and minimum flow requirements of swamps/wetlands) and negative (leakages from transmission lines, private premises and illegal connections) demand. Population size and density, scale and intensity of commercial/industrial activity, availability of the resource itself, economic conditions, attitudes toward use of water and management practices are some of the factors which influence demand for water in Trinidad and Tobago, and the significance of the factor varies by geographic location. If the demand for each watershed in Trinidad were to rely on its own natural attributes, the western part of the island would experience major shortages by reason of its low annual rainfall. In Tobago the situation is more favourable, although only marginally, with a surplus for the south-western part of the island.

Customers serviced by the statutory water authority are categorised primarily by the type of activity carried out on their premises. Other criteria for categorisation include the level of service on premises and the presence or absence of a metered system. These categories include domestic, institutional (charitable), industrial (major and minor), commercial and agricultural and reflect a significant omission - the (non-consumptive) water demand of the natural environment. This demand simply is served by whatever is left after the defined categories are taken care of. This is in keeping with our usual tendency to ignore the needs of other forms of life and the natural ecosystems of which they are a part and to continue to undervalue fresh water ecosystems.

5.3 AND HOW MUCH?

5.3.1 Domestic and Industrial (Public Water Supply)

Trinidad and Tobago's combined demand for domestic and industrial water comprises the public water supply demand and is calculated using the national average population growth rate of 1.2% per annum. On this basis domestic demand is largest among the categories, followed by the demand of major Industry. Using 1997 as a base year, **Table 5-2** shows the current public water supply demand and projections for the years 2000 and 2025. It is to be noted that the 'Unaccounted for'/Negative Demand category is greater than the domestic demand presently.

In Tobago the public water supply demand is estimated at 7% of the estimated water availability of 140 MCM per year.

TABLE 5-2

Total Public Water Supply Demand (MCM/year)

YEAR	DOMESTIC	MAJOR INDUSTRIAL	MINOR INDUSTRIAL	UNACCOUNTED FOR/NEGATIVE	TOTAL
1997	118	36	9	124	287
2000	120	51	10	126	307
2025	203	112	15	141	471

Source: Water Resources Agency

5.3.2 Irrigated Agriculture

Irrigated agriculture therefore uses but a small percentage (about 5%) of the total water demand in Trinidad. In south Trinidad and Tobago, the quantities used are even smaller, since agriculture is practised on a smaller scale. Agricultural water demand from surface systems is determined by the area under irrigation and efficiency of use. Compared to other land uses, the total area under agriculture is relatively small, about 3050 ha, and is located mainly in north Trinidad. Areas such as the lower Caroni Basin and Plum Mitan also contribute to this total water demand which varies widely over the year and is estimated at about 12 MCM per year. As expected, the highest demand is in the dry season.

5.3.3 Non-consuming water demand

The non-consuming water demand comprises the minimum flow requirements for maintaining healthy fresh water species and systems. It is difficult to assess the quantum of water required for such flows, but the intended supply strategy for this category is to allow for minimum flow requirements to the main wetland areas after upstream demands are satisfied. These requirements are therefore given the lowest priority and it is believed that they cannot be met for most of the time.

5.4 HOW MUCH IS REALLY CONSUMED?

Very reliable estimates of unit consumption of water in Trinidad and Tobago are difficult to provide since only 1% of the population is metered and about 22% of customers have a 24-hour (continuous) supply. As indicated earlier, there is also a relatively large percentage of 'unaccounted-for' water. Various studies carried out between 1990 and 1997 show that the highest daily unit consumption is by unmetered domestic users; the lowest by rural and non-domestic (small commercial and agricultural) users.

5.5 WHAT IS PRODUCED

5.5.1 From Surface

Raw water sourced from major and minor intakes is sent to water treatment works (**Maps 5-1** and **5-2**) before being piped to the different categories of consumers. The first water treatment works to be established in Trinidad was the Maraval Waterworks in 1853 with a production rate of approx. 4500m^3/d followed by the River Estate Waterworks in 1902. Both were built to provide water for the Port of Spain area. The development of the country's water resources continued in the 1900s and groundwater resources were gradually developed. In 1936, when the Hollis system was commissioned, it served almost all of Trinidad with a human population at the time of about 413,000. With current production of 32 000m^3/d it now serves Port of Spain, the Eastern Main Road communities and Sangre Grande.

By 1949 Trinidad and Tobago's total water production was 68 000 m^3/d and the total population just over half a million. At current total production of approximately 680 000m^3/d the increase in production in the fifty-year period

1949 to 1998 has been tenfold and the population has doubled.

The Navet System is the principal source of supply for San Fernando and the south of Trinidad. Between 1962 and 1976 the capacity of this system was increased from 55 000 m^3/d to 77 000 m^3/d.

The most recent and largest water production facility in Trinidad is the Caroni Arena System with a capacity of about 273 000m^3/d –approximately 40% of the total water produced by the country's statutory water Authority, the Water and Sewerage Authority (WASA). The Caroni River itself has a significant natural dry season flow as a result of groundwater contributions to its base flow. The North Oropouche system which draws from the North Oropouche River in north-eastern Trinidad is interconnected with the Caroni Arena system.

The major contributors to the total production capacity of 25 300 m^3/d estimated for Tobago are the Hillsborough Reservoir and the Courland intake (**Map 5.2**). The Hillsborough system is the principal source of supply for the Scarborough and south-west Tobago areas accounting for 10 500 m^3/d. There are local wells and river intakes at Richmond, Kings Bay, Craighill and Courland. The largest direct river intake is the Courland Waterworks with a production capacity of about 6 900 m^3/d.

The average yearly total production by the statutory water Authority is about 270 MCM, a small percentage (about 8%) of the available surface water. (Table 5-3 shows average daily surface water production for the ten-year period 1987 – 1996). Ten major and thirty-two minor river intakes are the sources of supply for areas in the North of Trinidad (**Map 5-1**). There is a seasonal variation in production from these intakes, production decreasing during the dry season.

Table 5-3

Average Daily Surface Water Production for Trinidad and Tobago

YEAR	PRODUCTION MCM/day
1987	.655
1988	.661
1989	.676
1990	.699
1991	.698
1992	.744
1993	.713
1994	Unknown
1995	.685
1996	.700

MCM = millions of cubic metres
Source: Water Resources Agency

5.5.2 From Ground

Groundwater production is about 25% of the surface water production total. The total yield of groundwater recorded for Trinidad in 1995 was 77.5 MCM of which 88% or 68 MCM was for public supply and 9.47 MCM or 12% was for users holding private licences. Groundwater production rates are provided in **Table 5-4**.

TABLE 5-4

Groundwater production rates in Trinidad

Well Fields	Total Present Yield (m^3/s)
Chatham, Granville	0.09
Mayaro	0.06
Las Lomas	0.10
Freeport, Carlsen, Todd's Road	0.29
POS-St. Clair, POS-Savannah, POS-King George V, El Socorro, Valsayn, Tacarigua, Arouca, Arima + Moka	0.85
Chaguaramas, Tucker Valley, River Estate, Diego Martin, Dorrington Gardens	0.64
Cap-de-Ville, Palo Seco/Carapal	0.02
Penal, Siparia/Coora, Fyzabad, Clarke Road	0.08
Guayaguayare	0.01

Source: Water Resources Agency

The groundwater potential (and production) in Tobago is very low, the two operating wells giving a combined yield of 0.2 MCM/year.

5.6 How much is Supplied

5.6.1 From the Surface

Overall, surface water accounts for about 75% of the total volume of water supplied for drinking, industrial/commercial purposes and irrigated agriculture. The production capacities of the service plants range from less than 500m^3/d to 273 000m^3/d. When all service plants are operational, there are 99 authorised water supply sources, 86 in Trinidad and 13 in Tobago.

During 1970 to 1990 the average volume of water supplied to the various categories of customers increased from 270 000m^3/d to 700 000m^3/d, an increase of about 160%. This was due primarily to extensions to old and construction and commissioning of new waterworks during this period. Since 1990 total production has increased little and is exceeded by demand. This has resulted in 78% of clients obtaining a 'scheduled' or discontinuous water supply.

5.6.2 From the Ground

Groundwater was the source of 49% of the public water supply in Trinidad prior to 1981. Since the Caroni-Arena water scheme was commissioned however, the contribution of groundwater to the total water supply of Trinidad has been reduced to about 25%.

5.7 A WATER BALANCE

An annual water balance for Trinidad and Tobago will be deceptive since it will show an overall surplus without accounting for variances in time (wet and dry seasons) and space (hydrometric areas). Monthly water balances demonstrate the seasonal water demand and the evident dominance of the wet season. Outflow from reservoir storage to accommodate shortages in supply reaches a maximum between March and May (in the dry season) but is negligible in the wet season. In Port-of-Spain however, a negative value is recorded even in the wet season because of the relatively low water availability compared to supply.

While Trinidad and Tobago is not a freshwater scarce country there is not an overabundance of available water. It is to be noted that the methods currently used to calculate safe yields of water are not based on probability analysis but on mean minimum flow, selected reservoir capacities, intensity of dry period, etc.

Areas with a surplus of water are mainly found in the eastern part of Trinidad. However, these areas are not automatically synonymous with potential future sources of water since the surplus may be reflecting a small water demand in relation to availability. Some areas such as the Toco watershed, although showing relatively large surpluses, have difficulty accessing the resource because it is distributed among a number of relatively small rivers.

In Tobago the water availability of the watersheds exceeds demand even in the dry season. Like the north-east of Trinidad, the water is contained in a number of small streams and is difficult to exploit. The difference between water demand and water availability in Tobago is smallest in the Hillsborough watershed which accounts for 41% of Tobago's water supply.

Shortages in water supply are most severe in the west-central and southern areas of Trinidad and the south-west of Tobago. External supply is therefore necessary to supplement the watersheds in these areas.

CHAPTER 5

SUMMARY BOX

- Trinidad and Tobago is not a water-scarce country but distribution of the supply is critical
- A high volume of run-off results from unauthorized and indiscriminate human activity in watersheds
- Actual surface water availability in Trinidad is 3600 MCM only about 8% of which is available in the dry season
- Total water storage capacity for the public water supply is only 3% of total annual water demand for Trinidad and Tobago
- Per capita annual water availability is 2500m^3
- The safe yield from groundwater is about one and one half times the combined reservoir storage capacity
- Water storage in the rainy season and efficient distribution are critical to water supply of the ‘drier’ areas of the country
- The non-consumptive water demand of the aquatic environments has the lowest priority for water supply
- ‘Unaccounted for’ water compares very closely with domestic demand, the largest among the categories
- With only limited metering of premises, it is difficult to make reliable estimates of unit consumption of water, but unmetered domestic users are believed to have the highest daily unit consumption
- Although not an insignificant contribution to water supply, groundwater production is small when compared with that of surface water
- Hillsborough Reservoir and Courland intake are the main contributors to water production in Tobago
- In the 20-year period 1970 - 1990 annual volume of water supplied increased by 160%
- At present water demand exceeds production resulting in only 22% of customers obtaining an interrupted 24-hour supply

6.0 LEGISLATION

6.1 THE SCOPE

Despite the threats to, and problems identified with fresh water quality and quantity, there is a plethora of legislative mechanisms to regulate the resource. These regulations are operated at different levels – sectoral, local and national. The range includes everything from watershed management to pollution prevention and control on land, water sources, natural watercourses and drains, to alteration of watercourses, standards for acceptable water quality, land use plans and integrated environmental management.

6.2 THE EFFECT

Despite this range of legislative mechanisms there has been only limited success in addressing issues of water pollution, abuse and wastage. This situation is attributed to several key factors.

6.2.1 Penalties

Penalties for violations of various rules and regulations are very low, in the vicinity of TT $600.00. Instead of acting as a disincentive, therefore, it is cheaper to pollute rather than find more responsible ways than of disposing into fresh water systems and environments. Increasingly it is being recognised that the polluter must pay for his environmental transgressions and the payment required should act as a deterrent from future misconduct. Such sanctions are generally not found in the multiplicity of laws dealing with water pollution and management in Trinidad and Tobago.

6.2.2 Inadequate Regulations

Several pieces of legislation such as the Water and Sewerage Act require the making of regulations to bring effect to their use for water management and pollution prevention. Unfortunately, in many instances, the power to make regulations in primary legislation has been ignored. The result is the presence of framework legislation that cannot be enforced to achieve the objectives for which they were designed.

6.2.3 Specificity and Standards

Many of the legislative prohibitions are couched in non-specific terms and there are few or no standards for specific categories of discharges into water. Without specificity, it is almost impossible to enforce the existing laws.

6.2.4 Dissipation of Authority

The presence of multiple agencies with similar, joint or complementary activities presents a major challenge to deliberate action and historically has not been an effective approach to the protection of the freshwater resource. The situation with multiple agencies can and has created problems such as informal rationing of responsibilities. With respect to the role of the public health inspectors for example, there appears to be the perception that the thrust of their responsibilities is food protection while the relevant legislation has a broader scope. It is felt that protection of water resources is more within the portfolio of agencies such as WASA. Thus, there is an informal rationalising of responsibility that may create inefficiency and elude the realisation of the goal of water pollution prevention.

Laws relevant to the protection of watersheds fall under the jurisdiction of the Forestry Division and no formal collaboration and enforcement exists between this agency and WASA.

6.2.5 Lack of Resources for Enforcement

There is clearly an absence of personnel to enforce the existing laws that impact on freshwater. Most of the agencies responsible for enforcing legislation dealing with freshwater management, point to the absence of enforcement resources such as the human expertise, laboratory facilities and mechanical resources as the root causes of non-enforcement of laws.

6.2.6 General Powers

The vesting of general powers in bodies like the Tobago House of Assembly and the Bureau of Standards, to deal with specific responsibilities can lead to ambiguity, duplication and inefficiency.

CHAPTER 6

SUMMARY BOX

- Legislation for watershed management and pollution prevention needs to be updated and streamlined
- Regulations to implement legislation need to be created and enforced urgently
- Roles and responsibilities for water management must be clearly articulated and an integrated approach promoted
- Adequate resources must be allocated for the personnel and equipment needed for integrated water management

7.0 CHALLENGES AND IMPERATIVES FOR ACTION

7.1 The Challenge

The foregoing chapters of this report indicate that in terms of quantity, there is adequate fresh water resources to supply the various needs of the country. However, due to the location of these resources in relation to current and projected demand, there is urgent need to improve the management of the water sources and efficiency of distribution. Even more challenging is the need to protect the water sources and aquatic environments from pollution. From the actual pollutants identified in water bodies and the distribution system and the location of potential threats to surface, ground and freshwater environments, it can be concluded that any river or stream which traverses an urban, industrialised or intensive agricultural area is likely to be polluted. The specific pollutants and degree of impairment of the resource is determined by the types and levels of activity in the area. It is also very evident that unless immediate and deliberate action is taken to address these concerns, the gap between demand and supply of potable water will continue to increase and so will the costs of supply. The major challenges to be met for this resource are therefore protection of freshwater at source, the prevention of pollution in raw water and increased efficiency in water distribution.

7.2 The Strategy

In order to meet these challenges, a mix of strategies is required which must include an appreciation of the real value of freshwater and freshwater environments, stewardship of these resources, partnerships for effective management, ongoing dialogue and an institutionalised system of monitoring and data collection that will provide continuous feedback.

7.2.1 The EMA's Role and Responsibility

In this regard, the provision made in the Environmental Management Act No. 3 of 1995 for integrated environmental management through public education and awareness, the rationalisation of environmental laws and the use of incentives/disincentives, embody this strategic approach. The current initiatives which will contribute to improvement in freshwater include the following programmes:

- the <u>Water Pollution Programme:</u> which will prevent and control fresh water pollutants emanating from both point and non-point sources. It will involve primarily a system of permits for compliance with established compulsory standards for different environments;

- the <u>Legislative Programme:</u> which is a system of rules and regulations to anticipate, prevent or mitigate significant environmental impacts through a Certificate of Environmental Clearance (CEC); designate special areas and species as environmentally sensitive and regulate the types of activities to be associated with them; provide incentives and disincentives to pollution through deposit legislation; and evaluate, rationalise, modernise and consolidate written environmental laws; and

- A Research Programme with the University of the West Indies on the scientific collection of data to determine fresh water quality using biological indicators.

7.3 IMPERATIVES

Urgent and deliberate action is needed to ensure the availability of an adequate and safe supply of water and therefore the health, food and livelihood security of the nation. This will require the early allocation of substantial resources and the introduction of mechanisms for cost recovery to do the following:-

- Takeover, rehabilitation/ replacement and maintenance of all non-functioning sewage systems in the country;
- Integrated watershed management – a 'lasting process for partners working together' - to build management decisions on sound science and cost-effectiveness. This process is essential in arresting the destruction of forests and squatting in watersheds/catchments critical to the potable water supplies, and controlling the locations and operations of quarries;
- Establishment of a system and infrastructure to handle grey water in the country;
- Establishment and maintenance of a hazardous waste landfill;
- The proper management of sanitary landfills and collection, treatment and disposal of municipal wastes and wastewaters;
- No net loss of wetlands to ensure the continued performance of their vital functions such as water storage, storm protection, flood mitigation, shoreline stabilisation, groundwater recharge, water purification and support of biological diversity;
- Continued development, implementation and enforcement of standards and regulations to eliminate the discharge of untreated or inadequately treated effluents into watercourses to meet basic and specific water quality criteria.

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