



5.1 Introduction

Barbados' freshwater supply is primarily a function of its climatic and physical conditions. The island is characterised by a tropical maritime climate which has two pronounced seasons: one dry and one wet. The wet season, which lasts from around June to October, is the fundamental source of potable water on the island. The amount available for use is heavily influenced by the island's geological structure and thereafter by the distribution system in place for water supply. In considering the state of the island's water resources, it must be borne in mind that Barbados is ranked among the world's ten most water scarce countries.

Based on this, the annual renewable freshwater resources have most recently been estimated at 225 410 m³ or 49.59 mgd per day⁴.

At its current population, these figures allow an available supply that is well under the 1 000 m³ per capita set internationally as the limit below which a country is classified as "water scarce"⁵.

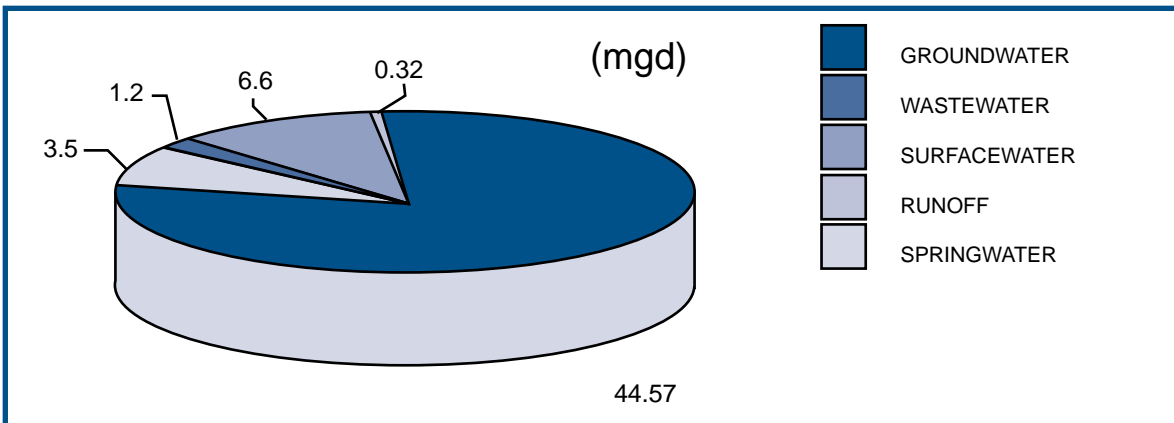
Ground water accounts for by far the largest proportion (79 per cent) of the island's water resources (Figure 5.1), and for 98.6 per cent of its public water supply⁶. This is due to the fact that the limestone cap covers 86 per cent of the island. The limestone, which is up to 300 feet in thickness, is highly permeable, allowing for a well-developed aquifer system beneath the surface catchment areas (Map 5.2).

5.2 Fresh Water Occurrence and Quantity Issues

Rainfall varies across time and space, even for a small island like Barbados. Map 5.1 shows rainfall distribution on the island, which averages 56-60 inches per year. The rainwater is distributed among groundwater, springwater, surface water and runoff. A 1978¹ water resources study estimated that, under average annual rainfall conditions of 60 inches, a total of 54.79 mgd (million gallons per day) is available, and 34.37 mgd in a drought year. The 1996/98 Water Resources Management and Water Loss Studies² have determined, based on an analysis of available data from 1947 to 1994, that an average annual rainfall of 56 inches represents the most reliable rainfall figure for Barbados³.

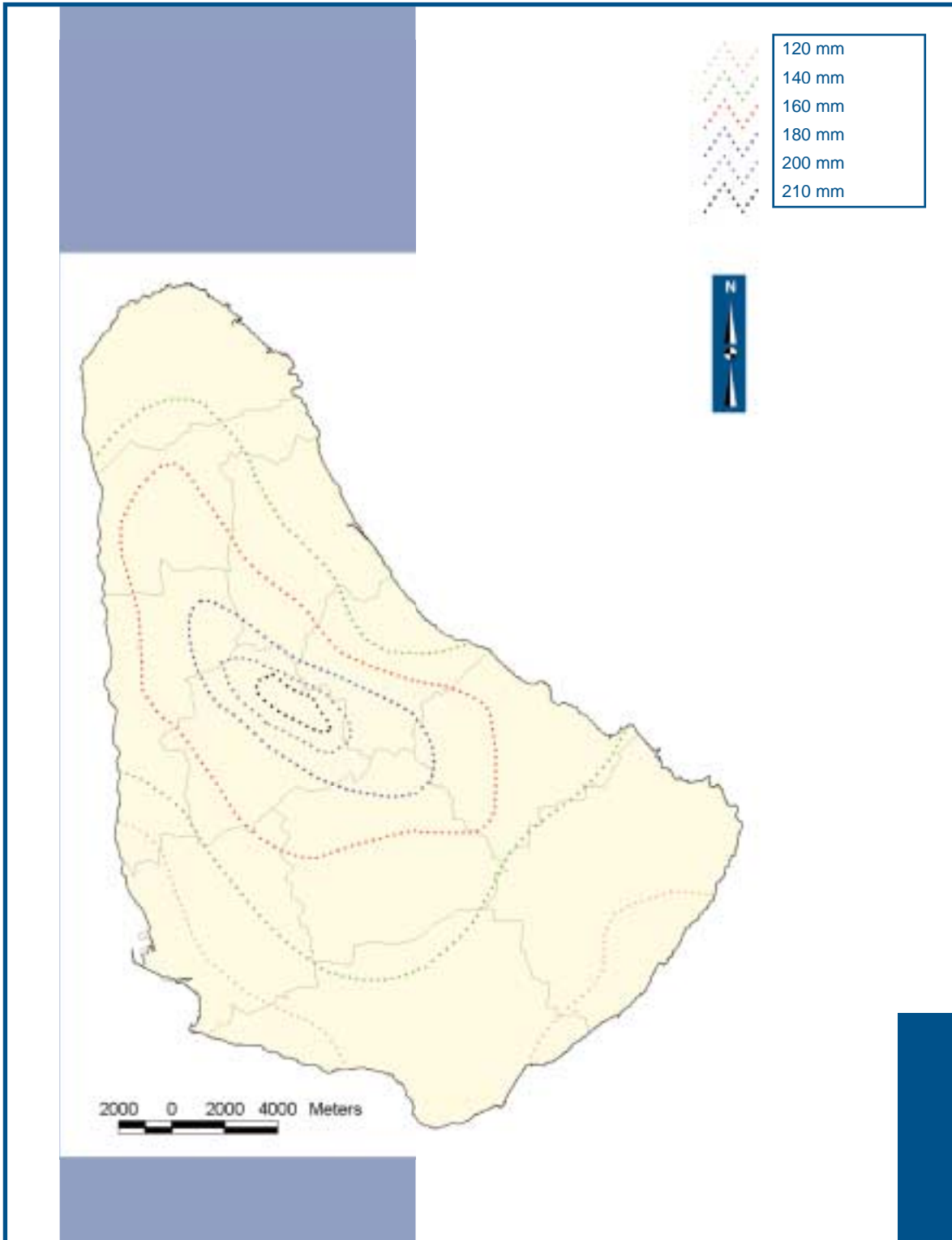
Once the rainwater has percolated through the limestone layer it flows from the central highlands towards the sea, following the slope of the interface of the limestone and underlying oceanics by means of both underground sheetwater and streamwater flow. As a result, the groundwater catchment areas are to the west and south of the central upland area of the island, correlating very closely with the surface catchment areas. Extraction for the supply system is by means of pumpage from wells or boreholes. The Barbados Water Authority currently pumps around 35 million gallons per day into the public supply system. Groundwater also reaches the surface through springs, two of which are used to augment the public supply.

Figure 5.1: Available Water Resources by Source 1996



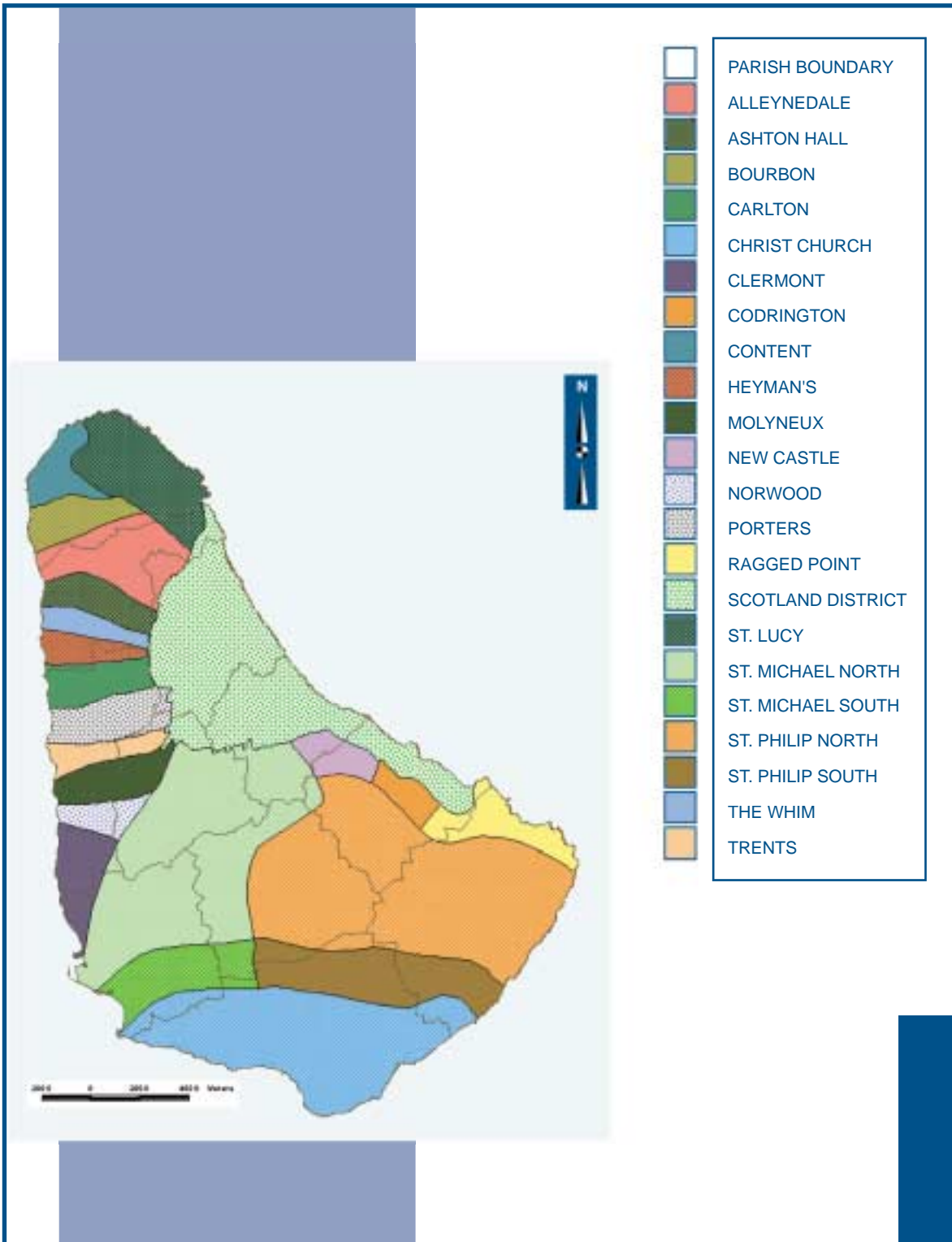
Source: Barbados Water Authority, 1996 and Klohn-Crippen Associates, 1977.

Map 5.1: Rainfall Distribution



Source: The National Natural Resources Data Base, 1998.

Map 5.2: Ground Water Catchments



Source: The National Natural Resources Data Base, 1998.

5.3 Fresh Water Quality

The quality of potable water has met all international standards for safe drinking water. In general the water is clean, clear, tasteless and odourless.

Since 1963 a zoning system has been in place to protect the ground water against bacteriological contamination. It was not designed to protect against chemical pollution. The criteria used for demarcating the zones were the attenuation rates of bacteria based on travel times. This system divides the island into five water protection zones - Zone 1 to Zone 5 - with Zone 1 being the most restrictive with respect to allowed physical development, and Zone 5 having no such restrictions (Map 5.3).

The Zoning system, along with an effective disinfection system⁷, has been partially effective in ensuring a biologically-safe water supply⁸. This is evidenced by the fact that indicator diseases such as

cholera, dysentery, giardiasis or hepatitis have not occurred in Barbados on any significant scale, and the few cases of dysentery that have occurred have not been linked to the public water supply. It has been concluded, however, that the overall groundwater protection policy could be effective in controlling biological risks if operated in conjunction with an upgraded and properly operated chlorination system.

The public water supply covers the entire island in that 94 percent of the households are connected, and the remainder has easy access. There are a few complaints of taste and discoloured water in small sections of the distribution system, which may at times be attributed to maintenance problems. Sporadic observations of a chlorine taste in the water are occasionally made. In addition, some saltiness is detected in the Western catchment in the dry season, which may be indicative of high extraction levels from the aquifers. Table 5.1 shows the quality of public water supply.

Table 5.1: Public Supply Water Quality

Parameter	International Standard	Barabados Average	Catchment Average		
			St. Michael	St. Philip	West Coast
Nitrate_N (mg/L)	10	7.11	6.87	8.15	6.54
Chloride (mg/L)	250	112.6	63.5	68.7	183.9
Sodium (mg/L)	200	50.26	24.6	52.9	75.8
Sulphate (mg/L)	250-400	33.5	24.1	36.4	37.8
Phosphates	N/A	0.07	0.07	0.08	0.06
PH	8.5	7.6	7.37	7.35	7.33
Atrazine (ug/L)	3.0	0.46	0.38	0.61	0.37
Amertyne (ug/L)	3.0	0.13	0.087	0.302	N/A
Faecal Coliform (colonies/100ml)	<1/100	<1/100	<1/100	<1/100	<1/100
TDS* (mg/L)	500	426	335	423	618

Source: Barbados National Consultation on Sustainable Development, 1997---Technical Paper 2.2: Sustainable Water Quality Management. * TDS = Total Dissolved Solids

The ground water protection policy has little effect on the source control of nitrate and pesticide. Water quality risks from agricultural chemicals have seen upward trends in nitrate and atrazine concentrations, towards levels that are unacceptable for drinking water. While concentrations are still marginally compliant with international standards, there is the need for strict control on the release of chemicals in these areas.

5.4 Pressures on Fresh Water

The main areas of concern with respect to water resources management and the environment are water scarcity and protection of the groundwater resources. The sources of pressure include increases in demand that result in raising the abstraction levels at the various wells - particularly the Belle and Hampton pumping stations (Map 5.3) - and the risk of contamination from the following: agricultural activity, the petro-chemical industry, industrial facilities and hazardous wastes, urban development and domestic waste disposal, and solid and liquid waste disposal.

Additionally, the maintenance of the distribution system is a source of concern. The 1996/1998 Water Resources Management and Water Loss Study (WRMWLS), the most significant study of Barbados' water resources of recent years, notes that bursts in the distribution network are frequently reported, averaging two to four reports a day. This is believed to be largely responsible for leakage losses, which are in the order of 62 per cent of the pumped volume⁹.

5.4.1 Demand Pressures

The WRMWLS has concluded that, from a reserve estimated at 44.8 million gallons per day (mgd), 47.3 mgd of freshwater is abstracted for public (35 million) and private (12.3) supply. The studies further concluded that with business as usual (i.e. if nothing is done), total water requirements could reach 53.8 mgd (89.4 million m³) by 2016, of which 38.8 mgd or 64.5 million m³ will be needed for public supply and 15.0 mgd (24.9 million m³) for private abstractions¹⁰. Actual consumption trends from 1978 to 1998 are presented in Figure 5.2. Total consumption by sector is presented in Figure 5.3.

It is clear that Barbados' water demands exceed a sustainable yield. Under these circumstances the risk of salt-water intrusion into the aquifers due to over-abstraction constitutes a significant source of stress to the quality of the water supply.

5.4.2 Water Quality Pressures

(i) Agricultural Activity

Zones 1 and 2 under the current water protection policy are also areas of intense agricultural activity. It is considered that the current level of protection from pesticides and fertilizers applied within Zones 1 and 2 may need to be strengthened. The WRMWLS reported that agricultural practices have been responsible for most of the increase in nitrate loading since 1977. It also indicated that while atrazine levels are still below the WHO threshold for potable water, it is on the rise¹¹. Any significant increase in the use of agricultural chemicals in these zones could compromise the safety of the water supply.

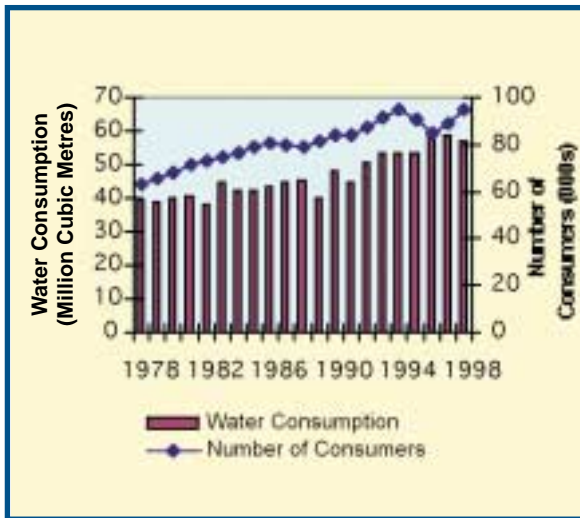
(ii) The Petrochemical Industry

The petrochemical industry comprises the drilling and storage of oil and petroleum based products. Bulk storage is regulated and occurs at petrol stations. The drilling of oil and its associated activities, however, are not similarly regulated. These activities occur predominantly in the Zone 1 and Zone 2 areas of the Hampton catchment, which accounts for approximately 25 per cent of the national water resources. They therefore present a significant threat, as has been confirmed by field investigations conducted in 1993 and 1997.

(iii) Industrial Activity and Hazardous Waste

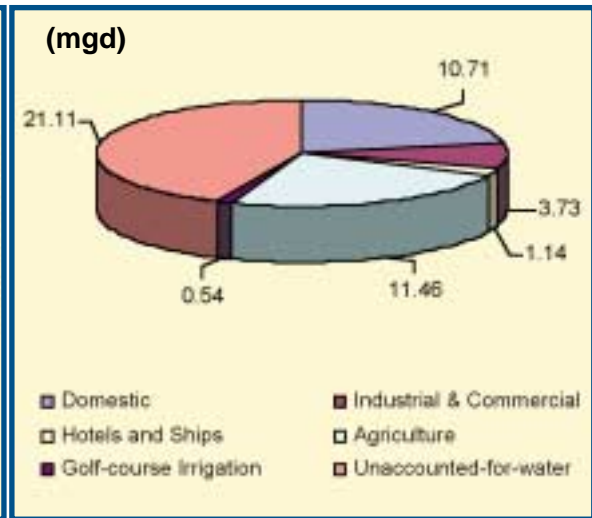
The encroachment of industry, including small-scale operations such as vehicle repair and maintenance shops, into highly protected water zones is an area of concern. A survey of industrial activity and their waste streams, conducted under the WRMWLS, found that 34 per cent of the industries surveyed operated within Zones 1, 2 and 3. The chemicals handled included lead oxide, nickel sulphate, photographic developer, perchlorethene, fenithronthion W/P, D/P, malathion dust, commodore W/P, dursban 4E and diazinon among others¹².

Figure 5.2: Water Consumption and Number of Consumers 1978-1998



Source: Barbados Social and Economic Report, 1998.

Figure 5.3: Water Consumption by Sector 1996



Source: Barbados Water Authority 1997.

Another survey, conducted by the Environmental Unit of the Ministry of Physical Development and Environment, compiled data on, among other things, trends in the importation of hazardous chemical/substances in the island over the period 1995-1998. The data from responding firms show an increase in reported imports, from over 456 000 kilograms of solids in 1995 to over 2.56 million kilograms in 1998, and an increase in liquids from 3.43 million litres to 23.23 million litres. The solids included such chemicals/substances as sodium hypochlorite, lead oxide, ammonium sulphate and sodium silicate, and the liquids included naphtha, calcium carbide, sodium sulphate, hydrochloric acid, benzene sulphonic acid and liquid propane/butane. Particularly noteworthy is the inclusion of polychlorinated biphenyl (PCB)-1254, a persistent organic compound with severe public health and environmental health consequences.

The distributional analysis of the results of this survey was on the basis of parish rather than water protection zones, and waste generation and handling was not reported. However, the trends noted are useful in indicating potential pressures on the potable water supply and the need for an appropriate response.

(iv) Urban Development and Waste Disposal

As population pressure on the island increases, there is likely to be an increase in the pressure for settlement encroachment on the areas protected by Zones 1 and 2 of the zoning policy. At present the safety of the water supply in these areas is ensured only by limiting encroachment in the Zone 1 areas and by the chlorination system. Thus the expansion of settlement would demand a careful analysis of ground water flow regimes and of the ability of biological agents to survive in these environments, as well as continuous monitoring and full enforcement of regulations in these areas.

Waste disposal in general can pose a serious problem for water resource protection. In Barbados the disposal method of choice is by landfill. Leachate from both official and unofficial landfill sites poses a threat to the groundwater supply. With respect to official sites - Mangrove I and Mangrove II - the first is unlined and therefore escaping leachate can potentially contaminate the groundwater, particularly the nearby Molyneux well. The second was engineered with a liner and recirculation system and should therefore be less of a threat.

In addition, unofficial operations have been identified in the vicinity of the Belle Zone 1 area and the

Hampton catchment. Such sites are not appropriately engineered and therefore pose a threat to the groundwater supply.

5.5 Policy Response

5.5.1 Water Quality Protection

Water quality protection is implemented at three levels. First, through the national water protection policy which targets the groundwater resource; second through a disinfection programme and the pumping stations; and third, monitoring the distribution system to ensure delivery of a safe product.

The 1963 Underground Water Protection Policy (revised in 1972) protects water catchment areas and the subterranean supply through the establishment of water zones. This zoning policy is based on bacteriological travel time of flow through the limestone to the pumping station. It is implemented through the collaborative efforts of the Barbados Water Authority, the Town and Country Development Planning Office, the Environmental Engineering Division (EED) of the Ministry of Physical Development and Environment, and the Public Health Division of the Ministry of Health.

Incorporated into the Zoning Policy is the Revised Policy on Private Sewage and Waste Water Disposal Systems, which seeks to control any development or liquid waste disposal systems that could be damaging to the national water resources.

The Zoning Policy was established under development conditions that were substantially different, in character and scale, from what currently obtains. The policy therefore needs to be reviewed to incorporate the potential impacts of the release of modern industrial chemicals and agro-chemicals into the environment.

Responsibility for monitoring and surveillance is shared by several agencies. The Barbados Water Authority has legal responsibility for monitoring and maintaining water quality standards. The Environmental Engineering Division (EED) has power to enforce standards on water quality and waste water discharge. The Coastal Zone Management Unit has powers of enforcement in matters relating to discharge into the marine environment.

The efforts of the above-mentioned agencies are hampered by the absence of a comprehensive legal framework or national water quality standard. Such a legal framework is provided in the draft Environmental Management Act now under review, while the national water quality standard is being discussed by the EED and the Caribbean Environmental Health Institute.

5.5.2 Water Scarcity

Several policies, programmes and strategies have been proposed or are being implemented to address the looming problem of water scarcity, using both short-term and long-term measures.

Since 1982, the Barbados Water Authority (Water Services) Regulations were enacted to facilitate promotion of the use of water conservation strategies including the temporary reduction of water pressure in the supply system, the temporary shut down of all or part of the system, and the temporary increase in the tariff blocks of the pricing system.

The 1990s saw a more concentrated focus on the problem following periods of serious water scarcity on the island. The 1996/8 Water Resources Management and Water Loss Studies (WRMWLS) were commissioned to address the growing concerns of quality and supply including:

- The rapidly increasing fresh water demand and consumption from residential, commercial, tourism and industrial developments;
- The increase in use of agricultural chemicals which have the potential to impact negatively on the quality of the potable water, and
- Reducing rates of aquifer recharge from rainfall due to increasing terrestrial runoff associated with urban development.

The results and recommendations of the studies have been reviewed and are being implemented, with a strong focus on the two main areas of (a) reduction in consumer use and (b) reduction in losses from the distribution system.

The 1997 Policy Framework for Water Resources Development and Management took into account the findings of the WRMWLS and of previous stud-

ies, and used these as the basis for developing a comprehensive water resources development and management plan to the year 2016 and beyond. The policy direction now includes a series of strategies in the areas of demand management, supply management and augmentation, institutional capacity building, and policy and legislation.

Additionally, the Government has constructed a desalination facility which is already in operation, and is projected to provide at least ten per cent of reserve capacity.

Finally, the draft 1998 Environmental and Natural Resources Management Plan proposes a number of institutional changes for a more streamlined and integrated approach to natural resources management, including specific recommendations for water resources management. This includes a look at the situation, in which the BWA functions as both the standard setter and the regulator of water supply. The recommendations, which took into account the Klohn-Crippen WRMWLS, are being reviewed as part of the consideration of a comprehensive environmental and natural resources management framework.

5.6 Conclusion

There are several concerns regarding water resources in Barbados. With respect to maintenance of quality and supply, they include: the rapidly increasing demand and consumption of residential, commercial, tourism and industrial developments; the increase in use of agricultural chemicals which have the potential to impact negatively on the quality of ground water; increased risk from the release of hazardous chemicals and substances into the environment; and reducing rates of aquifer recharge due to increasing runoff associated with urban development.

The Government has undertaken and is actively considering policy options to address these concerns in the areas of demand management, supply management and augmentation, institutional restructuring and capacity building, and policy and legislation.

There is some measure of urgency attached to finding sustainable solutions to water resources management, given in particular the scarcity issue. Timely policy response to, and implementation of findings and recommendations of recent studies will be key in this regard.



Notes

1. This refers to the "Barbados Water Resources Study" conducted by the Government of Barbados and Stanley Associates Engineering Limited and Consulting Engineers Partnerships Limited, Volumes 1-6, 1978.
2. The Barbados Water Resources Management and Water Loss Studies 1996-1998, prepared for the Government of Barbados by Klohn-Crippen Consultants Ltd. in association with Stanley Associates Engineering Ltd.
3. After analyzing the records in 30 year periods from 1947 to 1994, the consultants on the study concluded that of all the long range studies on record, the precipitation distribution analysis conducted by Rouse (1960) constituted the most reliable data set. It also corresponds most closely with the average annual precipitation value for the last 30 years, based on data from viable monitoring stations. The variation between this figure and that reported in the 1978 study appears to be due more to a matter of analysis and reliability than to a variation in actual rainfall amounts.
4. Barbados Water Authority, "Draft Policy Framework for Water Resources Development and Management in Barbados." Paper presented to the Planning and Priorities Committee of the Government of Barbados, August 12, 1997.
5. Barbados Water Authority. "Sustainable Water Resources Management – Recommendations". Paper presented at the Barbados National Consultation on Sustainable Development, November 1996/7.
6. Barbados Water Authority. "Sustainable Water Quality Management". Paper presented at the Barbados National Consultation on Sustainable Development, November 1996/7, and Klohn-Crippen, 1997, Barbados Water Resources Management and Water Loss Studies.
7. The zoning system and the disinfection system are collectively referred to as the Groundwater Protection Policy.
8. Klohn-Crippen, 1998. Report on Task 12: Development and Management Plan. For the Water Resources Management and Water Loss Study.
9. Ibid.
10. See note 4.
11. Government of Barbados, Environmental and Natural Resources Management Plan, 1998, prepared by Willms and Shier.
12. See note 5.